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THE AUSTRALIAN ZOOLOGIST

Issued by
The Royal Zoological Society of New South Wales

Vol. 5.—1927-1929.

WITH FORTY-ONE PLATES,
And Numerous Text-figures.



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THE AUSTRALIAN ZOOLOGIST

Issued by the
Royal Zoological Society of New South Wales

Edited by
A. F. BASSET HULL, C.F.A.O.U.

Vol. 5—Part 1

(Price, 6/-.)



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Royal Zoological Society of New South Wales.

Established 1879.

REGISTERED UNDER THE COMPANIES ACT, 1899 (1917).

COUNCIL, 1927-1928.

President:

J. Roy Kinghorn, C.M.Z.S.

Vice-Presidents:

Professor Launcelot Harrison, B.A., B.Sc.,
G. Athol Waterhouse, D.Sc., B.E., F.E.S., Aubrey Halloran, B.A., LL.B.,
and A. J. Nicholson, M.Sc.

Members:

E. J. Bryce.	W. W. Froggatt, F.L.S.
Neville W. Cayley.	A. Musgrave.
A. H. Chisholm.	E. F. Pollock, J.P.
Robert C. Dixson, J.P.	David G. Stead.
E. A. D'Ombraïn, M.B., B.S.	Ellis Le G. Troughton.

OFFICERS.

Hon. Secretary and Editor: A. F. Basset Hull, C.F.A.O.U.

Hon. Treasurer: Phillip Shipway.

Hon. Librarian: A. S. Le Souef, C.M.Z.S.

Hon. Auditor: E. E. Coates.

OFFICERS OF SECTIONS.

Entomological Section.

Chairman: G. Athol Waterhouse, D.Sc.
B.E., F.E.S.,
Vice-Chairman: H. J. Carter, B.A., F.E.S.
Hon. Secretary: G. M. Goldfinch.

Ornithological Section.

Chairman: Clifford Coles.
Vice-Chairman: A. S. Le Souef.
Hon. Secretary: Neville W. Cayley.
Committee: A. H. Chisholm, P. A. Gilbert,
J. R. Kinghorn, M. S. R. Sharland, and
H. Wolstenholme.

Biological Survey Section.

Chairman: Professor Launcelot Harrison.
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B.E., F.E.S.
Committee: Professor Griffith Taylor, Pro-
fessor W. R. Browne, A. J. Nicholson,
M.Sc., Neville W. Cayley, and E. Cheel.

Marine Zoological Section.

Chairman: T. C. Roughley.
Hon. Secretary: F. A. McNeill.

Royal Zoological Society of New South Wales.

THE ANNUAL MEETING.

The 1926-7 Annual General Meeting was held at the Union Hall, University of Sydney, on Tuesday, 25th July, 1927, at 8 p.m., forty-five members and visitors being present.

The President (Mr. A. J. Nicholson, M.Sc.), read the following report:—

THE ANNUAL REPORT.

On 30th June, 1927, there were 408 members on the Register, divided into the various categories as follows:—Life members 27, ordinary members 254, life associate members 20, associate members 100, honorary members 6, honorary associate member 1. Four members died during the year, six resigned, the names of seventeen members were removed from the Register, and thirty-two new members were elected, giving a net increase of five members. The Society has again suffered loss by death. Of one of its oldest and most valued members, Mr. Charles Hedley died in September, 1926. An obituary notice and portrait of this distinguished scientist was published in *The Australian Zoologist* (November 30, 1926). Mr. Henry Luke White died on the 30th May, 1927. He was a life member of this Society, and had contributed articles to *The Australian Zoologist*.

Mr. E. Howard, solicitor, Yass, and Mr. Herbert E. Rae, of Sydney, both members of the Society for some years, also died during the year.

The Council.

Owing to his intended departure from Sydney, Mr. D. G. Stewart, Honorary Treasurer, resigned his seat on the Council in December, 1926, and Mr. Phillip Shipway was elected Honorary Treasurer in his stead. Dr. E. W. Ferguson resigned from the Council in March, 1927, on account of continued ill-health. Mr. A. H. Chisholm and Dr. W. E. J. Paradise were elected to fill the vacancies on the Council. Nine meetings of Council were held during the year, at which the attendances were:—Messrs. Nicholson and Musgrave 9, Messrs. Hull and Shipway 8, Dr. D'Ombrain and Mr. Troughton 7, Messrs. Halloran, Cayley, Kinghorn, Stead, and Dr. Waterhouse 6, Messrs. Dixon and Pollock 5, Professor Harrison 4, Mr. Froggatt and Dr. Paradise 3, Messrs. Bryce, Chisholm and Stewart 2, and Dr. Ferguson 1. Leave of absence was granted to Messrs. Bryce and Froggatt who are absent on extended European and American tours.

Sections.

The sectional meetings maintain their popularity, and are well attended by enthusiastic specialists, with a sprinkling of other members. It is to be regretted that ordinary and associate members do not take more advantage of these meetings, which are generally conducted in such a manner as to provide interesting matter for the least expert member. Lectures, lantern slides, and exhibits are always features of the meetings, and the discussions are quite within the definition of "popular." From time to time members write to the Hon. Secretary suggesting that more popular meetings should be held, but they apparently overlook the fact that there are three such meetings on stated evenings in each month.

The Australian Zoologist.

Two parts of this journal were issued during the year, completing volume four. It is hoped to increase the issue for next year, and members are invited to contribute papers, photographs for reproduction, and notes of zoological interest.

Publications.

A second edition of the late A. R. McCulloch's "Fishes of New South Wales" has been prepared. It contains a supplement compiled by Mr. Gilbert P. Whitley, recording the additions made to our fish fauna since the first edition was published (1922). Issued in paper wrappers at the remarkably low price of two shillings, it should meet with a steady demand.

The "Monograph of the Australian Loricates" by Messrs. Iredale and Hull which appeared in sections in *The Australian Zoologist*, has been prepared for issue in book form, and is now obtainable, price five shillings.

Finances.

The funds of the Society are in a very satisfactory state, notwithstanding that there are no donations to be recorded for the past year.

Aquarium at Taronga Park.

The Aquarium at Taronga Park has now been opened to the public, and a full description of this splendid addition to the attractions of the Park will be given elsewhere in *The Australian Zoologist*. It will not be open free to members of this Society, who will be required to pay the same amount as the general public. The reason for this is that the Aquarium has cost £18,000 to construct and equip, and a substantial financial return is naturally looked for by the Trust. Further, it is considered that the privileges already granted to members constitute a very liberal return for their subscriptions.

Amendment of Articles.

Some important suggestions as to alteration of the Articles of Association of the Society will be submitted to members for their consideration. At present the number of ordinary members is not specifically limited by the Articles, but, as the Society can only issue three hundred passes to Taronga Park, it is considered desirable to restrict the ordinary membership to that number. Provision is to be made for the removal from the Register of the names of members who are six months in arrears with their subscriptions. It is found that some mem-

bers leave the city or the vicinity of Taronga Park, and no longer require the privileges of admission thereto, but neglect to send in their formal resignations. In the past the Society has been unable to create a vacancy until the member has been unfinancial for over twelve months. It is also proposed to authorise the Council to confer honorary titles upon members or other persons who contribute substantially to the funds of the Society, or who by rendering valuable personal service to the Society or to Australian zoology merit some form of recognition. It is anticipated that an opportunity will shortly be afforded this Society of joining in the great movement for a Science House, in which all the scientific societies may carry on their work, and funds will be required for the purpose of enabling this Society to be adequately and worthily represented.

Representation on Park Trusts.

Reference has already been made in *The Australian Zoologist* to the appointment of several members of this Society as Trustees of the great Parks. It is a matter upon which the Society may fairly express its gratification.

The Library.

Extensive additions have been made to the shelving in the large room in the Administrative Building at the upper entrance to Taronga Park which the Trustees have placed at the disposal of the Society. Numerous additions to the Library are now made more easily accessible to members, and Mr. A. S. Le Souef, who occupies the adjoining room, has kindly consented to act as Librarian and to issue books (during the day-time) to members requiring them.

The Honorary Treasurer (Mr. Phillip Shipway) then presented the balance sheet, which follows. (Page 4).

Councillors Re-elected.

The retiring Councillors were Drs. E. A. D'Ombain and W. E. J. Paradise, Messrs. A. H. Chisholm, W. W. Froggatt, A. Musgrave, and E. F. Pollock, all of whom were re-elected.

Officers for 1927-8.

At a meeting of Council, held on 11th August, 1927, the following members were elected officers for the year ending 30th June, 1928:—

President: J. R. Kinghorn, C.M.Z.S.

Vice-Presidents: Professor L. Harrison, Dr. G. A. Waterhouse, Aubrey Halloran, and A. J. Nicholson, M.Sc.

Honorary Secretary and Editor: A. F. Basset Hull, C.F.A.O.U.

Honorary Treasurer: Phillip Shipway.

Honorary Librarian: A. S. Le Souef, C.M.Z.S.



ROYAL ZOOLOGICAL SOCIETY OF NEW SOUTH WALES

BALANCE SHEET FOR YEAR ENDING 30th JUNE, 1927.

LIABILITIES.	£	s.	d.		ASSETS.	£	s.	d.	&	s.	d.
Capital Account	791	0	0		Capital Account—						
Income Account	100	18	7		Commonwealth Inscribed						
Handbook Fund Account	230	5	1		Stock (f. v. £650)	641	0	0			
					N.S.W. Funded Stock (f. v.						
					£50)	50	0	0			
					N.S.W. Debentures (f. v. £100)	100	0	0			
						791	0	0			
					Income Account—						
					Commercial Banking Co. of						
					Sydney	5	4	11			
					Government Savings Bank ..	95	13	8			
						100	18	7			
					Handbook Fund Account—						
					War Bonds (f. v. £200)	188	5	0			
					Government Savings Bank ..	41	9	11			
					In Hand	0	10	2			
						230	5	1			
						£1,122	3	8			
											£1,122 3 8

HANDBOOK FUND ACCOUNT.

	£	s.	d.		£	s.	d.
Balance from 30th June, 1926	217	17	6		Balance 30th June, 1927, Government Sav-		
Sale "Fishes" Handbook	1	0	2		ings Bank	41	9 11
Interest	11	7	5		War Bonds (f. v. £200)	188	5 0
					In Hand	10	2
						£230	5 1
						£230	5 1

INCOME ACCOUNT.

RECEIPTS.	£	s.	d.		DISBURSEMENTS.	£	s.	d.	£	s.	d.
Balance from 30th June, 1926 ..	29	4	3		Publication Account—						
Subscriptions—					Printing	87	6	6			
Life Associat:	26	5	0		Blocks, etc.	11	19	2			
Ordinary—Arrears	1	1	0		Postage and Delivery	7	5	1			
Current	250	8	6			106	10	9			
In Advance	12	12	0		Printing, Stationery				33	4	1
Associate—Arrears	2	5	0		Office Accommodation				63	0	0
Current	30	4	6		Books for Library				15	7	0
In Advance	2	5	0		Annual Dinner				9	17	0
					Shelving for Library				26	8	9
					Petty Cash				4	8	6
					Postage				6	4	0
					Miscellaneous				18	9	
					Capitalisation (purchase of £100 N.S.W.				100	10	3
					Debenture)						
					Balance on 30th June, 1927—						
					Commercial Banking Co. of						
					Sydney	5	4	11			
					Government Savings Bank ..	95	13	8			
						100	18	7			
						£473	7	8			
											£473 7 8

Audited and found correct, 22nd July, 1927.

EDW. E. COATES, Hon. Auditor.

PHILLIP SHIPWAY, Hon. Treasurer.

REPORTS OF THE SECTIONS.

BIOLOGICAL SURVEY.

Although no formal meetings were held, this Section has been active during the past year, and a considerable quantity of valuable material and data have been collected.

A physiographical and geological study of the area in the vicinity of the Cabin was commenced, together with a general review of its plant associations. This work has suffered from a series of unfortunate but unavoidable delays; considerable progress has nevertheless been made.

Entomological studies have been carried on as intensively as time and opportunity have permitted, and many thousands of specimens have been collected, both at the Cottage and at the Cabin. A number of undescribed species have been discovered, species described many years ago have been rediscovered, the range of certain known species has been greatly extended, and much valuable information relating to seasonal distribution and to the habits of particular groups of insects has been collected. Certain of these results have been incorporated in papers already published or in preparation, but much remains to be done before any useful purpose would be subserved by the publication of collected data concerning the insect fauna of the Park as a geographical unit or the faunal differences and relationships of its several environmental components.

Apart from ornithology, which is in the hands of another Section, other branches of zoology have suffered from a lack of workers.

I. M. MACKERRAS, Acting Hon. Sec.

ENTOMOLOGICAL SECTION.

Nine well-attended meetings were held during the year, and several inter-State visitors were welcomed. Amongst the interesting exhibits were a male of *Pelecorrhynchus taeniatus* (previously unknown); a collection of 28 species of mosquitoes, being the whole of this group recorded from the Sydney district; insects from the Santa Cruz Islands, collected by Messrs. Troughton and Livingstone; gynandromorphous butterflies; specimens of all the various orders collected at Barrington Tops, and insects from Papua, collected by Mr. Nicholson.

Discussions included one on "Distribution," introduced by Mr. Nicholson, and one on "Aberrations and Abnormalities amongst Insects."

Interesting notes on collecting experiences in Western Australia were contributed by members who attended the R.A.O.U. Congress, and Mr. Nicholson contributed notes illustrated by lantern slides of his visit to Papua.

The following officers have been elected for the current year:—Chairman, G. Athol Waterhouse, D.Sc., B.E., F.E.S.; vice-chairman, H. J. Carter, B.A., F.E.S.; honorary secretary, G. M. Goldfinch.

G. A. WATERHOUSE, Chairman.

MARINE ZOOLOGY.

At a meeting held on August 9, 1926, it was decided to form a Section of Marine Zoology, and the following officers were elected for the ensuing year:—
Chairman: Mr. T. C. Roughley.

Vice-Chairman: Mr. F. A. McNeill.

Hon. Secretary: W. E. J. Paradise, M.B., Ch.M.

Since the inauguration of the Section meetings have been held each month.

At every meeting an address liberally illustrated by lantern slides has been delivered by a member of the Section, and in many cases interesting exhibits were shown.

The list of subjects on which addresses were delivered covered a very large field, and the members of the Section agree that the year's work has been both interesting and instructive to them.

The following are the titles of the addresses delivered before the Section:—
"The Life of the Sand Flats of Gunnamatta Bay," F. A. McNeill; "The Biology of Sir Edward Pellew Group of Islands," W. E. J. Paradise; "The Biology of Bottle and Glass Rocks," F. A. McNeill; "Goldfish and Their Breeding Habits," A. Royce; "Pile Boring Animals," F. A. McNeill; "Crabs of the Queensland Coast," M. Ward; "Oyster Culture," T. C. Roughley; "The Mollusca," W. Boardman; "Sharks and Rays," G. P. Whitley; "Bryozoa," A. A. Livingstone; "Fossil Marine Life," H. O. Fletcher; and "Mangroves," A. Musgrave.

At several meetings various members recorded recent observations, those recorded by Dr. Paradise having since been grouped together and published in the *Australian Zoologist* under the heading, "Some Recent Natural History Observations."

One of the aims of this Section is to further the study of marine biology, and we are of the opinion that this can best be done by the establishment of marine biological stations along our coast, and members are therefore using their influence where possible in order to bring about the establishment of these stations.

The Trustees of Taronga Park have offered to afford facilities for members of this Section to carry out scientific work at their new aquarium when opened.

Members of the Section prepared an exhibit of interesting forms of marine life for the 1926 Nature Exhibition.

W. E. J. PARADICE, Hon. Sec.

Office-bearers for 1927-8:—Chairman, Mr. T. C. Roughley; vice-chairman, Dr. W. E. J. Paradise; hon. secretary, Mr. F. A. McNeill.

 ORNITHOLOGICAL SECTION.

In submitting the fifth annual report of the Section, we again have pleasure in stating that the year has been a very satisfactory one. Nine well attended meetings were held, and the lecturettes and discussions were both enjoyable and informative. During October the twenty-sixth annual Congress of the R.A.O. Union was held, in Sydney, followed by a "Camp-out," held at the head of the William's River, in the vicinity of the celebrated Barrington Tops. The success of both was due chiefly to the enthusiastic co-operation of members of the Section. The Bird Cabin in National Park has been well patronised by members, and much useful information gained of the bird life of that interesting locality.

A trip to Lord Howe Island organised by Mr. E. F. Pollock was well attended, and judging by the splendid collection of bird photographs taken by

members of the party and exhibited at our meetings, proved both enjoyable and fruitful. Messrs. A. Musgrave and P. A. Gilbert visited the Macpherson Ranges of southern Queensland, and gained much useful knowledge and excellent photographs of that wonderful National Reserve.

Members of the Section feel justly proud of the following appointments:—Mr. A. F. Basset Hull to the Taronga Zoological Park Trust, Mr. A. H. Chisholm to the National Park Trust, and Mr. H. Wolstenholme to the Kuring-gai Chase Trust. These gentlemen, we feel sure, will, with their enthusiasm and knowledge, prove useful trustees.

A summary of the lectures given during the year is as follows:—

August 20th.—Mr. E. F. Pollock, a lecture illustrated profusely with lantern slides made from photographs taken by himself and others, entitled: "With the Sea-birds and Turtles of the Capricorn Islands."

September 24th.—Mr. A. Musgrave exhibited some fine lantern slides of scenes taken on Duggan's Creek, an arm of the Chichester River, and Mr. J. R. Kinghorn showed some beautiful coloured slides of bird subjects taken by Messrs. D. W. Gawkrödger, J. J. Jerrard, J. S. P. Ramsay, A. E. Keene, and himself.

October's meeting took the form of a "Bird Night," when visiting ornithologists from other States were entertained by the members of the Section.

November 19th.—Mr. A. J. Nicholson delivered a most instructive lecture entitled "Insect Photography," illustrated with numbers of remarkable lantern slides made from his own photographs. Incidental to Mr. Nicholson's lecture were some clever attachments to the camera he uses, invented by him to overcome some of the difficulties met with in Nature photography, especially in connection with accuracy in focussing.

December 17th.—Exhibition of lantern slides by Mr. Norman Chaffer of some pretty pictures taken during the R.A.O. Union's "Camp-out," held on the Upper William's River.

February 18th.—A general discussion on bird protection.

March 18th.—Mr. A. S. Le Souef gave an interesting address on the bird life observed during his trip abroad.

April 22nd.—Mr. E. F. Pollock exhibited as lantern slides a very fine collection of bird photographs. The studies were mostly taken by him during trips to the Capricorn Group and Lord Howe Island. Other subjects were taken by Dr. W. MacGillivray and Messrs. Otho Webb and Bell.

May 20th.—Mr. A. Musgrave gave an interesting account of his trip to the Macpherson Ranges of southern Queensland during the latter part of 1926. He illustrated his remarks with many beautiful lantern slides, chiefly scenes, views of many beauty spots of that magnificent National Reserve.

June 17th.—Mr. N. W. Cayley led a discussion on waders, and exhibited lantern slides from photographs taken by Messrs. Littlejohns, Chaffer, Burrell, and Webb. Mr. J. R. Kinghorn exhibited some interesting specimens from the Australian Museum collections.

15/7/27.

J. R. KINGHORN, Chairman.

The following office-bearers were elected for the year 1927-8:—

Chairman: Mr. Clifford Coles.

Vice-Chairman: Mr. A. S. Le Souef.

Hon. Secretary: Mr. N. W. Cayley.

Committee: Messrs. A. H. Chisholm, M. S. R. Sharland, P. A. Gilbert, and J. R. Kinghorn.

Mrs. C. A. Messmer was appointed Hon. Secretary of Field Club.

AMENDMENT OF ARTICLES OF ASSOCIATION.

At a Special General Meeting of the Society, held on 8th September, 1927, several of the Articles of Association of the Society were amended by resolutions, confirmed at a special general meeting, held on 6th October, 1927. The following is a copy of the resolutions:—

(a). That Article 5 be repealed and the following Article substituted, namely:—

“5. The Society shall consist of (a) ordinary members, limited in number to three hundred; (b) associate members, unlimited in number, (c) honorary members, not exceeding at any one time ten in number, and (d) honorary associate members, not exceeding at any one time five in number for each section of the Society.”

(b). That Articles 8, 9 and 10 be repealed, and the following Articles substituted, namely:—

“8. Any person approved by a majority of the Council shall be eligible for admission as an ordinary or associate member. Every candidate for admission may apply to the Council in writing for admission, or may be proposed by an ordinary member. Provided that if the register of financial ordinary members contains the full complement of three hundred any person desirous of becoming an ordinary member shall first apply for associate membership and await a vacancy, and shall take precedence in accordance with the date of his admission to associate membership.”

“9. Until otherwise determined by an ordinary resolution of a General Meeting every ordinary member of the Society shall pay an annual subscription of one pound one shilling, and every associate member of the Society shall pay an annual subscription of seven shillings and sixpence. Such subscriptions shall be payable on admission and thereafter on the first day of July in each year. Provided that any ordinary or associate member admitted between the first day of January and the thirtieth day of June in any year shall be required to pay one-half of the annual subscription only for that year. The Council shall have power to remove from the Register of Members the name of any ordinary or associate member whose subscription is more than six months in arrear.”

“10. The Council shall have power until otherwise determined by ordinary resolution of a General Meeting to accept the amount of ten annual subscriptions at any time in one sum from any ordinary or associate member as a life composition for the annual subscription: Provided that any ordinary member of the unincorporated Society who had compounded his annual subscription under the Rules of the said unincorporated Society and who shall become a member of the Society shall not be required to make any further payment.”

(c). That Article 14 be repealed, and the following Article substituted, namely:—

“14. Honorary members shall be persons who have rendered distinguished service to the Society and shall be proposed by a member of the Council and elected by a majority of the Council present at a meeting thereof: Provided that not less than three weeks' notice in writing of the intention to propose such honorary member shall have been given at a meeting of the Council: Provided further that honorary members of the unincorporated Society shall be entitled to become honorary members of the Society upon notifying the secretary as provided by Article 7. Honorary members shall be entitled for such period as the Council may determine on election to all the privileges and rights of ordinary members excepting the right to vote at any meeting of the Society. Honorary

associate members shall be persons not resident in New South Wales who have rendered distinguished service to Australian zoology. They shall be elected by a majority of the Council present at a meeting thereof upon nomination by a duly convened meeting of a section of the Society. Honorary associate members shall be entitled for such period as the Council may determine on election to all the privileges and rights of associate members."

(d). That the following Article be inserted after Article 17:—

"17a. The Council shall have power to confer the following titles upon any person, corporation, or trust who or which has contributed to the funds of the Society:—

- i. A sum of not less than one thousand pounds, the title "Endowment Member";
- ii. A sum of not less than five hundred pounds, the title "Benefactor";
- iii. A sum of not less than one hundred pounds, the title "Associate Benefactor."

(e). That the following Article be inserted after Article 50:—

"51. No alteration shall be made in these Articles except by resolution carried by a majority of not less than three-fourths of the members present at an annual or special general meeting called in accordance with the provisions of Article 41."

A proposed amendment to authorise the Council to confer the title "Fellow" upon members who had rendered valuable service to the Society or to Australian zoology, failed to receive the necessary support of a three-fourths majority of the members present.

GREAT BARRIER REEF NATURE STUDY EXPEDITIONS.

Great interest is being taken by naturalists in the expeditions which are being organised in Sydney for visiting several of the coral islands at the southern end of the Great Barrier Reef, off the coast of Queensland, in November and December next. Scientists and naturalists are coming from every State of the Commonwealth, excepting only West Australia, to make the journey to the fascinating atolls. The most favourable time of the year has been selected for the visits, as not only is the weather at its best at this period, but it also coincides with the breeding season of the many kinds of seabirds and turtles, all of which breed on the islands in prodigious numbers. Students of marine zoology will be afforded an exceptional opportunity for research work among the corals and coral animals during the month it is intended to be away. Others will be more interested in the large game and other fishes which abound in these waters, and which will also afford great opportunities and exciting sport to anglers. Special attention is to be paid by another section of the party to an investigation of the huge sharks and rays.

The expeditions, which are the third and fourth of a series of nature study excursions organised in recent years by Mr. E. F. Pollock, of Carrington Avenue, Strathfield, New South Wales, will leave Sydney by rail for Bundaberg, Queensland, on 13th November and 27th December. The second one has been specially timed to enable school teachers and others to make the trip during the summer vacation, and it is gratifying to learn that the opportunity has already been availed of by teachers from each of the three eastern States.

Mr. Pollock is most enthusiastic about the bird and animal life on the Barrier Reef, and he says no one can witness it without being enraptured by the wonderful sight.

PRESIDENTIAL ADDRESS.

A NEW THEORY OF MIMICRY IN INSECTS.

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Introduction.

The phenomenon of the resemblance of an animal either to the background on which it is normally found or to some other animal has been a source of great interest to naturalists of all times. In this address I shall call this phenomenon "mimetic resemblance," in spite of the fact that the term "mimicry" is commonly now used in a more restricted sense, for the restriction of the latter term appears to have left the major problem without a suitable name. Considerable controversy has raged round this problem, particularly with regard to the evolution and significance of mimetic resemblance, and the controversy has by no means diminished with the passing of the years. On the one hand there are many biologists who have studied large numbers of cases of mimetic resemblance and have been impressed by the beautiful and often very complex adaptation exhibited. The perfection of this adaptation has convinced them that it must be of fundamental importance to the animals exhibiting it, and they have therefore put forward theories as to the evolution and significance of mimetic re-

semblance which are dependent on the primary hypothesis that it is of vital importance to the possessors. When one applies these theories to the known facts of mimetic resemblance, however, it is found that in many ways they are inadequate. Probably the most important objection to the theories put forward is that in many cases there is considerable evidence indicating that mimetic resemblance does not give the possessors any advantage over non-mimetic animals.

In order to deal with this objection it has been suggested that the factors operating against mimetic animals are more effective than those operating against non-mimetic animals, but there is absolutely no evidence that this is so. There is also a considerable number of other important objections to the theories commonly put forward with which I cannot deal at present, though many of them will be dealt with later. The unsatisfactory nature of these theories has caused many other biologists not only to dispute the theories, but often to doubt the actual existence of mimetic resemblance, apparently on the general principle that a phenomenon which cannot be explained satisfactorily therefore cannot exist. This is obviously illogical, but it will be found that practically the whole of the arguments directed against mimicry are actually only arguments against the truth of the current theories as to the evolution and significance of mimicry. In this, as in all other scientific problems, it is important that a sharp distinction should be drawn between fact and theory.

It is the purpose of this address first to examine the evidence for the actual existence of mimetic resemblance and then to consider in what manner it may have been evolved. It will be shown that a simple mechanism exists by means of which mimetic resemblance may have been evolved which does not entail any necessity for the vital importance to the species either of the perfected resemblance or of the various steps which must have preceded this in the evolution of many mimetic species. Unlike the theories already mentioned, the theory concerning this mechanism appears to be in entire agreement with the known facts, which it explains without the assistance of any supplementary hypotheses. Whether this theory is to be considered as giving the true explanation of the evolution of mimetic resemblance will depend on the manner in which it explains, or fails to explain, such new facts as come to light, for direct proof appears to be out of the question, but it at least forms a more satisfactory working hypothesis than previous theories.

As far as possible I shall illustrate my remarks with examples of Australian mimetic insects, for we have in this country large numbers of such insects, few of which have yet been described. It will be possible to illustrate most types of mimetic resemblance in this manner but, when dealing with the objections to mimicry which are commonly put forward, it will be necessary to deal with certain exotic forms, as these are specifically involved in some of the objections.

Before going any further I must define what I mean by the term "mimetic resemblance." Using the term in the broad sense I have adopted it may be defined as the phenomenon of resemblance in an animal produced as a response to the appearance of another animal, or of some object in its natural environment. It is the problem of resemblance, resemblance itself being the end product of some process and not simply the incidental attribute of some other factor. Similarity of appearance and not of structure is its characteristic, and the appearance of the mimic is essentially a response to the appearance of the model which it resembles, and would not have been produced, or at least preserved, if the model had not existed. It is most important that this necessary dependence of the appearance of the mimic on that of the model should be borne

in mind in order to exclude other types of similarity which are due to other causes. Thus similarity in fundamental structure due to close relationship often causes resemblance, and unrelated animals which inhabit a common environment often exhibit similar modifications in structure which cause them to appear very much alike. In such cases similarity in structure is produced in two or more animals by some common cause and, appearance being simply an attribute of this structure, resemblance must be considered fortuitous. As mimetic resemblance is purely a phenomenon of appearance, it is obvious that such cases do not come within the scope of the subject under consideration.

It is probable that some biologists will take exception to the definition of mimetic resemblance given, on the grounds that I imply one type of explanation, to the exclusion of others. I contend that this implication is a necessary part of the definition in order to confine attention to a single homogeneous problem. If it should be proved that resemblance is never produced, as such, but is always the accidental result of the independent production of structures which have either a fundamental or superficial similarity, my view is that it would be proved that the phenomenon of mimetic resemblance does not exist, rather than that a different type of explanation is the true one. The supposed phenomenon of mimetic resemblance would be proved to be only a part of the phenomenon of convergence.

It has been the practice in recent years to confine the use of the term "mimicry" to one portion only of the subject under consideration, that is, to the mimetic resemblance of one animal to another, and I have but little doubt that I shall be severely criticised by many interested in this subject for using the term in a much broader sense than is usual, in spite of the fact that I have modified it slightly. Unfortunately there appeared to be no other course open to me, for the restriction of the term "mimicry" to only one portion of the subject which it originally designated has left the major problem without a suitable name. Also "mimicry," involving as it does the idea of imitation, appears to be the only really suitable term for the problem I have defined, and I therefore feel justified in using this term in its original sense, even at the risk of adding a little further confusion to that which already exists owing to its use in a number of different senses by different authors. The only other term which appears to me to be in any way suitable is "adaptive resemblance," but I do not consider this to be as suitable as "mimetic resemblance." The problem is sometimes considered under such headings as "animal colouration" and "adaptive colouration," but it is evident that these do not adequately cover the problem under consideration.

It is evident that some term is now required for the phenomenon of the mimetic resemblance of one animal to another, as I no longer use "mimicry" in this sense. The alternative term proposed by Poulton, "pseudosematic colouration," does not appear to me to be completely satisfactory as it is unwieldy and directs attention to only one portion of the subject, viz., colouration. I shall, therefore, use "deceptive resemblance," as this term is descriptive of the two outstanding features of mimetic resemblance of one animal to another. The other major division of mimetic resemblance, that is, the resemblance of an animal to some portion of its normal background, is commonly referred to either as "protective resemblance" or "cryptic colouration." The former term is particularly unsatisfactory as it is not descriptive, but indicates one possible explanation of this type of resemblance. Also, according to the theory usually put forward as to the significance of mimetic resemblance, this term applies

equally well to all cases of deceptive resemblance. It will be shown later that "protection" has probably but a very minor significance in all kinds of mimetic resemblance but, whether this be so or not, it is desirable that a term used to define a phenomenon should describe it rather than indicate a particular explanation. I shall therefore use "cryptic resemblance," which simply describes the phenomenon and does not confine attention to colouration only.

Now that I have defined what I mean by mimetic resemblance, a few examples of different types of similarity will illustrate more clearly the limitations of this term. It is so obvious that resemblance due to close relationship cannot be considered as a problem of appearance, that illustrations are scarcely necessary; but I might give the resemblance of the fox to the wolf as an example. There never has been any suspicion that the considerable similarity of these two animals is due to mimetic resemblance. The resemblance is evidently due to the fact that both have arisen from a common ancestor, comparatively recently, and that each still retains the general structure of that common ancestor and only differs in minor characters from the other. The appearance of each is simply an expression of this fundamental similarity in structure, and resemblance has not been produced, but remains. The problem is rather to explain the differences which have arisen between the fox and the wolf, than the general resemblance which persists.

The similarity in appearance of animals, which are only very distantly related, due to similar adaptation to a common environment, may not at first sight appear so obviously to be unrelated to mimetic resemblance; but it can easily be shown that resemblance is fortuitous and, in itself, of no significance to the animals bearing it. Thus several very distinct types of beetles which bore in wood in their adult state are extremely similar superficially. These are the Bostrichidae, the furniture beetles and their allies belonging to the Ptinidae and the ambrosia beetles belonging to the Scolytidae. In each case the beetle is cylindrical in form, the sides being parallel, the ends appearing to be truncated, and the cross-section is almost circular. Also the mouthparts are borne on the periphery, the thorax being hood-like, causing the head to occupy a ventral rather than an anterior position. This form is excellently adapted to the environment of the insect. A cylindrical form is most suitable for an insect which has to move about in a tubular gallery, the truncated ends enable it to push the debris, produced while burrowing, out of the hole, or to pack it into the portion of the gallery it no longer occupies, as is the common habit. The situation of the mouthparts on the periphery of the insect enables it to bore a hole large enough for its body to pass through.

In the same manner many insects which live under water have a considerable general resemblance owing to similar adaptations to the aquatic environment. The Dytiscidae, Gyrinidae and Hydrophilidae amongst the Coleoptera, and the Notonectidae, Corixidae, Belostomatidae and Naucoridae amongst the Hemiptera have much in common in appearance. The parts of the body are beautifully coadapted so as to give simple contours to the insect, consisting of gentle and continuous curves, which enables the insects to slip easily through the water, and the legs are modified to form oar-like structures for the purpose of swimming, these often being built on exactly the same mechanical and structural plan in widely distinct forms, for example, in the Dytiscidae and Notonectidae.

Similar functional requirements also often give rise to similar structure in dissimilar animals, though it is impossible to draw a sharp distinction between

the results of functional requirements and environment. Thus the Mantidae and Mantispidae, belonging respectively to the widely separated orders Orthoptera and Neuroptera, have a very considerable superficial resemblance (Pl. iii., figs. 9 and 10). The insects belonging to both families are predaceous, and the striking similarity is due to similar adaptations to the predaceous habit. The front legs are highly modified to form efficient grasping structures which are built on exactly the same plan in each case, and the front coxae and prothorax, normally very short structures in insects, are greatly elongated to give the insects a longer reach. In a similar manner oar-like hind legs are built on exactly the same plan and have been evolved quite independently by a series of distinct types of aquatic insects and, though this can be considered as an adaptation to a common environment, as I have already shown, it can also be considered as due to similar functional requirements.

It is evident, therefore, that similarity in appearance is often due to structural similarity, this, in its turn, being produced in some manner as a response to the similar requirements of the insects; or, in other words, it is the result of similar environmental or functional influences. The structure in each form is produced without reference to other forms which happen to have a similar structure. The fact of resemblance is quite fortuitous and without significance to the animal bearing it, and it therefore cannot be considered as mimetic resemblance. In such cases the similarity is referred to as convergence.

It sometimes happens that two or more insects resemble one another owing to the fact that they have all developed a mimetic resemblance to the same type of background. For example, certain longicorn beetles and weevils which live on tree-trunks have a considerable general resemblance to one another, and each species is inconspicuous in its normal habitat. It is evident that the resemblance between such beetles is fortuitous, similarity in appearance being due to the fact that each species has responded to the same environmental influence, viz., the appearance of the tree-trunks on which the insects live. This is referred to as syncryptic resemblance and is not mimetic.

When one considers the vast number of different species of insects and the comparatively homogeneous nature of the class, it would appear highly probable that purely accidental similarity must sometimes occur. That such cases exist there can be very little doubt, but they are difficult to recognise as it is necessary first to prove that the similarity has not been produced as the result of some common cause. For this reason it is difficult to give examples from the Insecta, but the type of similarity under consideration is such as exists between certain flowers and sea-anemones, or between the stalked green eggs of the green-lacewing, *Chrysopa*, and the sporangia of certain mosses, as a species of which they were originally described! It should be noticed that the chances of such an apparent mimic resembling its apparent model in more than one conspicuous character, and differing widely from its close relatives in these same characters, is extremely improbable; and that therefore cases of such apparent mimicry would be extremely unconvincing except, possibly, in a museum collection. It is possible that a certain number of the cases of mimicry which have been described should be placed in this category; but, for reasons I shall give later, I do not think they are many.

There is at least one other possible type of similarity in addition to mimetic resemblance. When two groups of insects are fairly closely related it is probable that the genetical constitutions of the individuals will be very similar, for they have all been derived from that of the common ancestor. With similar genetical constitutions it seems probable that the potencies should be similar, so

that mutations of the same, or very similar, type might be expected to occur quite independently in the two groups. In this manner species might be modified, or new species arise, in exactly the same manner and quite independently in the two groups; the resultant resemblance being the expression of some underlying genetical similarity. This is not the same as similarity due simply to close relationship, as in this case it is due to something new which has appeared independently in each group, and not to the inheritance by each of the structure of the common ancestor. In such cases the resemblance might be very great and even extend to more than one character, but it should be noticed that this is not necessarily independent of a mimetic explanation. If a new mutant receives any advantage from its resemblance to some other form, this advantage will be an important factor in its preservation. Therefore, though resemblance takes no part in the production of such a mimetic form, it may play an all-important part in its preservation. On the other hand, it must be admitted that, even though it be proved that such a mimetic form receives some advantage from its apparent model, a mimetic explanation to account for its production or preservation is not warranted, as it is superfluous, unless there be evidence to show that the mimetic form would not have been preserved in the absence of the model.

In his classical work, "Mimicry in Butterflies," Punnett has shown that there is strong evidence for believing that many of the striking resemblances between somewhat distantly related butterflies are due to the similar genetical constitutions of the groups to which the mimics and models belong, and that therefore there is a possibility that such resemblances are not truly mimetic. It is evident, however, that all supposed cases of mimetic resemblance cannot be considered to be explicable in this manner; for, in the first place, reasonably close relationship is necessary and, secondly, mimics resulting from similar mutations must have a similar structural basis for the colour, form, etc., which produce the resemblance. When, for example, colour markings on the mimic produce a resemblance to the form of the model, or the corresponding colour markings which appear so similar in the two insects are found to occupy different morphological positions, it is evident that the resemblance cannot be due to similar mutations, that there is no actual underlying similarity and that therefore there is nothing but appearance in common between the two insects.

I have now outlined the various types of resemblance which may exist between animals for which a mimetic explanation is superfluous. It remains to show what evidence there is for the existence of true mimetic resemblance, and to describe the main types of mimetic resemblance which will be illustrated as far as possible with examples of Australian mimetic insects. After this I shall describe the probable method of evolution of mimetic resemblance.

The Existence of Mimetic Resemblance.

At the outset it is necessary to point out that we are faced with two distinct questions:—

1. Has mimetic resemblance been evolved?
2. How has mimetic resemblance been evolved?

The problem is essentially a branch of the larger problem of evolution, and it presents the same difficulties. I think it can safely be said that at the present time all biologists believe in the fact of evolution, but there is by no means general agreement as to the process of evolution, and there is still considerable controversy between biologists with regard to the latter problem. This con-

troversy about the process of evolution appears to be taken by the general public as evidence that biologists disagree amongst themselves about evolution, and that therefore evolution is but an unproven theory which need not be taken seriously. A similar confusion between the mechanism and fact of mimetic resemblance by many biologists appears to be the cause of much of the criticism directed against the subject. This criticism is directed almost wholly against the theories commonly put forward as to the manner of evolution of mimetic resemblance, yet the conclusion often drawn is not simply that the evolutionary explanation is inadequate, but that mimetic resemblance does not exist and that some other type of explanation will have to be found to account for the undoubted fact of resemblance. The attitude adopted on this question, as on so many others, is that the fact does not exist because the critic is unable to conceive of a mechanism to account for it. Criticism of mimetic resemblance has been to a very large extent criticism of the theory that mimetic resemblance has arisen by the natural selection of small favourable variations, the cumulative result of which has been the production of a mimetic from a non-mimetic form, and that comparative freedom from attack by the natural enemies which exercise selection is essential to the success of the species. This, obviously, is not a criticism of mimetic resemblance itself, but of one theory of evolution which is still held to be true by many biologists, but is disputed by others. To dispute the fact of mimetic resemblance, because those who write on the subject account for it by a theory of evolution which is at variance with one's own ideas, is indefensible.

It appears to me highly improbable that a direct proof of the fact of mimetic resemblance will ever be possible. It is required to prove that the appearance of a certain animal has been produced as a response to that of some other animal or of some object in its natural environment. To demonstrate this directly it would be necessary to produce a mimic artificially, by breeding under experimental conditions in such a manner that the production of the appearance of this new mimic could only be interpreted as a response, however indirect, to the appearance of the model. For many and obvious reasons such an experiment appears to be quite out of the question.

Alternatively it would be necessary to observe the complete process of the production of a mimic under natural conditions. A singularly complete series of observations would be required in order to prove, not only that a mimetic can be produced from a non-mimetic form, but that the resemblance produced was due to the influence of the appearance of the model alone. This would not only entail a most laborious and lengthy piece of research, but also amazingly good fortune. Mimetic forms are far from common when one considers the enormous numbers of species of animals, and at any given time the number of mimetic forms which are being produced must be remarkably small. In fact it would appear probable that such cases would only be found at intervals of long periods of time, unless the process of production of mimics is extremely slow, in which case observations extending over many human lifetimes would be required. We should be unduly optimistic, therefore, if we expected to obtain evidence with regard to mimetic resemblance in this manner.

In this connection it will be instructive to examine the phenomenon of the appearance of melanic forms of various moths near industrial centres, as it has often been considered that this provides an example of observation of a mimetic form such as I have stated to be desirable for proving the fact of mimetic resemblance. During recent years many records have been made of the appearance of black or very dark forms of a number of different species of moths,

mostly belonging to the Geometrites; and these have practically all appeared near industrial centres, in England, on the continent of Europe and in the United States of America. A series of observations extending over a number of years has demonstrated the gradual displacement of the typical by the melanic form in several different cases; and it is known that in certain districts near industrial areas only the melanic form of a particular moth now occurs, while records show that in the same districts some years ago only the typical form of the moth was known.

For example, 25 years ago only the typical form of *Boarmia repandata* occurred on the Tyneside, while every specimen captured now is black. The case of *Amphidasys betularia*, the "peppered moth," is perhaps better known. The melanic form of this insect, var. *doubledayaria*, is recorded as far back as 1850, but it was then considered to be a great rarity. For many years now it has been the dominant form in many industrial districts, and in some areas it has completely displaced the typical form. This has happened in various parts of England, on the continent of Europe and in the United States of America, and everything indicates that the melanic form has been evolved independently in many different species of moths, and new cases are constantly coming to light.

To many it has seemed obvious that the appearance of black forms of many different moths in association with industrial areas is to be explained as a response of the insects to the altered appearance of their surroundings, due to the deposition of quantities of soot. It has been suggested that the black forms would be less conspicuous on the blackened trees than the typical forms, and that therefore the black forms would be selected by the action of their natural enemies. At first sight this appears to be a very reasonable explanation, but further examination of the problem brings to light important objections. In the first place, my experience, which is by no means inconsiderable, of the appearance of vegetation near industrial centres is that it is by no means black. Trees and shrubs if touched will dirty the hands, but, except for a somewhat lessened luxuriance, they differ but little from trees and shrubs which have received no deposit of soot; so that a black form of a moth would have little, if any, greater advantage than the normal form near an industrial centre than in any other region.

A still more important objection is afforded by the experimental work of Heslop Harrison. He has shown that the melanic forms are produced, not as a response to the blackness of the surroundings, but by the action of metallic salts contained in the sooty deposit on the leaves of the food-plant. He has taken a number of species of moths from areas in which the melanic forms are unknown and, by feeding the larvae of these on food-plant which contained small quantities of certain metallic salts, he has produced melanic forms in considerable numbers. In many of the experiments the cut ends of the food-plant were simply immersed in dilute solutions of metallic salts so that the melanic forms were produced without the influence of any blackness in the surroundings. Further than this Heslop Harrison has proved that the melanic pattern is heritable, and, in fact, behaves like a normal Mendelian character. Once the melanic pattern has been produced under the influence of metallic salts it is inherited from generation to generation in a normal manner, even though the larvae are fed on normal untreated food-plant.

Heslop Harrison's work throws light on a very important factor in evolution. It has demonstrated that the environment may influence the production as well as the selection and preservation of mutations, and one of the most im-

portant evolutionary problems with which we are faced is the nature of the causes which determine the appearance of mutations.

It is evident from what has been said that any attempt to observe the production of a mimetic form in the field is fraught with grave difficulties. Not only is it probable that a suitable opportunity for such observation will seldom be offered, but the greatest care must be taken in the interpretation of such observed facts as appear to have a bearing on the subject. It is particularly important that the mind should not be concentrated wholly on mimetic resemblance, as it must be realised that the true explanation of the observed facts may have no connection with this subject, as in the case of the melanic forms of the moths I have referred to.

In order that the account I have given of the production of melanic forms in moths may not cause confusion at a later stage in this address, I must point out that these melanic forms appear to have completely displaced the typical forms in certain districts entirely without the aid of natural selection. The chemical stimulus has acted on all the individuals in a particular district, causing the independent production of a large number of similar, or probably identical, mutations. The whole of the insects in the community, acted upon by the same new environmental factor, have been modified in appearance in the same manner; and but few of the black individuals are the descendants of the first insect which produced the black mutation. It appears highly probable that most of the mutations which have taken part in the production of the appearance of truly mimetic insects were not of this type. In general mutations seem to be rare and sporadic in their appearance, and it is probable that most cases of mimetic resemblance have been built up or preserved by the selection of such apparently chance mutations as had a special survival value. If this be the case, it follows that all the surviving individuals of a mimetic species must be the descendants of the first insect, or possibly small number of insects, in which the mimetic mutation appeared. It is difficult to conceive how an adaptive character such as mimetic resemblance could have arisen without the action of natural selection. If an environmental influence caused the simultaneous production of the same mutation in all the individuals of a species, there is no reason why the new character should be adaptive and the chances are greatly against this. On the other hand, in order to be selected directly, a character must be adaptive. Natural selection, therefore, is an adequate mechanism for the preservation of adaptive characters, such as mimetic resemblance; while an environmental factor which causes the production of a particular mutation throughout a species is not likely to produce an adaptive character. It must be born in mind as a possibility, however, that some of the apparent examples of mimetic resemblance have been produced as a direct response to some environmental factor. Such resemblance, of course, would actually be fortuitous.

As there appears to be but little hope that the direct proof of the existence of mimetic resemblance will ever be possible, it is desirable that the available evidence should be examined to see whether this supports the contention that it does exist, or not. As cryptic and deceptive resemblance afford somewhat different lines of evidence, it will be necessary to deal with the evidence separately under these headings.

(a) *Cryptic Resemblance.*

Cryptic resemblance is an exceedingly common phenomenon amongst animals and particularly in insects. Insects are to be found in practically every conceivable situation on land, and in most situations some species have such an ap-

pearance that they are difficult to see when on their normal background. Though the Insecta forms a very homogeneous class in many respects, there is a surprisingly great diversity of colouration, form and habit within it. Also the variation in the appearance of the backgrounds on which insects are found is almost infinite. It is evident from these considerations that the probability of any particular insect resembling its normal background purely by chance is extremely remote; and that, therefore, if cryptic resemblance is always due to the accidental association of an insect with a background of suitable appearance, the number of species exhibiting cryptic resemblance should be extremely small. This follows purely from a consideration of probabilities. In actual fact, a very large percentage of insects exhibits cryptic resemblance, so it seems necessary to consider, either that the appearance of cryptic insects is in some manner produced as a response to that of their respective backgrounds, or that there is some mechanism which causes insects to become associated with backgrounds which have a suitable appearance to afford concealment.

When a careful examination is made of even a few species exhibiting cryptic resemblance another important point becomes evident. Concealment in many instances, probably in most, is due not to a single factor but to several. Colouration, form and attitude commonly take part in the production of cryptic resemblance; and each of these factors may be easily divisible into several minor factors which can only be considered to have been produced independently of one another. If there be but a very remote possibility that an insect may accidentally have a general resemblance to the normal background on which it is found, it is obvious that the possibility of accidental resemblance in several independent characters must be extremely remote. The fact that cryptic resemblances commonly consist of several independent characters is additional proof that cryptic resemblance cannot normally be fortuitous.

A further argument against the possibility of cryptic resemblance being fortuitous is that many different mechanisms appear in different insects, each of which causes concealment of the bearers. It would appear, therefore, that concealment is an end attained by the utilisation of any suitable kind of mechanism, and the obvious inference is that cryptic resemblance has been evolved on account of the concealment which it affords.

The foregoing considerations indicate clearly that cryptic resemblance in general cannot be fortuitous, though these do not preclude the possibility that in a few instances the resemblance may actually be due to the accidental association of an insect with a suitable background. As resemblance is produced in many different ways, but is always associated with some particular object in the insect's normal environment, it appears evident that the resemblance must have been produced either directly or indirectly by the action of some environmental factor. It might be considered that general environmental influences, such as temperature, humidity or food material, might bring about the observed result. A detailed examination of the occurrence of cryptic species, however, will immediately demonstrate that this cannot be so in most cases. Many cryptic insects, some of which are closely related, may be found in the same environment. All are inconspicuous on their normal backgrounds, and all are subjected to the same general environmental influences, but they do not resemble one another. The same influences, particularly when operating on closely related species, would be expected to produce the same kind of result in each insect, but they do not. The appearance of each cryptic insect is associated with that of its normal background and not with general environmental conditions. It is evident, therefore, that the factor responsible for the production and preser-

vation of cryptic resemblance cannot be a general environmental factor, but must be one the action of which is in some way determined by the nature of the association of an insect with its background. There is nothing in common between the various cryptic insects except the resemblance of each to its normal background. It appears necessary to consider, therefore, that the manner of operation of the determining factor on each insect should be influenced in some manner by the nature of the resemblance of the insect to its normal background; and to do this it must be capable of being affected by appearance. The factor must have two properties; it must be able to see and it must operate on insects in such a manner that resemblance, when it appears, will tend to be preserved. Only the natural enemies of insects fulfil these two conditions, so it appears evident that cryptic resemblance must have been produced by the discriminative action of natural enemies.

It will be noticed that not only sight, but also discrimination on account of appearance, is necessary in order that cryptic resemblance may be selected. By no means all the enemies of insects are capable of such discrimination. Many parasitic insects, for example, appear to use sight but little when hunting for their hosts; so that, though they are amongst the most important enemies of insects, they cannot take part in the preservation of cryptic resemblance. Higher animals, such as birds, lizards and insectivorous mammals, would appear to be the most probable agents of selection. Another important point is that only those enemies which attack the stage of the insect which exhibits resemblance can bring about the selection; so that, though the severest attack may be delivered against a non-cryptic stage of the insect, the only possible agents for the selection of resemblance are the enemies of the cryptic stage, which may otherwise be comparatively unimportant.

There is a very simple mechanism by means of which discriminating natural enemies may bring about the selection of cryptic resemblance. All that is necessary is that an insect which is more perfectly concealed than most of the individuals of the same species should be less easily found, so that its chance of survival is greater than normal. This greater chance of survival would cause individuals with a more perfect resemblance to tend to increase in numbers and gradually to displace normal individuals with a poorer chance of survival. Actual experiments* have proved that birds do more frequently pass over cryptic insects on a suitable background than when they are on an unsuitable background. It is evident, therefore, that the action of some discriminating enemies at least is modified by the appearance of their prey, in such a manner as to tend to preserve those individuals which are more perfectly concealed than is normal. Provided suitable variations appear, this is all that is necessary to cause the gradual building up of more and more perfect resemblance. I must leave the more detailed consideration of the manner of action of natural selec-

*"Cesnola's Experiments with Mantis.—To test the selective value of color markings, Cesnola fixed specimens of the brown and green *Mantis religiosa* on plants, some of which were against harmonious, others against disharmonious backgrounds. The result was that most of those which were inconspicuous because of a harmonious background escaped, while most of the others were eaten up by birds.

"Poulton's and Sanders' experiments with butterfly pupae.—Numerous pupae of various colours were placed under conditions favouring protective coloration and others under opposite conditions. The conclusion was that protective coloration is a real survival factor, and one that operates so as to give the protective coloured individual a decided advantage in the struggle for existence."

H. H. Newman, "Evolution, Genetics, and Eugenics," p. 257.

tion in the preservation of resemblance to a later stage of this address; but I must point out that the existence of such an adequate mechanism for the production and preservation of cryptic resemblance is an added argument in favour of the hypothesis that cryptic resemblance is truly mimetic.

Some cryptic insects are predaceous and it is possible that in some such species the resemblance may have given the possessors a special survival value by enabling them to approach their prey more successfully without being observed. This would permit of the natural selection of cryptic resemblance in such cases, but it is probable that in most, if not all, such insects, concealment from their natural enemies would be a more potent factor in selection than concealment from their prey.

I have pointed out that the natural selection of cryptic resemblance is dependent on the appearance of suitable variations. To some it may appear that natural selection is therefore of but minor importance, and that the major problem is to determine what factors cause the appearance of suitable variations. Undoubtedly this is a most important problem, but its solution is not as essential to a proper understanding of the subject under consideration as would appear at first sight. Everything indicates that the suitable variations are produced entirely without reference to any possible resemblance, and that they are not produced as a response to the appearance of the normal background of the insect in which they appear. Only such variations as happen to be suitable are selected; others, having no special survival value, are not preserved. The factor which causes the appearance of a suitable variation has therefore no direct connection with the production of cryptic resemblance; while natural selection operating through the medium of discriminating agents appears to be the only possible factor which can directly produce true mimetic resemblance. Appearance can only be produced as a response to appearance by some agency which can see and discriminate, and only natural selection appears to be able to employ such an agent. Natural selection is generally considered to be at least one of the most potent factors in the evolution of all kinds of organisms and their adaptations, yet no more is known of the actual cause of the variations which are considered to have been selected in these than of the variations which are selected in the production of mimetic resemblance. Natural selection explains the evolution of mimetic resemblance as adequately as that of any other adaptation.

Before describing a number of examples of cryptic resemblance, in order to illustrate the foregoing considerations, I must mention the criticism often made that, though very inconspicuous when on the correct background, cryptic insects are commonly found in other positions. For example such remarks as this are often made: "Stick-insects would be very inconspicuous if only they would live amongst sticks." It is obvious that the casual observer in the bush, who is not specially looking for such insects, will only see insects with an effective cryptic resemblance when the background does not harmonise with their appearance, that is, when they are not in their natural environment. As the insects are only to be seen easily when in an unsuitable position, a very false impression is apt to be created.

A very large percentage of the specimens of cryptic insects which are taken are found resting on an unsuitable type of background, causing them to be conspicuous; and it is somewhat difficult to prove, even by careful observation in the field, that normally the insects occupy a suitable environment in which they are inconspicuous. That this is so, however, is strongly indicated by such observations as the following. I have sometimes spent as much as half an hour un-

successfully searching for certain green long-horned grasshoppers, which I have known to be present close to me, as I could hear them chirping all around at some little distance. I have also spent practically a whole day collecting insects in a certain small area without seeing a single mantis, and yet at night, by lantern light, mantids were observed in large numbers in the same area, as they have the habit of climbing to the top of grasses and other plants at night, in which position they are naturally very conspicuous. Sometimes, having the good fortune to have distinguished an insect on a suitable background, I have described the insect and indicated its position to within a few inches to a friend, and even then it has taken him a matter of minutes to find it. In the same manner on a number of occasions I have had the greatest difficulty in distinguishing an insect the general position of which had been indicated to me by a fellow entomologist. Also the fact that "rare" species of insects, seldom seen under natural conditions, may be quite common amongst the debris deposited by flood-waters, indicates that the keenest eyed entomologist fails to perceive many insects in their natural environment.

If a long series of insects exhibiting cryptic resemblance be examined, it will be found that concealment is brought about in two quite distinct manners. Some forms closely resemble a definite object which occurs in their normal environment, such for example as a stick or a leaf; and the resemblance is often surprisingly perfect, minute details of the model appearing to be copied with marvellous accuracy. This is termed special cryptic resemblance.

The majority of insects exhibiting cryptic resemblance, however, do not definitely resemble any particular object in their natural environment. The general appearance of these insects is such that it closely conforms with that of each insect's normal background, and when such an insect is removed from its natural environment there is nothing in its appearance to suggest clearly what it resembles. This type of resemblance may be termed general cryptic resemblance.

Many insects exhibiting general cryptic resemblance often appear to be most conspicuously coloured when removed from their natural environment, contrasting colours being distributed over the body in bold stripes or blotches; yet in their natural habitat many of these forms are amazingly difficult to see. The principle of "camouflage" is here in evidence, a principle with which most people are now familiar, owing to its extensive employment recently in war. In order to conceal a gun or other military object it was not given a uniform coat of colour of exactly the same shade as its surroundings, but large irregular blotches or stripes of a number of strikingly contrasting colours were painted on it. From a comparatively short distance the form of a gun so painted was no longer obvious. The attention of the observer was distracted from the shape of the gun, and what appeared to be a number of quite independent and irregular small objects was all that was seen. The outstanding effect of camouflage is to prevent the eye from seeing the light and shade on the object it is desired to conceal, as the visual perception of the solidity of an object depends entirely on the arrangement of light and shadow on it. For the production of the most effective kind of camouflage it is necessary not only to paint a number of irregular patches of contrasting colours on the object, but also to make these approximate to the average shape of the various objects forming the background; and the total effect of the contrasting colours, that is the colour of the whole as it would be seen from a distance too great for the perception of the individual patches, should approximate closely to the average colour of the background.

It might be inferred from the description I have given of the two main types of cryptic resemblance that it would always be easy to distinguish one

from the other. In practice, however, this is not the case. There is a very large number of intermediate forms; and, in fact, these intermediate forms predominate. It is not often that an insect looks like some definite object in its background, but frequently the colour markings or form of the insect appear to be an almost perfect copy of a portion of some object on which it commonly rests, for example, the bark of a tree or the surface of a rock. There is every transition between this type of resemblance and true "camouflage," in which bold markings simply serve to obscure the true form of the insect.

Really good examples of special cryptic resemblance do not appear to be common in Australia. Probably the best known examples of this type of mimetic resemblance are *Phyllium* and *Kallima*, both insects belonging to the Indo-Malayan region. Close relatives of these insects occur in the northern parts of Australia, but they do not exhibit as perfect mimetic resemblance as the Indo-Malayan species.

Phyllium is one of the "leaf-insect" type of phasmid. In colour and form the resemblance to a leaf is very perfect. The insect is bright leaf-green; it closely resembles a broad leaf in shape; and, perhaps the most remarkable resemblance of all, the venation of the front wings has been fundamentally altered so that it looks like the normal venation of a leaf. The front wings cover practically the whole dorsal surface of the insect, so that the resemblance to a leaf is principally due to these.

Kallima resembles a dead leaf and the resemblance is perhaps even more perfect than that of *Phyllium*. In shape the resting insect is almost exactly like a leaf and the venation of a leaf is beautifully indicated by a series of colour markings, which are quite independent of the true venation of the wings. In addition to this there is a number of circular marks which have a considerable resemblance to mould spots on a leaf and in the centre of some of these is an apparent hole, consisting of a piece of clear membrane free from scales. Of a comparatively long series of specimens of a Javan species, *K. paralecta*, which I possess, no two are of exactly the same colour, the ground colouration being of many shades of brown, and in each specimen the resemblance to a leaf can only be described as amazing. The singular perfection of the resemblance in this insect has for long attracted a great deal of attention to it; and, strangely enough, it has been claimed by some writers on this subject that the perfection of this resemblance is strong evidence that a mimetic explanation is inadequate to account for it. The resemblance is so perfect and detailed, they say, that it is impossible to conceive how such perfection could have been produced by natural selection and that therefore some other process must be the true cause. It is generally suggested that some form of orthogenesis has probably produced the resemblance. I shall deal with this problem in more detail later.

Perhaps the best common example of special cryptic resemblance to be found near Sydney is *Acrophylla chronus* Gray (Pl. ix.), though many other less common phasmids are equally good and some may well prove to be even better. This insect is almost exactly like a long leafless twig. The thoracic and abdominal segments are elongate and of almost uniform diameter and the whole insect is dull brown in colour. The legs are very long, and the front legs are often held straight out in front of the insect, the pair being closely applied together to form a thin prolongation of the body; and there is a special excavation near the base of each leg to accommodate the head when they are held in this position. At the posterior extremity are two structures, the cerci, which look like small curled portions of dead and dry leaves. The perfection of the concealment afforded by this form and colouration will be appreciated by referring

to the photograph of this insect (Pl. ix.), which, like all similar photographs illustrating this address, was taken of the insect in its natural environment, just as it was found and without interfering with it in any way. In one respect, however, it must be admitted that the concealment is not perfect and, had it not been for this curious defect, I should certainly not have seen the specimen I have photographed. I have noticed, not only in this species, but also in a number of other species of phasmids, that when disturbed they will often commence a curious movement consisting of a slow jerky swaying of the body from side to side. The movement is so unusual as to attract attention immediately. However, I do not believe that it is an invariable response to the approach of a possible enemy. I have taken specimens of phasmids which did not behave in this manner, and the almost invariably accidental manner in which I first observed such specimens leads me to believe that I must frequently pass by specimens which are fully exposed.

Many other orthopterous insects show special cryptic resemblance, but this is usually less perfect than amongst the phasmids. Many long-horned grasshoppers not only have a green colour which almost perfectly matches the leaves amongst which they live, but the shape of the exposed wings is very leaf-like and the venation has often a strong resemblance to that of a leaf. The wings meet over the back of the insect at such an acute angle that the insect appears to be not only flat but excessively thin, which adds further to its leaf-like appearance. A photograph of such a long-horned grasshopper, *Caedicia olivacea* Brun., is shown on Pl. viii., fig. 2. It will be observed that the legs are stretched out behind the insect and are not greatly flexed. This appears to be the normal position of rest and renders the insect distinctly less conspicuous than when the legs are flexed ready for jumping, which position is commonly assumed when the insect is disturbed. The insect photographed was not in its normal environment, but on a rose tree in a garden. Its colouration and form render it much less conspicuous when living, as it normally does, amongst leaves of *Angophora* and *Eucalyptus*. I have already mentioned how very effective is the concealment of these insects and the difficulty I have experienced in finding them, even when I have known that numbers were present in a comparatively small area.

The larvae of geometrid moths have for long attracted attention owing to the almost perfect resemblance to dead twigs which many species show. The long cylindrical form and the position of the legs and prolegs at the extremities of the body appear to be normal for this group of insects; and these characters probably form the basis on which the mimetic resemblance has been developed, and were probably not themselves developed to take part in the production of resemblance. This is indicated by the fact that throughout this group of moths these larval characters are practically uniform, in spite of the fact that in many species the larvae do not exhibit cryptic resemblance; and, in some which do, the resemblance is quite independent of this peculiar form. In many species, however, the resemblance of the larvae to dead twigs is very remarkable, this resemblance being brought about by the colouration, the habit of the larva of clinging to a twig by the prolegs only and holding out its body stiffly at an acute angle to the twig on which it is resting, by its immobility in this position, and, in many species, by the development on the body of small outgrowths which closely resemble irregularities which occur on the type of twig on which it is normally to be found.

I have already pointed out that an intermediate type of resemblance between special and general cryptic resemblance is very common. Examples are extremely numerous and I can select only a few for purposes of illustration.

An excellent example is afforded by the common *Cryptolechia raphidias* Turn (Pl. xiv., fig. 1). This small oecophorid moth has the habit of resting on the bark of the stringy-bark gum and, as will be seen from the photograph, it is extremely inconspicuous in such a position. The front wings, which cover the body when at rest, bear a number of irregular markings varying from dark brown to dirty white, and these markings correspond closely to the appearance of the surface of the bark of the stringy-bark gum. The markings also have the effect of distracting the attention from the general form of the insect.

In the same manner the irregular brown lines and other markings on a general whitish background cause *Ectropis desumpta* Walk. (fam. Boarmiidae, Pl. xiii., fig. 1) to appear very much like the lichens which cover the trees in the brush country in which this species is found. It will be seen that the insect I have photographed is resting with the right wings covering a piece of lichen, while the left wings overlie bare bark. The former are difficult to see, while the latter are quite conspicuous. This illustrates the fact that a cryptically coloured insect is inconspicuous only on its correct background and that it will not invariably settle on a suitable background. There is, in fact, very little evidence that such insects ever select suitable backgrounds. Their colouration has been evolved to be in conformity with the normal background, or some common background, and the selection of a suitable resting place is evidently by means of other characters than suitable appearance. For example, some moths only settle on the surface of rocks, others on particular kinds of tree-trunks, but the appearance of the surface of these objects is by no means always in conformity with that of the insect, though commonly it is.

In *Syneora silicaria* Gu. (fam. Boarmiidae, Pl. xiii., fig. 2) colouration and attitude appear to be definitely correlated in the production of cryptic resemblance. It will be noticed that, in the photograph, the insect is orientated on the tree-trunk in a somewhat unusual manner. Instead of the body being more or less vertical with the head uppermost, as is usually the case when a moth settles, it is horizontal, and it will also be noticed that the bold striped markings render the insect very inconspicuous when settled in this position. If it settled with the head uppermost the markings would be at right angles to the principal markings of the tree, the edges of the flakes of bark, and it will readily be understood that it would be most conspicuous in such a position. Another point of interest is that when an attempt was made to place this insect in a box it was only detached from the bark with difficulty. Instead of flying away the moment an attempt was made to touch it, it remained completely immobile. It was possible to lift up the wings, and even the thorax, without disturbing the insect, which immediately resumed its normal position when released. This habit of immobility appears to be characteristic of a large number of cryptic insects, and it is easy to appreciate its importance in connection with concealment. I have noticed this habit in a considerable number of insects exhibiting cryptic resemblance, and it seems probable from my general observations that it is very common, if not the rule, in such insects, and that it is seldom, if ever, found in other types. In order to prove this interesting and important point, however, it would be necessary to make a statistical record of careful observations on a large number of cryptic and other insects. Though this habit has often been claimed to indicate intelligence in an insect, or other animal exhibiting it, it is almost certainly a tropistic response to a particular set of conditions. There is little question that the insect remains immobile, not because it knows that it is concealed, but because the nervous system is so constituted that under the influence of certain stimuli it responds by retaining the insect in a state of

immobility. This is indicated by the common observation that a cryptic insect remains equally immobile whether the background on which it is resting affords it concealment or renders it conspicuous. On the other hand it is unreasonable to believe, as some apparently do, that a mimetic explanation is disproved because such habits as this can be interpreted as purely tropistic responses. It may be admitted that the insect remains immobile because it cannot do otherwise under the prevailing conditions, on account of the construction of its nervous system, but this does not account for the production of such a habit. It is probable that habits are evolved and submitted to selection in the same manner as structure. In all probability it is actually special structure of the nervous system which is inherited, the habit being an expression of this structure. It is probable, therefore, that habits, such as immobility, have been evolved in mimetic forms as a definite portion of the whole mimetic facies; the preservation of such habits being due to factors similar to those which have caused the preservation of adaptive structure, and that they are dependent on structure just as is appearance. The tropistic theory deals only with the nature, and to some extent the mechanism, of response in an organism with a given nervous constitution, and does not even attempt to deal with the manner in which this nervous constitution came into being. This theory, therefore, does not account for the presence of a particular habit, but describes its nature and manner of operation.

Another Sydney moth which shows this intermediate type of colouration well is a species of *Scoparia* (fam. Pyraustidae) which is very common in Hawkesbury sandstone country in September and October. It is to be found on lichen covered rocks. The marbled wings, of various shades of brown and dull white, approximate to the appearance of the lichen very closely, and I have several times found a moth only after examining a small piece of lichen for the space of a minute or more. The marbling of the wing cannot be considered as a copy of the background, but the small areas of varying colours into which the wing is divided give the illusion of a number of small separate things, like the small expansions of the lichen, and the form of the moth is thus overlooked.

A large number of different species of Australian moths are known to show this type of resemblance, in spite of the fact that the majority of moths are collected after they have been disturbed or when out of their normal environment. There is, however, no point in multiplying the number of examples for the purposes of this address.

Many other types of insects besides moths exhibit resemblance of this nature. For example, a number of longicorn beetles belonging to the Lamiinae are coloured with varying shades of grey and brown, in such a manner as to be extremely inconspicuous on bark; and such forms of these as have come under my notice have the habit of holding the antennae straight out in front of the head, and closely applying them to the bark of the tree. This not only conceals what would otherwise be conspicuous structures, but causes the contours of the beetle to pass almost imperceptibly into those of the tree-trunk or branch.

Cryptic resemblance of this type is also well developed in the Neuroptera. Examples are particularly common in the families Myrmeleontidae, Osmylidae, Hemerobiidae and Psychopsidae. It has not been my good fortune to see specimens of the last family settled in their natural environment; but, from descriptions I have heard, it would seem that they are amongst the most perfect examples of cryptic resemblance. The resemblance of neuropterous insects to their background is considerably assisted by the normal transparent nature of the wings. Blotches of pigment, usually brown or black, commonly exist on the wings, and bring about concealment in the manner I have already described; but

the general colour of the background showing through the transparent parts of the wing causes the insects to be equally inconspicuous on a large variety of backgrounds. The expansive and membranous wings are usually held closely applied to the surface on which the insect is at rest, so that there is no perceptible change in the general contours of the surface. This is well shown in the photograph of *Formicaleo brevisculus* Gerst. (Pl. viii, fig. 1) in which it will be seen that the faintly mottled wings are practically wrapped round the small twig on which the insect is resting, and that all parts of the body are closely applied to it. Thus the head, antennae, and legs, as well as the wings, appear to be continuous with the contours of the twig. An exactly similar habit of *Archichauliodes guttiferus* Walk. (fam. Corydalidae) causes this large and common insect to be seldom seen. On a flat rock surface the wings and the rest of the body are held flat against the surface, while on a twig of a bush at the edge of a stream the insect will often wrap its wings completely round it so that it is equally inconspicuous in either position. Perlids, which closely resemble corydalids in many respects, have in general the same habits as *A. guttiferus* and are equally inconspicuous.

Even a brief survey, such as the present, of the general type of cryptic resemblance would be incomplete without mention of orthopterous forms, as it is particularly well developed in this order. It appears to me, in fact, to be the normal system of colouration in this order, but a few examples will suffice.

Goniaea australasiae Leach is a common grasshopper to be found on the ground amongst dead gum leaves. It is usually pale brown in colour, but there is a considerable variety of shades of brown in different individuals. The variations in colour appear to have approximately the same range as those of dead gum leaves, and the insects are very inconspicuous in their natural environment. Were it not for a special modification in structure, however, the robust nature of these insects would render them conspicuous amongst such thin flat objects as gum leaves. The large prothorax bears a prominent laterally compressed ridge along the mid-dorsal line, and, in the adult insects, this ridge is practically continuous with that formed over the body by the closed tegmina. In the larvae, the prothoracic ridge is continuous with a similar ridge which extends along the mid-dorsal region of all the abdominal segments. This thin edge formed along the whole length of the insect gives a very deceptive appearance of thinness and flatness, except when viewed from immediately above.

In the Mantidae, cryptic resemblance, so characteristic of the family, is almost entirely of the general type. The dull brown and grey and often grotesquely formed Perlamantinae are most inconspicuous on the ground amongst dead leaves and sticks, in which situation they are normally found. The common *Orthodera ministralis* Fabr. is almost uniformly green in colour, and harmonises with the leaves amongst which it lives; and the various shades of green and brown of *Tenodera australasiae* Leach (Pl. ii., fig. 23) cause it to be almost completely concealed. The narrow white line running along the anterior edge of each tegmen tends to break up the apparent mass of the insect, and this effect is heightened by the bold longitudinal green and brown markings. The inconspicuous nature of this insect is well shown in the coloured photograph, but to appreciate this fully it is necessary to imagine its appearance when viewed from a short distance amongst large quantities of vegetation. The insect would probably be even less conspicuous amongst plants with larger leaves, but I can vouch for the fact that it was inconspicuous in the extreme in the position in which it was photographed. I stood within a yard of it for at least five minutes before

seeing it, and it was only owing to the fact that the insect I was trying to photograph flew close to it that I saw it eventually.

I might remark that the cryptic colouration exhibited by predaceous insects, such as mantids, is often referred to as aggressive resemblance. It is considered that the inconspicuous nature of these insects enables them to approach their prey without disturbing it, as well as concealing them from their natural enemies. Cases are known to exist in other countries of mantids which closely resemble flowers, and it is claimed that insects are attracted to these apparent flowers and so fall an easy prey to the mantids. I know of no such case amongst Australian insects.

I have already indicated that every gradation is to be found between the two extreme forms of cryptic resemblance, viz., special cryptic resemblance and camouflage. In many of the cases I have cited in connection with general cryptic resemblance the principle of camouflage is evident; for example, in *Tenodera australasiae* and *Syneora silicaria*. A few examples of insects in which it is developed in almost its pure form will, however, be of interest.

The hawk-moth larva shown in Pl. xii., fig. 1, illustrates the principle very well. The ground colour of the dorsal region is dark green and of the ventral region pale green and at regular intervals along the sides of the body are bold triangular areas bordered by bright blue lines. When the insect is taken from its natural environment it appears to have the most conspicuous type of colouration imaginable, but these large and robust larvae are amazingly difficult to find in bushes in which they are known to be living. Imagine the insect amongst a mass of foliage, instead of being picked out on a single twig as it is in the photograph, and I think it will be realised that it would be far from conspicuous. The bold markings distract the attention from the mass of the insect, which appears to be broken up into a number of disconnected small objects, closely corresponding to the light and shade on the leaves.

In the species of *Betiza* (fam. Acridiidae, Pl. xii., fig. 2) photographed, it will be seen that the mass is very effectively broken by a bold longitudinal white line. This insect lives in clumps of wiry grass, and its form and habits are closely correlated with this environment. The whole body is elongate and very narrow, tapering gradually towards the posterior end and more rapidly anteriorly, the head being conical in form, with the antennae arising from the extreme tip. At rest, the antennae are commonly closely applied to one another, appearing to be a narrow continuation of the body; the legs are closely applied to the sides of the body, with the femora and tibiae parallel to it; and the body is held firmly against the grass on which the insect is resting. Smaller species, and possibly the larvae of this species, are uniformly green, or sometimes brown, and such small individuals are of approximately the same thickness as the blades of grass on which they settle. The characteristic form and attitude which I have described causes these small individuals to be very inconspicuous. Were it not for the bold longitudinal white stripe, larger individuals such as the one I have photographed would, however, be conspicuous, in spite of their form and attitude, as they are so much thicker than a blade of grass. The white line completely destroys all appearance of bulk and renders the insect very inconspicuous. It is worthy of note that the white line is not morphologically a longitudinal line but continues from the head across the thorax and then along the femur. Owing to the resting attitude of this insect, a simple and continuous longitudinal line is produced; and the perfect continuity of this line on such a heterogeneous basis is strong presumptive evidence that continuity and straightness have definitely

been produced as such. This in its turn indicates that a mimetic explanation is required to account for the production of the appearance of this insect.

In *Urnisa erythrocnemis* St. (Pl. xi.), a common grasshopper in sandy areas, concealment is also effected by means of a number of bold markings which destroy all appearance of continuity in the form of the insect. In this insect there is a number of irregular black marks on a general pale grey background. The insect is usually to be found fully exposed on the surface of sand; and commonly scattered over this are innumerable small objects, mostly black or dark brown, such as bits of stick and charcoal, which give the surface of the sand a mottled appearance. On this *U. erythrocnemis* is surprisingly difficult to see, unless it moves. Attention is only directed to the dark markings of the insect, which appear to be isolated and irregular small objects similar to hundreds of other small objects on the surrounding sand. The adult grasshoppers illustrate very clearly the efficiency of the camouflage system of colouration, as the one part of the insect not so coloured, the tegmen, is the only part which is in any way conspicuous. The infinite variety of small objects on the sand, however, distracts attention even from these tegmina, though the complete visible form of a uniformly coloured insect would doubtless be conspicuous on account of its special and characteristic symmetry.

In some insects what is essentially a camouflage system of concealment is in evidence which does not depend on a bold pattern of contrasting colours. In such forms irregular expansions and spines conceal the true bulky form of the insect, and special habits and attitudes often assist in the perfection of the cryptic resemblance. *Extatosoma tiaratum* Mael. (fam. Phasmatidae, Pl. x.), forms a good example. In this insect certain segments of the legs, and some of the posterior abdominal segments, are drawn out into leaf-like expansions, and irregular short spines are to be found on many parts of the body. Also the abdomen is normally curled upwards, so that the end of it lies practically over the thorax. This habit appears to be well developed in all but the full-grown and egg-laden females, in which the body is so large that such flexion would be impossible. It will be seen from the photographs (Pl. x.) that this structure and habit do not cause the insect to resemble a leaf, or any definite object in its background, but they do render it very inconspicuous. The eye does not perceive the large robust insect, but a group of apparently independent irregular flattened objects which do not attract attention. In taking the photograph shown in Pl. x., fig. 2, I, with some difficulty, persuaded the insect to uncoil the body; and it will be appreciated by comparing this photograph with the other shown in fig. 1 how important is the habit of curling the abdomen in rendering the insect inconspicuous.

I have shown that in a suitable environment many insects are very efficiently concealed by their colouration, form and habits. It is important to know to what extent such insects are confined to a suitable environment. Casual observation gives a very definite impression that cryptic insects are almost completely confined to a particular environment, in which suitable backgrounds are common, though they are by no means always to be found on such backgrounds. It appears doubtful if insects ever select a place to settle on account of the concealment it may afford, but if suitable backgrounds are common in the type of environment to which a particular species is confined, it follows that a considerable proportion of the individuals will be found in concealment on such backgrounds. If cryptic resemblance is to give a special survival value to the possessors, it is not necessary that each individual of a species should always be found on a suitable background. It is sufficient that they should often occupy such a posi-

tion. Lack of recognition of this point has led to much irrelevant criticism of the theory of mimetic resemblance.

Casual observations, and impressions created by such observations, are unsatisfactory. It is eminently desirable that statistical observations should be carried out in various areas to show to what extent the colouration, form, etc., of insects are correlated with the environment. For convenience, areas of very distinctive types should be chosen, and closely related insects should be collected in two or more such areas. This will bring out most clearly the correlation in appearance, if any, between the insects and the backgrounds existing in their respective environments. I regret to say that I have so far carried out only one such observation, but it is instructive. Two small areas were chosen and, with the aid of several friends, all grasshoppers were collected first in one area and then in the other, about a quarter of an hour being spent in each. One area consisted of practically bare sand, scattered over the surface of which were numbers of small objects, mostly tiny bits of twigs and charcoal. The other area was under trees, the sandy soil being covered completely by dead leaves, twigs and branches. The grasshopper population of each area was very distinctive. In the former area practically all the grasshoppers obtained were *Urnisa erythrocnemis* (Pl. xi.), which I have already shown to be very inconspicuous in just such areas. In the second area the predominant grasshopper was *Goniaea australasiae*, already referred to as being very like a gum-leaf, and *Coryphistes ruricola* Burm. was common, this insect having a close resemblance to a dead stick. Correlation between the appearance of the grasshoppers and that of objects in their normal environment was therefore shown very clearly.

So far I have dealt only with a constant type of cryptic colouration, but in some species the colouration is variable, either in different individuals of the same species, or in the same individual at different times of its life-cycle, or in the same individual, according to its environment and irrespective of the period of its life-cycle.

Individual variation in colouration is very common amongst insects, and may be due to different environmental conditions operating on different individuals, such as temperature, humidity, light, etc., to hereditary factors, or possibly to some innate tendency to variation within the species. It often happens that each of the various forms of a species is of such a nature that it would be inconspicuous in one or other of the types of environment the species is known to inhabit. It is often claimed that dark forms are predominant in an unusually dark-coloured environment, and light forms in a light environment; and, from superficial observations I have made in the bush, I am inclined to believe that there is some direct relationship between the colour of a variable cryptic insect and its environment. Again, however, careful statistical observations are required, as general impressions may be misleading and most certainly cannot be considered as evidence.

Good examples of this type of variable colouration are to be found amongst the short-horned grasshoppers. Thus *Goniaea australasiae* is as variable in colour as are the dead leaves amongst which it lives and *Cirphula pyrrhocnemis* Stal. varies from pale grey, through all shades of brown to almost pure black, each of these shades of colour rendering the insect inconspicuous in parts of its natural environment. From casual observation there appears to be a tendency for the black form to be more numerous in bush through which a fire has recently passed, and in which, therefore, charcoal is a conspicuous part of the environment. This, and other species of grasshoppers with a similar range of

variation, form very suitable subjects for statistical observation, and it is important that such observation should be made.

Variation in appearance at different periods of the life-cycle is well marked in many species, and a number of such cases have been described. A good illustration is afforded in the larva of *Papilio aegaeus* Don. The young larva has a curious series of black and white markings which, together with its form, give the insect a considerable resemblance to a bird dropping. When the larva increases in size, the colour is completely changed to a bright green with a few vague markings, which causes it to be very inconspicuous on its food-plant. Such variation in colour has evidently an hereditary basis, but it is possible that in other cases the change may be due to a change in the environment. It is possible, for example, that the younger stages of the variably coloured grasshoppers I have already mentioned may vary in colour if they move, say, from a dark to a light environment, the variation being due to a direct effect of the environment. Very interesting, and extremely useful, breeding experiments might be carried out in order to determine if this is really the case.

Some animals have the power of changing their colour, according to the nature of the environment. The chameleon has achieved a quite undeserved reputation in this connection, as many other animals, particularly other lizards and also many fish, have the power of changing their colour much more rapidly, and have a greater range of colour than the chameleon. This type of variable colouration is not common amongst insects though, as I shall show, it is known to occur in some species. The change in colour is brought about by means of chromatophores which lie just under the skin of the animal. These chromatophores are branched and contractile cells, which contain pigment; and there may be several systems of chromatophores, each containing a different coloured pigment. The colour of the animal depends on the degree of expansion of the chromatophores. When these are expanded their pigment determines the colour of the animal, and when they contract the pigment is localised in a number of tiny spots which have little effect on the general colouration. The expansion and contraction appear to be controlled by the nervous system, and this receives the requisite stimulus from the colour of the surroundings, through the medium of the eyes.

It is sometimes said that a mimetic explanation is unnecessary to account for the resemblance to their background of animals which possess a chromatophore apparatus; as it is claimed that a tropistic response of the animal, by means of this apparatus, adequately accounts for the resemblance, and that a mimetic explanation is therefore superfluous. Again there is confusion between a mechanism within the individual and the mechanism of the evolution of the species. It is possible to account for the resemblance of an animal to its surroundings as a tropistic response, provided the animal has already the requisite structure with which to respond; but the tropistic theory does not attempt to explain how that structure was evolved. As this appears to be a clear case of the evolution of appearance, as such, some form of mimetic explanation appears to be necessary. If the colouration of the animal and the manner of operation of the chromatophore apparatus have not been evolved definitely in connection with the animal's environment, it is impossible to explain why the tropistic response under a given stimulus is always such as will cause the animal to resemble its surroundings. There is not merely a variation of response to different stimuli, but the variation is always of an adaptive nature, which strongly suggests the operation of natural selection.

An excellent example of an insect exhibiting this type of variable coloura-

tion came under my notice recently. This is the larva of *Nacaduba biocellata* Felder, a common blue butterfly which ranges over practically the whole of Australia. The larvae feed on the flowers of the wattle (*Acacia* spp.) and vary according to the colour of the flowers. Dr. Waterhouse informs me that the colour exactly corresponds to the colour of the flower on which the larva is feeding, whether this is a deep orange-red or lemon-yellow or green, when the flower is still in bud. I collected a considerable number of lemon-yellow larvae from similarly coloured wattle flowers by shaking these and picking up the larvae from the ground. In spite of the fact that the larvae were very common, prolonged search over the flowers failed to reveal a single specimen in its natural position. The larvae were placed in two white lined glass-topped boxes and one of these was placed in the dark and the other kept exposed to light. When I examined these later I found that all the larvae had changed colour. Those left exposed to light were almost transparent and of a pale cream colour, apparently the nearest possible approach to white. Of the larvae kept in darkness, most had changed to pale green, but two were a deep orange red, and one, which had been slightly injured near the middle, was green on one side of the injury and orange-red on the other. Though I unfortunately had no opportunity of examining these insects under the microscope, there can be but little doubt that the variable colour mechanism of this insect is in the nature of a system of chromatophores. Dr. Waterhouse informs me that there are several other species of lycaenids in which the larvae have a similar power of changing their colour.

In all the examples of cryptic colouration I have already mentioned, the concealment of the insect depends on its close similarity in appearance to its surroundings. In some insects another principle is employed, though it is commonly found in combination with normal cryptic colouration. The insects are so coloured that they may be extremely conspicuous at one moment and almost completely concealed the next. This is sometimes referred to as confusing colouration. I will take as an example the common *Castulo catocalina* Walk. (fam. Arctiidae). This moth has chocolate-brown fore-wings vaguely mottled with cream and white, and when settled on a sandstone boulder it is very inconspicuous. The hind-wings are bright yellow with an irregular black border and are only exposed when the insect is flying. When flying the insect appears to be bright yellow, and as soon as it settles on a rock it almost completely disappears. I think it will readily be understood that such a sudden complete change in appearance would cause an insect to disappear more completely than if the insect were brown both while flying and when settled, the perfection of the cryptic colouration being the same in each case. It is worthy of note that, unlike most cryptically coloured insects, this species takes to the wing readily on being approached, when it flies for a short distance and then resettles. The same system of colouration is found in many butterflies, the upper surfaces of the wings of these being brilliantly coloured and the under sides, the only portions exposed when the insects are at rest, are cryptically coloured. The common yellow-winged grasshopper, *Gastrimargus musicus* Fabr., also exhibits this type of colouration. The exposed portions when at rest, the head, thorax, tegmina and legs, are coloured with green and brown, forming a fairly efficient type of cryptic colouration, while the large fan-shaped hind-wings are bright lemon-yellow with a border of black. This insect also takes to flight easily when disturbed, flying a short distance and then settling again. It has been suggested that this system of colouration has a protective value of another kind. The sudden appearance of a brilliantly coloured insect close to the observer, in a position which a moment before appeared to be completely devoid of insect life,

is apt to startle him and enable the insect to reach a safe distance before pursuit commences, when, almost simultaneously, the insect disappears again. This startling effect is heightened in the case of *G. musicus* by a loud clicking noise emitted by the flying insect. The explanations given seem plausible, and even probable, but careful observation in the field is required in order to prove their truth.

Similar explanations may be applicable to a somewhat different type of confusing colouration which is only too well known to those who collect Diptera in this country. A confusing effect is produced quite independently of any normal cryptic colouration. Some species of bombyliids, and also of a number of other dipterous families, possess a brilliantly shining pubescence which, viewed from one angle, is most conspicuous, but is almost invisible from another. Take, for example, *Systoechus vetustus* Walk., a large and very common bombyliid in the Sydney district. The insect is completely covered by a long and dense pubescence, the hairs forming which slope backwards over the body. When flying in bright sunlight, the insect viewed from in front appears like a small ball of silvery light, but when it turns away from the observer it often seems to disappear suddenly in mid-air. The pubescence no longer shines, owing to the different angle it presents to the light, and disappearance is due to something in the nature of dazzle, combined with the fact that, when following an object with the eye, one does not expect it suddenly to change completely in appearance. Two views of a specimen of this species are shown on Pl. iii. In fig. 17 the insect is facing the observer, and the brilliant lustre of the pubescence will be noticed; while in fig. 18 it will be observed that the insect when viewed from behind is very inconspicuous against a dark background. No great stretch of the imagination is required in order to conceive that the natural enemies of such an insect might sometimes be deceived in the same manner as a human observer. It is suggestive that in this, and many other insects, the position in which the insect is least visible is that in which it is flying away from the observer.

Deceptive Resemblance.

I will now deal with the second main division of mimetic resemblance, deceptive resemblance or "mimicry," using the term in the restricted sense in which it is commonly now employed; but it will be necessary first to outline the theory of sematic or warning colouration, as this is very closely bound up in the subject under consideration.

Many insects have a very conspicuous form of colouration; so conspicuous that it gives the observer the impression that it must have been evolved in order to draw attention to the insects bearing it. It has been shown that, in a large number of such insects, conspicuous colouration is associated with some distasteful characteristic of the insect, such as the possession of a sting or an unpleasant taste. It is claimed that the colouration advertises the fact that the insect which bears it is unpleasant to eat; and that predaceous enemies, having, when young, experienced some unpleasant surprises which were associated with a particular form of conspicuous colouration, avoid insects so coloured. The advantage of this to the possessors of warning colouration is obvious, but it must be noticed that even according to this theory, the protection is not absolute. It is necessary to the theory that warningly coloured insects should sometimes be attacked, so that observations of attack on warningly coloured insects by no means disprove the theory. Still, it is most important that the theory should be based on ascertained facts, and not on general impressions and plausible

theories, as, unfortunately, there has been a tendency to do. It is important that as many observations as possible should be carried out in the field, though it is an unfortunate fact that opportunities for such observation are seldom presented. Much useful information should also be obtained from carefully controlled experiments made by feeding warningly coloured insects, and others, to birds, lizards, etc., in captivity. These experiments must be carried out with the greatest care as, when dealing with animals in captivity, it is difficult to avoid introducing abnormal conditions which may vitally affect the value of the experiments. Many such experiments have already been carried out by a number of competent observers, notably Marshall in South Africa, but the results of these have not been very conclusive, and puzzlingly conflicting results have not been infrequent. In general, however, they do demonstrate that warningly coloured insects are often distasteful to some animals; and the failure to give complete and convincing support to the theory of warning colouration may be due to the difficulties encountered when dealing with animals in captivity, such as varying degrees of starvation and satiety of the predators, or the use of the wrong type of predator. The last difficulty should be clearly appreciated. It is probable that different animals have different likes and dislikes so that, for example, an insect which is very distasteful to a bird may not be unpalatable to a wasp. On this theory it is only necessary that a warningly coloured insect should receive some protection on account of the association of its colour with some distasteful quality; complete immunity from attack by all kinds of enemy is not essential. I hope that in the near future careful experiments will be carried out in Australia on this subject, as we have many beautiful examples of warning colouration in insects which are easily obtained and with which it should be easy to experiment. It is most important that much more work of this type should be carried out than has already been recorded. The whole theory of deceptive resemblance appears to be dependent on the truth or otherwise of the theory of warning colouration.

Before giving examples of Australian insects which exhibit deceptive resemblance, I must point out that two main types of mimic are recognised. Sometimes it appears that a non-distasteful insect mimics a distasteful and warningly coloured model, and, by advertising distasteful qualities which it does not possess, it receives a protection from attack created by the model which is distasteful. Obviously, if protection is to be received in such a case, the mimic must be much less numerous than the model, as otherwise the colouration would not be associated with distastefulness by the enemy. This is known as Batesian mimicry, as the theory is to be attributed largely to the important work carried out by Bates on this subject. In the other type of deceptive resemblance both mimic and model are distasteful, and the terms mimic and model often appear to be interchangeable. If each distasteful species developed a separate type of warning colouration, each species would lose a large number of individuals in the process of educating its enemies and bringing about a recognition of its distasteful qualities. On the other hand, if a large number of species adopt the same system of warning colouration, each species would only lose a comparatively small number of individuals in this process of education, as the total number which must necessarily be destroyed in this process would be spread more or less evenly over all the species; whereas, in the previous case, a similar number of each species would be destroyed. This is known as Müllerian mimicry, after Fritz Müller, another of the early workers who have contributed so largely to our knowledge of this subject.

It has been found that no sharp line of demarcation can be drawn between

Batesian and Müllerian mimicry. It is probable that no insect is wholly distasteful to all kinds of predaceous animals, and every intergrade appears to exist between the most distasteful species and those which are palatable to all predators. Batesian and Müllerian mimicry are therefore to be considered as the extreme types of deceptive resemblance, and not as two separate phenomena. As will be shown later, it is probable that exactly the same processes have been involved in the evolution of each of these types.

In view of the complete lack of experimental evidence as to the unpalatability or otherwise of Australian mimetic insects, it will be impossible to divide them into the categories I have described; though it is possible to indicate, from various general considerations, to which category many mimics probably belong, with, I think, a fair degree of accuracy.

From an examination of the coloured photographs with which I am illustrating this address, it will be seen that there are many examples of remarkable resemblance between totally unrelated forms, often belonging to widely distinct orders of insects. It will be noticed that this resemblance is due to colouration, form and size, while some of the other photographs show that habit and attitude are also often involved in the resemblance. The latter characters also occur in many other mimetic forms, which I have not had an opportunity of photographing when alive, but I shall be able to give descriptions of some of these. Unfortunately there are a number of the mimetic forms I have figured with which I am not familiar in their natural environment, but I have every reason to suppose that, when observed in their natural state, many will show mimetic habits as equally perfect as those of the insects I am about to describe. Again I must stress the importance of making observations on the living insect in its natural environment. That insects might come to resemble one another in, say, colour, it is not difficult to believe; but, when resemblance involves such fundamentally dissimilar characters as colouration, form and habit, and when, further, it is found that close resemblance in one such character is commonly associated with resemblance in the other types of character, accidental resemblance appears to be quite inadequate as an explanation. As habit and attitude, which play such an important part in producing resemblance in many forms, are only to be observed when an insect is in its natural environment, it is important that research on this subject should be carried out as far as possible in the field.

If a long series of mimetic forms be examined, it will be found that these can be classified in various manners. One convenient method is to divide them into specific and group mimics; that is, those which have a single model and those which have a general resemblance to a group of closely related insects, but do not resemble any single species in particular. There is, however, no sharp dividing line between these two groups. For example, in a series of similar mimetic forms which have a general resemblance to wasps, some species may have a fairly close resemblance to one type, or even species, of wasp, while others resemble a different type, but a definite specific model cannot be found for any one of the mimics.

In this country specific mimics appear to be very rare and the best examples I can give are the species of *Systropus* figured (Bombyliidae, Pl. ii., fig. 5) and *Sceliphron laetum* Sm. (Sphecidae, Pl. ii., fig. 6), and *Chrysopogon crabroniformis* Roder (Asilidae, Pl. ii., fig. 3) and *Abispa ephippium* Fabr. (Eumenidae, Pl. ii., fig. 2). The resemblance in detail between mimic and model in these two cases is very remarkable, but it is possible that neither mimic exhibits a truly specific resemblance. In addition to resembling *S. laetum*, the species of *Systropus* mentioned bears a considerable resemblance to certain species of *Am-*

mophila; and *C. crabroniformis* resembles *Abispa splendidum* just as closely as *A. ephippium*. These two extremely similar species of *Abispa* are considerably different in appearance from any other species of eumenid, principally on account of their large size; and it is natural, therefore, that if these act as models for a mimetic insect the latter should resemble them specifically. On the other hand, when a long series of related species are similar in appearance and size and act as models, one would expect mimetic insects to approximate to the general colouration, form etc., of this series, rather than to that of individual species of the series. This is found to be so, for example, in the long series of mimics of *Odynerus* and related genera. This consideration would seem to account for the fact that specific mimetic resemblance is so common amongst butterfly mimics. Differences in appearance between closely related species of butterflies are often so great that a general resemblance to a group of butterflies would be of little use to a mimic; in fact it is difficult to conceive a general resemblance possible in many cases, so greatly does the colouration of related forms differ. It is a curious fact that those groups of butterflies which serve as models are precisely those in which specific differences in colouration are most marked; while groups with a fairly uniform system of colouration, such as the Lycaenidae, Pieridae, Hesperidae and Satyrinae, seldom or never serve as models. Excellent examples of such specific mimics amongst butterflies in other countries are well known and are to be found described and illustrated in most articles dealing with mimicry. When one considers the dominant position butterfly mimics have assumed in almost all discussions and considerations of mimicry in the past, it seems strange that such mimics should be almost completely absent from Australia, but such is the case. The only possible example I know of is the well known case of the female *Hypolimnas missippus* Linne., which is said to mimic *Danaida chrysippus* Linne., but, compared with other species of mimetic insects with which I am familiar, the resemblance in the field is not convincing. Colouration is certainly very similar, but the habits of the two butterflies are so very distinctive that they can be distinguished at a glance, even at a great distance.

Practically all the mimetic insects which have come under my notice are group mimics. To show clearly the perfection of these mimics it would be necessary to illustrate in each case the whole group of insects which serves as a model; but limitations imposed by space and expense forbid this. In the plates illustrating this portion of the present paper, therefore, I have selected from the groups of models representative species which illustrate the general colouration, shape, etc., of the models. It will be noticed that the mimics do not resemble such isolated models in detail; nor should they be expected to do so, though the resemblance is often very remarkable. Such selection of models might be considered to be open to criticism, as it is necessary that model and mimic should occur in exactly the same situation and at the same time; and I have to admit that not only were most of the specimens of models and mimics illustrated not taken together, but that in some cases I have not observed either model or mimic in the field. I can safely claim, however, that the majority, at least, of the models and their respective mimics illustrated do occur together. The models are almost all insects with a very extensive geographical and seasonal distribution and certainly occur in the localities in which the mimics were taken. Also, I have observed that the majority of the models and mimics illustrated are to be found together in exactly the same situation, and there can be but little doubt but that the other forms, which are nearly all closely related to the forms I have observed, will also be found together. I therefore consider that the selection of models I have mentioned is justified.

If an examination be made of the occurrence of mimetic forms in the various orders it will be found that this is by no means haphazard. In some orders mimetic forms are comparatively numerous, in others they are very rare or completely absent. Also, within a particular order it will be found that mimetic species are often confined to a few small groups, such as sub-families or genera, in which they are common, or may even be the rule; while completely absent from, or rare in, all the remaining groups of the order. Two types of such mimetic groups can be distinguished; those in which all the species resemble models belonging to a single group of closely related species, and those in which different species resemble very distinct types of unrelated models. The former type is much the commoner, but the occurrence of the latter is very significant and gives rise to important considerations which will be dealt with later. A further examination of the cases in which the species belonging to one group of insects resemble models belonging to a single group will show that these can again be divided into two categories. In the one the models and mimics belong to the same order and therefore have a general similarity in fundamental structure on which the mimetic resemblance can be superimposed. In the other the mimics and models belong to different orders and therefore differ considerably in fundamental structure, so that the resemblance is of a more superficial nature, though not necessarily less perfect, than in the previous case. This type of mimetic resemblance is naturally the rarer of the two under consideration but it is the most significant, as such mimics show most clearly that there is nothing but appearance in common between mimic and model; and therefore the clearest evidence for the fact of mimetic resemblance is to be expected from the examination of mimics of this type.

Though most mimics belong to a comparatively few definite groups, there are a few which are to be found scattered apparently at random through the remaining groups of insects. Many of these are very perfect, and their very marked dissimilarity from their close relatives gives very convincing evidence in favour of the fact of mimetic resemblance.

I find it convenient to classify the examples of Australian mimetic insects I am about to describe in the manner I have just indicated, as the manner of occurrence of mimetic forms in the Insecta has an important bearing, both on the evolution and significance of mimetic resemblance.

When examining these examples of mimetic insects two main considerations should be borne in mind. First the evidence for the fact of mimetic resemblance. In particular it should be noticed that in most mimics resemblance is due to two or more characters which are evidently independent of one another, and the resemblance is often of a very complex nature. When one considers the great variety of structure and appearance existing within the Insecta, it is evident that the chance of any two unrelated insects accidentally resembling one another even in a single conspicuous character is very remote; while the chance of resemblance in two or more independent characters is so remote that very few insects should possess such resemblance. Actually it is found that in most insects which show distinct resemblance in one character there are other independent characters which also take part in the resemblance. This being so it can only be concluded that resemblance has definitely been produced as such; for, if resemblance were purely accidental, the vast majority of mimics should show resemblance in one character only. The second important consideration to be borne in mind is that, though the best cases for demonstrating the fact of mimetic resemblance are those in which the mimic differs greatly from its close allies and resembles a totally unrelated form, it is not to be expected that even

the majority of mimics will be of this type. When a mimetic form arises, it is natural that it should resemble a suitable model which in appearance or fundamental structure differs as little as possible from that typical of the group to which the mimic belongs. This involves a minimum amount of change in the production of a mimic and, evolution being simpler, mimics of this type are more likely to be produced, and would be expected to be commoner, than those in which a more complex change is involved. This is found to be the case, and the above consideration appears to me to account, in an adequate manner, for the fact that the non-mimetic relatives of many mimetic forms often exhibit certain of the characters which take part in the mimetic resemblance of the latter. These characters, by themselves, do not produce a convincing resemblance to the model of the mimetic form and it is probable that they have been produced quite without reference to the appearance of the model and that, therefore, such slight resemblance as they produce by themselves is purely fortuitous. It seems reasonable to suppose that this primary fortuitous resemblance permits the commencement of natural selection, so that on this basis a truly mimetic resemblance can be built up. The change involved in the production of such mimetic resemblance is sometimes very slight, such as a simple change in colour, but it is usually fairly complex; though the fortuitous characters I have mentioned, such, for example, as the form of the insect, may still play an important part in the production of resemblance.

Before natural selection can commence to operate in the production of a mimetic form it is necessary that the incipient mimic should first bear a sufficient resemblance to a suitable model to be mistaken for it occasionally, and this primary resemblance must necessarily be fortuitous. It is not surprising, therefore, that most mimics resemble models belonging to their own order, or to an order in which the general appearance does not differ greatly from that typical of the order to which the mimic belongs. Thus normally beetles mimic beetles, wasps mimic other wasps, and flies mimic other flies or wasps, the last two types of insects having a certain superficial similarity. The exceptional forms, in which this does not apply, are most easily recognisable as true mimics but, if it be considered that these forms demonstrate that mimetic resemblance does exist, there is no reason why the less highly specialised form of resemblance I have mentioned should not also be considered as true mimetic resemblance.

An excellent example of a complex group of mimetic insects within one order is afforded by the red and black beetles illustrated in Pl. i., figs. 56-68 and 73-95. These beetles constitute one of the most conspicuous groups of flower-visiting insects in this country. The lampyrids, belonging to *Metriorrhynchus* and related genera, are extremely common; while the similar insects belonging to other families are very much less numerous than the lampyrids, which must therefore be considered to form the model group. It will be seen that these models have a very simple type of colouration and, though there is considerable variation within certain well-defined limits, the appearance of all these insects is very similar. They are rather broader than many other lampyrids, the elytra have a characteristic series of longitudinal ridges and the surface has a dull, almost velvety, appearance. The colour varies from pure red on the elytra and black on the rest of the insect, through forms with varying degrees of the displacement of the red from the central portions of the elytra by black, and sometimes with red borders to the thorax, to pure black forms. Pure black species are rare, however; the darker forms usually having conspicuous red borders and tips to the elytra. The mimics, belonging to the families Cerambycidae, Curculionidae, Buprestidae, Cantharidae and Oedemeridae, have exactly the same

type of colouration, with a similar range from red to black in each family; their size is within the rather considerable range of that of the models; the shape is very similar and, in the majority of cases, the surface has a dull, velvety appearance and the elytra have longitudinal ridges similar to those characteristics of *Metriorrhynchus*. In most of these characters the mimics differ considerably from their close relatives.

A system of colouration in which all parts of the body are black except the elytra, which are bright red, can only be considered as very simple; and it is reasonable to suppose that the genetical basis for such a system of colouration should also be very simple. Red and black pigments are very common amongst insects, and, given the similar structural basis afforded by the common structure of all beetles, it seems probable that such a simple distribution of common pigments might occur independently in many different types of beetles. The similarity in appearance of all the species in this group is due to a similar structure, and similar, or probably often identical, pigments distributed in the same simple manner. That there is a fundamental similarity in the nature of the pigments and the genetical basis which determines its distribution is indicated by the fact that precisely the same type of variation from red to black, through various similar combinations of the two colours, is found in each of the families containing the insects which constitute this group. This is not fully demonstrated by the illustrations, as only representative species have been selected; but an examination of a considerable number of species and individuals has demonstrated this clearly to me. Further, an identical type of variation is sometimes to be observed within a single species, for example, in *Pseudolychnus haemorrhoidalis* Carter, one form is almost pure black (Pl. i., fig. 95) while another, var. *ruffipennis* (Pl. i., fig. 91) has pure red elytra and the thorax is red at the sides, and figs. 88 and 89 on Pl. i. illustrate the sexes of an oedemerid, the male having almost pure red elytra, while in the female they are red with a large black central area.

This consideration, that the resemblance to one another of all the species in this group is due to fundamental similarity in structure and colour mechanism, would, at first sight, appear to indicate that we are dealing here, not with a true mimetic group, but with a group of convergent insects. Other considerations, however, place the matter in a very different light. If this type of colouration had arisen quite independently in each species, we should not expect to find any type of association between the insects; for there appears to be no reason why this type of colouration should not occur scattered at random amongst insects which live in different environments, unless the colouration could be considered as a response to common environmental conditions. All the species under consideration are typically flower-visiting forms, and are to be taken together on the same flowers; the greatest difficulty often being experienced in distinguishing mimic form model. The only characters in common between the mimics and models are similar colouration and occurrence in a similar environment in the adult state, and this combination is invariable. Though the life-histories of few of these species have been worked out, it is evident that the early stages of the various mimics and models must be passed in very different environments, for the typical habits of the larvae of the various families represented are as follows: Lampyridae, carnivorous, usually living under rubbish, etc.; Cerambycidae, Curculionidae and Buprestidae, bore in the wood of growing trees; Cantharidae, live on eggs and stored food of Hymenoptera and eggs of Orthoptera; Oedemeridae, tunnel in decaying wood. It would seem probable, therefore, that the colouration is, in some manner, a response to the environmental

conditions of the adult. In addition to the red and black models and mimics under consideration, close relatives of each of these types of beetles are to be found in exactly the same situation, at the same time, but the latter differ fundamentally in appearance from the insects belonging to the *Metriorrhynchus* mimetic group. Thus there are two parallel series of related insects, having the same general structure and living in the same environment, but this common environment has not affected the two series of insects in the same manner, though within one series it appears to have brought about uniformity in the appearance of the constituent species. It is necessary to look for some special factor in this environment which can discriminate between these two series of insects; something which could affect one series in a different manner from the other. This cannot be any uniformly operating factor, such as atmospheric conditions or the nature of the food, and the only factor capable of discriminating between insects differing in practically nothing but appearance would seem to be constituted by the natural enemies of the insects; something which can see and discriminate is essential. We are thus led to the conclusion that the red and black mimics belonging to the *Metriorrhynchus* mimetic group have evolved their present appearance definitely in correlation with that of *Metriorrhynchus*, and not independently, in spite of the fundamental similarity of the structure and system of colouration of mimics and models. Actually it is probable that the origin of the colouration was independent in each mimic; its appearance independently in each species being possible owing to the fundamental structural and genetical similarity, but its preservation was due to the fact that it resembled the colouration of *Metriorrhynchus*, and the preservation of characters which appear is of paramount importance in evolution by natural selection. I shall have more to say about this point later, but I must point out the importance of distinguishing clearly between two entirely different processes involved in the process of evolution, viz., the appearance of variations within a species, and the preservation, or otherwise, of such variations.

I have mentioned that close relatives of the insects which form the *Metriorrhynchus* mimetic group are to be found in exactly the same situations. Now, if the natural enemies are to be considered the active part of the environment which brings about the resemblance of mimic to model in the one series of insects, one would expect the natural enemies of the other closely related forms to bring about a similar result in their case. This is found to be so. The red and black type of colouration is dominant amongst lampyrids here, but scarcely less important is the blue-green and orange colouration of such forms as *Telephorus nobilitatus* Er., which is sometimes found in swarms on flowers. The *Metriorrhynchus* mimetic group is closely paralleled by a *Telephorus* group, characterised by a narrow form, orange-yellow thorax and blue-green elytra, often with a yellow band near the tip. Cerambycids, oedemerids, clerids and cantharids are represented in this group, while there are many species of *Stigmodera* (Buprestidae) which appear to have some connection with it, the colouration being somewhat similar, though the form is always much broader.

An examination of the flower-visiting species of the Cerambycidae, one of the families involved in the two mimetic groups under consideration, is particularly instructive. These form a fairly definite group of the Cerambycinae, and in this mimetic species appear to be the rule, their models being of many and various types. The remaining species of the Cerambycidae, which do not visit flowers, never exhibit true deceptive resemblance, with the exception of a few which resemble ants, though a very large percentage exhibits cryptic resemblance. The variety of the mimetic flower-visiting forms and the diversity of their re-

spective models is well shown in the illustrations accompanying this paper (Pl. i., figs. 5, 16, 52, 54, and 73-80, Pl. ii., figs. 1, 4, 12, and 24, Pl. iii., figs. 3, 4 and 7, Pl. v., figs. 1 and 2). It will be seen that each mimetic longicorn resembles some common insect which visits flowers and is therefore to be found in the same situation, and that the models, in spite of their great diversity in appearance, belong to two groups only; the Hymenoptera and the Lampyridae. The fact that the resemblance exhibited is not to any kind of flower-visiting insect, but only to one of these two types, suggests that these insects, the Hymenoptera and Lampyridae, possess some special advantage over other insects; an advantage which may be shared by any insect which happens to resemble them. A further indication of the truth of this suggestion is that the majority of other types of Australian mimetic insects also resemble models belonging to these same two groups. In addition it is known that many hymenopterous insects are distasteful to birds; they possess stings and probably have other unpleasant characteristics. Observations in other countries have shown that many species of lampyrids also appear to have unpleasant characteristics, as they are often rejected by birds. In view of the foregoing series of facts and considerations I am unable to conceive of any other theory to account for the production of mimetic resemblance in the insects under consideration than that it has resulted from natural selection; this selection being exercised by the natural enemies common to mimics and models, which are capable of discrimination on account of appearance and which associate distastefulness with the appearance of the models. Such natural enemies in exercising discrimination between palatable and unpalatable insects on appearance would reject mimics as well as their distasteful models, whether the former were distasteful or not.

There are many other cases in which insects with a very similar appearance are to be found distributed through a number of families in the same order, but in few is there as clear a demonstration of the dependence of the appearance of the mimic on that of the model as in the *Metriorrhynchus* and *Telephorus* mimetic groups already mentioned. It is even probable that in some such apparent mimetic groups there is no dependence of the mimic on the model, so that it may sometimes be necessary to use some non-mimetic explanation to account for the resemblance observed.

In view of the fact that lampyrids so frequently serve as models for other insects it is curious that some species, belonging to the genus *Laius*, should appear to mimic chrysomelids. The resemblance between certain species of *Laius* and species of *Aulacophora* (Chrysomelidae) is very considerable, both in form and colouration. This has every appearance of being a case of true mimetic resemblance and, if so, the chrysomelids must be considered to be the models; for the form is very unusual for lampyrids and is typical for a large group of chrysomelids, and the chrysomelids are far commoner than the lampyrids.

Resemblance between chrysomelids and coccinellids cannot be considered to be very remarkable, for the species belonging to the two families are normally very similar. The general resemblance between these families is evidently fortuitous and is to be considered as simple convergence. There are, however, some cases in which a species of chrysomelid is almost indistinguishable superficially from some species of coccinellid. Such detailed resemblance may be due to the existence of similar potencies for variation in two unrelated insects with a similar general structure, but it is not improbable that the normal general resemblance between the insects of the two families has served as a basis on which a true mimetic resemblance has been superimposed.

Recently a very remarkable series of examples of resemblance between

tachinids and blow-flies (Calliphoridae) have come under my notice. The resemblance is frequently so close that the two forms can often be distinguished only by a careful examination for the rather obscure family characters. Neither of these two types of insect has very well defined special habitats, so it is impossible to obtain evidence such as I have given in connection with the *Metriorhynchus* mimetic group, in order to show whether the appearance of one form has any relation to that of the other. The two families are so closely related, however, and the normal appearance of typical species is so similar that a mimetic explanation seems unnecessary in order to explain the resemblance. The close relationship, which involves a similar structure and genetical constitution, is probably, in itself, sufficient to account for the production of the same colour patterns, form, etc., in these two families; but this does not preclude the possibility that the preservation of such characters when they appeared was due to their resemblance to those of species belonging to the other family.

Similar considerations apply to the interesting case of the three moths, *Syntomis phepsalotis* Meyr., *Eressa paurospila* Turn. and *Trichocerosia zebрина* Hamps. (Pl. iii., figs. 19-30) the first two species belonging to the Syntomidae and the third to the Aretiidae. All the specimens figured were taken by Mr. G. Goldfinch at exactly the same place within a few days of one another. It will be seen that, not only is the resemblance between the three species very considerable, but each species is very variable, and the variations are of the same type in each species. The last point indicates that the moths are not only similar in appearance but that the structural basis of the colouration is very similar in each species; for it is impossible to imagine any type of evolutionary process which could cause the various individuals of a mimetic species to resemble respectively individuals of a long series of very different variants of the model, except by the production and preservation within the mimetic species of a colour mechanism similar to that of the model. Natural selection can only preserve definite characters which appear and cannot produce variability. If, however, a particular range of variability is an attribute of an hereditary factor this may be preserved, but not modified. The existence of a similar range of variation within the three species under consideration, therefore, indicates strongly that the colouration is due to a similar factor, or combination of factors, in each species; for otherwise it would be necessary to consider that different factors in each species accidentally happened to produce the same range and type of variation, which is extremely improbable. Though the insects belong to two distinct families, the Syntomidae and Aretiidae, their structural differences are slight, and the colouration of each may well be simply an expression of the fundamental similarity of the insects, not necessarily involving, or precluding, a mimetic explanation. Such insects may well be truly mimetic, but they are of little or no use in demonstrating the fact of mimetic resemblance. On the other hand they provide considerable evidence in connection with a mechanism which is probably involved in the production of mimetic resemblance in certain forms, as will be shown later.

Within the Hymenoptera a number of apparently mimetic groups can be recognised. For the purposes of this paper the most important of these is the yellow and black banded group which, for convenience, may be termed the *Odynerus* group, as *Odynerus* and related genera occupy a dominant position and are probably to be considered as the models. I have already shown that hymenopterous insects as a whole probably possess distasteful characteristics, for many different species serve as models for other insects. It is evident, therefore, that if the *Odynerus* group, within the Hymenoptera, is to be considered to be mime-

tie, it is almost certainly of the Müllerian type. Yellow and black banded species, similar in appearance to *Odynerus*, occur scattered through most of the superfamilies of the Hymenoptera; the Vespoidea, Sphecoidea, Apoidea and even Chalcidoidea. Hymenoptera are characteristically flower-frequenting insects, and all forms are to be found together on flowers, so it is again impossible to bring forward evidence for the dependence of the similar forms on one another, such as was used in the case of the *Metriorrhynchus* mimetic group. In each of the yellow and black banded species the colouration appears to have the same structural basis, and may have been produced independently in each species by the operation of similar influences on a similar structure. It is probable, however, that in many species this particular form of colouration has been preserved on account of the resemblance it produced to some common form, such as *Odynerus*. Thus, though the complete pattern which produces the resemblance may owe its origin to the similarity of the general structure and genetical constitution of the mimic to those of the model, it is probable that in many forms the preservation of this pattern is due to natural selection. Such forms would necessarily have to be considered as truly mimetic. Similar considerations apply to the other dominant forms of colouration within the Hymenoptera, such as the large yellow-winged forms and the black and white banded forms.

An examination of the cases of mimetic resemblance described as occurring amongst butterflies in other countries shows that these are somewhat more complex than the examples I have described. The species which serve as models amongst butterflies are confined to a very few well defined groups, and the butterflies which mimic them also mostly belong to a comparatively small number of groups in which mimicry is a relatively common phenomenon. In a group of closely related models, however, the colouration is far from uniform, and each species may have a very distinctive and complex pattern which differs radically from that of all closely related species. The mimics, therefore, cannot have a general resemblance to the average colouration of the group of models, as this would be quite without significance and scarcely recognisable. In a large percentage of the cases of mimetic resemblance in butterflies it is found that mimics and models occur in parallel series. The mimetic butterflies belonging to one group, say a genus, all resemble models belonging to a single group of closely related butterflies. Each mimetic species resembles a particular species belonging to the group of models, and not only differs considerably from the normal type of its own group, but from each of the other closely related mimics. The change from the typical colouration of the mimetic group to that of the complexly coloured model would appear to be so great that one naturally feels that a complex type of evolution must have been involved in the change, and that such complexity could only be considered to have arisen by a series of gradual steps. The possibility of the sudden appearance of the pattern in all its complexity seems incredible. Punnet has dealt with this problem in a masterly manner and has brought forward considerable evidence to show that the mimetic pattern not only may have arisen suddenly, but that this is probable. I cannot go fully into his evidence and considerations here, and must refer those interested to his book, "Mimicry in Butterflies," but I can indicate the main factors involved.

In the first place it must be realised that amongst butterflies mimetic resemblance exists between forms which are much more closely related than are the mimics and models belonging to other groups of insects, with which I have already dealt. In most cases mimics and models belong to a single family, the Nymphalidae, though they commonly belong to different sub-families; but some-

times both mimics and models belong to a single large genus, e.g., *Papilio*. Also, the butterflies form a very homogeneous group in which there is but little variation in structure. There is every probability, therefore, that the genetical constitution, as well as the structure may be very similar in both mimics and models. Another significant point is that great differences normally exist between the colour patterns of the most closely related species in the subfamilies to which the mimics and models belong. It seems probable, therefore, that the genetical basis, of which the colour pattern is an expression, is of a peculiar form in these groups, having potencies for producing radically different colour patterns suddenly. If this were not so, one would expect to find a fairly gradual series of changes in colour pattern through a series of closely related species, and sudden great changes in appearance between neighbouring species should be distinctly rare. If, then, the genetical basis of colouration in two closely related groups be considered to be of this type, and also fundamentally similar owing to close relationship, there is every reason to expect that some at least of the species in the one group should resemble some of the species in the other; the similarity in appearance of these species being simply an expression of the fundamental similarity of the genetical constitutions of the two groups. This conclusion involves the idea that the potencies for suddenly producing widely different colour patterns are of a special type, which permits the production of only a certain definite series of types of colouration. Thus, the groups are not considered to be highly plastic and capable of producing a multitude of different colour patterns within certain very wide limits, but are considered to have a genetical constitution which may contain one or more of a certain limited series of possible factors, any one, or any combination, of which will express itself in a certain definite colour pattern. When the same colour pattern occurs in two or more groups it is considered that this is due to the fact that similar factors, or groups of factors, are operative in each case, and, as the number of possible factors is considered to be very limited, the appearance of parallel series of species with similar colour patterns in two or more groups is accounted for.

That complete and complex colour patterns have a simple genetical basis, such as has just been assumed, is indicated by the manner in which colour patterns are inherited in butterflies with polymorphic females. Breeding experiments have been carried out with several such insects, notably *Papilio polytes* by Fryer in Ceylon, *Papilio dardanus* in Africa and *Papilio memnon* by Jacobsen in Java; and it should be noted that in each of these cases two or more of the female forms are considered to be mimics of different models. The outstanding point brought out in these breeding experiments is that, with any type of cross between different forms, no intergrades between the forms are produced, though all the forms may be represented in the offspring of a single pair. Also, it has been shown that in *P. polytes*, the colour patterns as a whole behave in the manner of Mendelian unit characters, and this is also indicated in the other cases. Had the complex colour patterns been built up by the selection of a series of small variations, each of these variations would be expected to have its own separate genetical basis, and the result of a cross between different forms would be a series of mixtures of the characters which constitute the two colour patterns, and the offspring ought therefore to show a series of intergrades between the two parent forms.

It is probable, therefore, that the resemblance existing between many butterflies, which have long been considered to be mimics and models, is to be accounted for as due to fundamental genetical similarity of a special type, in which a limited series of factors is represented. Any particular combination of these

will give rise to a particular colour pattern, and if the same combination exists in two species of butterflies resemblance will result.

I have noticed that there is a general tendency to consider that Mendelian unit factors can only express themselves in simple morphological changes of the organism in which they appear, and many people seem to experience difficulty in believing that a single factor can be responsible for a complex change. This is probably largely due to the fact that in the best known examples of the inheritance of Mendelian factors, simple morphological characters, such as a simple colour, or a change in form or size, are associated with the factors. There is also a tendency to confuse the factors with the characters which they produce, so that no difficulty is experienced in understanding that a single simple character may be separately inherited, while the concept of the inheritance of a complex series of characters as a unit presents great difficulties. It should be noticed that the primary effect of a factor must be to produce some modification in the normal physiological processes of the organism in which it appears; for preceding a new character there must be a new process to cause its production. It is easy to conceive that a small modification in the physiological processes of an organism may well have far-reaching results. The interaction of a particular modified physiological process with a series of normal processes would be expected to cause a modification in the action of each of these, and the nature of the modification would probably be different in each case. A simple primary modification, therefore, may cause the secondary modification of a number of different processes, and these, in their turn, might cause a considerable change from the normal in the structures which they produce. It will thus be seen that very considerable and complex changes in appearance from the normal may only be the expression of a single simple physiological modification. There should therefore be no difficulty in believing that the complex colour patterns of certain apparently mimetic butterflies may have arisen at a single step, in all their complexity; and that a single factor which produces a simple primary physiological modification may cause the production of similar complex colour patterns in two or more fairly closely related butterflies, in each of which it appears.

It has no doubt been noticed that there is much in common between the case of butterfly mimics and that of the *Metriorrhynchus* mimetic group. The main differences between these groups are that there is a greater diversity in the appearance of the models, and, in most, a closer relationship between mimic and model in butterflies than in the *Metriorrhynchus* group. Similar general considerations apply to each of these groups. In each something is known, or inferred, about the mechanism which underlies the colour pattern; but however perfect the knowledge of this mechanism may be, it cannot explain why a particular colour pattern has persisted. If a complete colour pattern appears as a mutation in a single individual, this individual must have some special advantage over the other individuals of the same species if this pattern is to persist and become the normal pattern of the species. Assuming that the species is in a state of equilibrium with its natural environment, and that the new form possesses no advantage over the normal form, there will be no tendency for this new form to increase in numbers, even if the factor for the new pattern be dominant over that of the old one. When a species is in a state of equilibrium, its numbers remain approximately constant from year to year. Therefore, from each family produced by a pair of insects an average of only one pair will survive and reproduce in each generation. If, then, an individual develops a new pattern, the factor for which is dominant over that of the old one, an average of two individuals in each generation might exhibit this new pattern, though the

probability is that only one would do so. These individuals would be heterozygous for the new factor, for the chances of the mating of two individuals bearing the factor are so remote as to be negligible, even in later generations. On the other hand, if the factor for the new character be recessive there is little probability that the new pattern will ever reappear after the parent generation. Also, with the normal fluctuations in number of the species from generation to generation, it would probably not be long before the variation from the average would reduce the numbers of the new form from two to nil.

It thus follows that, for a new mutation to form a new species or to replace the older form of an existing species, it is necessary that it should possess some special survival value. In the case of the butterflies which are considered to serve as models, we know that a certain series of colour patterns have both been evolved and preserved. What factors operated to their advantage, causing their preservation, we do not know; but there is no reason why the same or similar factors should not have preserved the similar forms which are considered to be mimics, since we consider that both mimics and models possess similar potencies for the production of colour patterns. On the other hand, there is the possibility that the factor operating in favour of the preservation of these forms may be their similarity to particular models which enjoy a certain measure of protection compared with other insects; a protection which may be shared by any insects which happen to resemble them. The fact that mimics and models are usually to be found together, and that apparent mimics of models living in another country are extremely rare, indicates that a mimetic explanation is necessary to account for the preservation of the mimetic forms. If this is not so it is difficult to account for the fact that apparently mimetic forms are not to be found scattered at random over the whole geographical range of the groups to which the mimics belong, quite without reference to the presence or absence of suitable models.

In many mimetic butterflies, therefore, as in the *Metriorrhynchus* mimetic group, fundamental structural and genetical similarity appear to provide the mechanism which produces mimetic forms, while natural selection is the mechanism causing the preservation of the mimetic forms, this operating with definite reference to the models.

Having shown that the resemblances existing between many insects belonging to the same order must be considered to be mimetic, I will now direct attention to the even more remarkable case of resemblances existing between insects belonging to totally different orders. In such cases the structural basis on which the resemblance is built is necessarily quite different in the mimics and models, and it is scarcely credible that such distantly related insects should have a similar genetical constitution. In addition, it will be found that similar appearance is commonly produced in mimic and model in totally different ways. It is therefore obvious that resemblance in such insects cannot be due to an underlying structural or genetical similarity; and consequently this comparatively simple mechanism for the production of complex resemblances cannot possibly be involved in the evolution of mimetic resemblance in the insects now under discussion. Some other mechanism, or mechanisms, must therefore be found to account for the production of the features which build up the resemblance, though it seems probable that the same mechanism operates to preserve the resemblance as before, namely, natural selection.

In the simplest cases of resemblance between insects belonging to different orders, the normal appearance of the insects in the group to which the mimic belongs does not greatly differ from that of the model. In such insects a com-

paratively slight modification of the normal structure may bring about a very close resemblance to the model. The family Mydidae forms a very good example of this. All the flies belonging to this family have a certain general resemblance to wasps. They are all robust, rather elongate, active and strong-flying insects, with unusually long antennae for the sub-order to which they belong, the Brachycera. Even the least wasp-like forms, such as *Miltinus viduatus* Wwd. (Pl. vi., fig. 2), are often very wasp-like in their actions. They are particularly swift fliers, often visit flowers, and when settled are often seen to vibrate their wings rapidly, after the manner of wasps. This is indicated in the photograph by the blurred nature of the distal portions of the wings. On the other hand, when settled on sand, in which situation they are most frequently found, they are commonly quite unmistakably flies. It is possible that *M. viduatus* should be considered as a mimic of the common black and grey-banded psammocharids, but, if so, the resemblance is not very close. As this species shows little more than the common characteristics of the family, however, I think it reasonable to look upon it as a simple representative member of the family.

It is evident that a very perfect mimic of a psammocharid could be built up on such a basis with very little modification; colour alone would be sufficient. A number of such mimetic forms exist and two are illustrated. *Dioclistus aureipennis* Wwd. (Pl. ii., fig. 8) is one of the most perfect wasp mimics I know, the distribution of the brilliant yellow colouration closely approximating to that characteristic of a large and extremely common group of psammocharids, of which *Salix bicolor* Fabr. is probably the commonest. The unusually broad abdomen of this mydoid heightens its resemblance. *Dioclistus gracilis* Macq. (Pl. ii., fig. 10) is also extremely wasp-like, appearing very like certain common thynnids. It is worthy of note that the double row of yellowish spots along the abdomen of this fly consists of almost transparent areas of chitin, through which the tissues show, while the corresponding spots on the abdomen of the thynnid are opaque pigment spots. The few specimens of this insect I have taken were found visiting flowers and in company with thynnids, which they closely resembled in habit as well as appearance.

In the closely related family Asilidae there is a similar, but less obvious, general superficial resemblance to wasps. This family is, of course, very much larger than the Mydidae and contains a much greater variety of forms. It will be shown that many very different types of Hymenoptera serve as models to insects in this family, and it is interesting to note that in each case the model is one which approaches in general appearance to that characteristic of the group of asilids to which the mimic belongs.

Chrysopogon crabroniformis Roder (Pl. ii., fig. 3) is, in many ways, the most perfect example of a mimetic insect I know. The yellow and black markings on the thorax and abdomen correspond exactly to those of the model, *Abispa ephippium* Fabr. (Pl. ii., fig. 2), in superficial, but not in morphological, distribution. The wings are similar in shape, have the same bluish-black tips, bright yellow anterior and smoky-black posterior borders. The legs, also, are similar in colour and size. Only the antennae appear to take no part in the resemblance, these being of the normal small form typical of asilids. This is characteristic of asilid mimics, and it is rather remarkable in view of the astonishing development of the antennae in many of the wasp-mimics belonging to other families of the Brachycera.

Unfortunately I have not observed this insect when alive, but its habits, as described to me, appear to be almost identical with those of the much less perfectly mimetic *Neosarapogon princeps* Macq. (Pl. ii., fig. 14), which I have

observed on a number of occasions. This insect occasionally visits flowers, probably in search of its prey, but usually it is to be found flying rather rapidly in and out amongst shrubs with a curious circling motion, which is almost identical with the habits of the common yellow and black psammocharids, such as *Salix bicolor*. The yellow and black colouration, together with this habit, causes *N. princeps* to exhibit an extremely close resemblance to common wasps which occur in its immediate vicinity.

That *C. crabroniformis* is an almost perfect wasp-mimic in its natural environment is well illustrated by the experience of my friend Dr. I. Mackerras. His particular interest is in Diptera, he has had a great deal of field experience and he has also a very keen eye, so that any dipterous insect which manages to deceive him accomplishes no mean feat. *C. crabroniformis* did accomplish this. Dr. Mackerras had just completed a day's collecting and was about to go home when he saw what he took to be a particularly fine specimen of yellow and black wasp. After the manner of my various entomological friends he thought of my needs and decided to catch the specimen for me. This he did; then he placed the specimen in a killing-bottle and went home. It was not till sometime later, when he emptied his killing-bottle, that he discovered that he had captured his first specimen of *C. crabroniformis*, a prize beyond price in his eyes at the time. He never tires of telling of the thrill he experienced when he made this discovery.

A scarcely less perfect mimic is *Codula vespiformis* King (Pl. i., fig. 3). The model of this fly appears to be the group of common black and orange-banded species of *Odynerus* and related genera. It will be seen from the illustration that this asilid closely resembles its model, both in the colouration and form of the body, though the orange colouration in the mimic is due to pubescence while in the model it is due to the pigmentation of the chitinous body-covering. In addition, it will be noted that the anterior border of each wing is heavily pigmented. This is a very common phenomenon in mimics of diplopterous wasps and, when settled with the wings parallel to the body, these dark borders cause the wings to look very much like the narrow plicately folded wings of diplopterous wasps settled in a similar manner. From an examination of Pl. i. it will be seen that a dark anterior border to the wing is the rule amongst mimics of diplopterous wasps, and is absent from all other types of mimics; a very suggestive phenomenon.

Brachyrhopala limbipennis Macq. (Pl. i., fig. 50) appears to be a general vespoid mimic. It is a very variable species, varying from a fairly uniform pale brown to black with conspicuous yellow marks on the hind tibiae and a very narrow yellow band on the abdomen, as in the specimen illustrated. The highly polished and narrow-waisted body, and the dark bands on the anterior borders of the wings, together with the active and alert habits of the insect, cause it to appear very wasp-like. The paler brownish specimens are not unlike *Polistes*, while the specimen illustrated was extremely similar in appearance to eumenids taken in the same situation. When flying it had the appearance of a black and yellow-banded insect, the yellow marks on the tibiae being confused with the yellow bands on the abdomen of the model. The almost black anterior border of the wings, together with the extremely transparent nature of the posterior border, caused the insect, when settled, to look very like a wasp with folded wings.

Several other species of *Brachyrhopala* appear to be mimetic, making use of other models. *B. fenestrata* Macq. (Pl. i., fig. 24), for example, is a very close mimic of certain species of *Cerceris* (Pl. i., fig. 23).

Cyanonedys leuceura Herm. (Pl. i., fig. 41) has a very unusual appearance for an asilid, and it will be seen from the illustration that its resemblance to the common *Megachile suffusipennis* Ckll. (Pl. i., fig. 40) is particularly close in almost every detail. The resemblance involves both shape and colouration of wings and body, and a characteristic pubescence which gives a furry appearance of both insects. The thick white pubescence at the base of the abdomen is perhaps the most important character involved in the resemblance.

There is quite a large number of other cases in which asilids mimic wasps, a few of which are figured (Pl. i., figs. 11, 21, 35 and 37) but sufficient have been described to indicate the perfection of many such mimics, the great variety in the appearance of the models and that in each case the model fairly closely approaches the normal appearance of the group to which the mimic belongs; the mimetic resemblance being brought about by the superimposition of mimetic characters on a basis which by itself exhibits a certain similarity to the model. The similar appearance of mimic and model is, however, due to a totally different structural development in the two forms.

The closely related family Therevidae also contains a series of mimetic species, though they are not as numerous or as varied in appearance as in the Asilidae. This is only to be expected in a family which is so much smaller and exhibits so much greater uniformity in the structure of its component species. Therevids are all rather elongate, active insects, and it is therefore not surprising that various psammocharids act as models for the mimetic species.

The specimen of *Agapophytus australasiae* Guerin (Pl. i., fig. 45) was taken while it was sipping water at the edge of a pool, where it behaved in a very wasp-like and active manner; and *Prionocnemis connectens* Turn. (Pl. i., fig. 46), its probable psammocharid model, was found amongst weeds at the edge of a slow-running stream. It will be seen that there is a considerable general resemblance in the colouration and form of these two insects. The wings have the same distribution of yellow and dusky marks, the body is similar in shape and colour, as also are the legs, and, perhaps the most remarkable development of all, the antennae of the fly are almost as long as those of its wasp model.

In the species of *Phycus* illustrated (Pl. i., fig. 39) the resemblance is to a black and grey psammocharid with bright yellow antennae, such as the species shown in Pl. i., fig. 38. As in *A. australasiae*, the antennae of *Phycus* are almost as long as those of its model.

In *Ectinorrhynchus superbus* Sch. (Pl. i., fig. 43) and *E. rufipes* Krob. (Pl. i., fig. 44) the resemblance to psammocharid wasps is as close as in the other therevids I have just mentioned, except that in neither species are the antennae longer than in normal non-mimetic therevids.

A black and yellow-banded wasp-like type of colouration appears to be the rule in the Conopidae, though there are many small and inconspicuous species which have little or no resemblance to wasps. In the latter the form is elongate and the abdomen is narrower at its base than towards the tip, so that the appearance of a waist in mimetic species may be regarded as a normal family character and not a mimetic adaptation. The resemblance of many of the species to wasps, however, involves a number of adaptations, such as dark anterior borders to the wings and amazingly long antennae for muscoid flies, as well as a considerable resemblance to eumenid wasps in colouration. In general the distribution of the colour bands on the body is not particularly close to that existing in the Eumenidae, though in general effect the colouration is similar (Pl. i., figs. 19, 29, 30 and 31), but in one species at least (Pl. i., fig. 9) the colouration closely approximates to a definite model. This species has a general black

colouration and a uniformly orange-red abdomen, causing it to appear very like *Odynerus bicolor* Sauss. (Pl. i., fig. 10). Unfortunately systematists appear to have left the Australian Conopidae severely alone.

Though the mimetic resemblance existing in orders in which various species mimic totally different types of models differs only in degree from the type I have just described, it is convenient to make use of such a classification.

Perhaps the best example of this type of mimetic resemblance is afforded by the Cerambycidae, which I have already mentioned in passing. The majority of Cerambycids are cryptically coloured and spend nearly all their time on tree-trunks or branches, and but few visit flowers. Of those which do visit flowers habitually the majority exhibit deceptive colouration, and different species resemble totally different kinds of flower-visiting insects. Also, the model of each mimetic form is a common and conspicuous flower-visiting insect, belonging to one of the groups which are generally considered to be distasteful. These facts alone give strong support to the general theory of mimetic resemblance, and the perfection of the resemblance in most cases strengthens this.

I have already mentioned the Cerambycids which resemble *Metriorrhynchus* (Pl. i., figs. 73-80). Even an examination of the illustrations will indicate that these mimics are by no means closely related, and the various species which mimic *Metriorrhynchus* are placed in several genera which are widely separated in the classification of the Cerambycinae. It seems that this particular form of resemblance has been evolved independently in a number of different forms, which is not surprising if the true explanation for the appearance of this type of colouration is that already put forward; that is, that it is possible owing to the possession of a certain general structural and genetical similarity to *Metriorrhynchus*.

The occurrence of other lampyrid-like forms, such as *Erinus mimula* Pascoe (Pl. iii., fig. 4), which closely resembles *Telephorus nobilitatus* Er. and other lampyrids in form and green and orange colouration, increases the probability of this explanation.

A similar explanation, however, cannot be given in the case of different forms which resemble different types of Hymenoptera, and do so by different methods.

The genera *Hesthesis*, *Tragocerus*, *Agapete* and *Macrones* each resemble hymenopterous insects, usually of different types, and the morphological modifications which produce the resemblance are different in each genus. Therefore, as there is nothing but appearance in common between mimic and model in any of these insects, the structure of the mimic being fundamentally different from that of the model; and as in each genus in which resemblance to some hymenopterous form appears to have been separately developed the structural modifications of the mimic have been of a different type, it is clear that the mimetic pattern must have been both produced and preserved in relation to the appearance of the model. It is perhaps incorrect to say that a mimetic pattern can be produced as a response to the appearance of another insect, as the variations which have taken part in the evolution of the mimetic pattern must have been produced from within the insect, but it is impossible to escape from the conclusion that in the mimetic insects under consideration the resemblance must have been built up in relation to the appearance of the model, and in that sense produced. As there appears to be no possible mechanism by which a complete and complex mimetic pattern could appear at a single step in an insect structurally and genetically different from its model, it can only be concluded that the complex pattern is the result of a series of steps, each of which would make

the resemblance more perfect when it appeared. We know no more in this case than in any other of the processes which produced the variations, but the action of natural selection, through the medium of the natural enemies of the insect, appears to be an adequate mechanism for the preservation of each favourable variation, provided it was large enough to be distinguished by the natural enemies. The problem of how these mimetic forms were produced is thus simply the problem of evolution, as a whole, with the only special character that in this case the operation of natural selection appears to be confined to the medium of the natural enemies which could perceive the variations and exercise discrimination on account of them.

Bearing the foregoing considerations in mind, let us now examine the various types of cerambycid wasp-mimics.

In the genus *Tragocerus* (Pl. ii., figs. 1 and 12) the colour pattern, corresponding to that of the body of the model, is borne on the elytra, and these are curiously modified to serve this purpose. They are joined together along the mid-dorsal line, so that they remain in position over the abdomen when the insect flies. In order that the wings may be extended while the elytra are thus firmly fixed above the abdomen, the side of each elytron is excavated just above the point of origin of the wing, so that the wings can be moved freely without displacing the elytra. The result is that these insects are very wasp-like while flying, though when settled on flowers the resemblance is not convincing. The apparent absence of wings, together with its rather sluggish movements while settled on flowers, causes the beetle to be readily distinguished from a wasp. The wasp-like colouration alone, however, may give this insect some protection from its natural enemies.

Resemblance to wasps is much more perfect in the genus *Hesthesis* (Pl. i., figs. 5, 16, 52 and 54, Pl. ii., figs. 4 and 24, and Pl. v., figs. 1 and 2). In this genus the elytra are reduced to short truncated flaps which do not extend over the abdomen. As a result, the hind wings are exposed, even when the insect is at rest. The colouration is borne principally by the abdomen, and an examination of the figures will show that this varies rather considerably in different species. In most species this produces resemblance to particular types of wasps, while in the remainder it produces a general wasp-like appearance. Specimens of *Hesthesis* are nearly always collected on flowers, and one's first experience of these insects in this situation is apt to be a little disappointing. On flowers *Hesthesis* is commonly sluggish in its movements, like *Tragocerus*, and, though very wasp-like, does not deceive (Pl. v., figs. 1 and 2). This, however, is by no means the invariable habit, and I have frequently seen these insects moving rapidly from flower to flower, often leaving the wings spread out while feeding, after the manner of wasps, and the resemblance to a wasp is then remarkable, as will be appreciated by examining the coloured photograph (Pl. ii., fig. 24). When flying the resemblance is almost complete, and I have observed a specimen flying about in a marshy place which mimicked the movements of a wasp to an almost incredible degree. Agitation was the outstanding characteristic of its movements. It would settle on a grass-stem or other plant for a moment or two, often keeping the wings extended, then it would fly a short distance and settle again, and it kept repeating this process, circling all the time within a comparatively small area, returning again and again over almost the same ground. Had I not had an opportunity of observing it at close quarters I should not have suspected that it was anything but a wasp. I may say that I have heard many accounts of cases of deception by various species of *Hesthesis* from a number of observers, including such a competent coleopterist as Mr. H. J. Carter, so

that, though these insects may not always deceive, they are certainly capable of doing so.

It is interesting to compare the structure of *Agapete* (Pl. iii., fig. 3) with that of *Hesthesis*. Superficially there is a considerable resemblance between the beetles belonging to these two genera. In both the elytra are short and the wings are almost fully exposed, even when the insects are at rest. It appears probable, however, that the two forms have evolved quite independently; for in *Hesthesis* the elytra appear simply to have shortened, while in *Agapete* it appears that reduction in size was due first to a narrowing of the distal part of the elytron, followed later by the disappearance of the greater portion of this narrowed part. An examination of the neighbouring genera indicates the probable steps in this evolution. In *Bimia bicolor* White (Pl. iii., fig. 1) the distal portions of the elytra are somewhat narrowed, while in *Aciptera waterhousei* Pascoe (Pl. iii., fig. 2) they are still more so and it is only necessary for this process to continue still farther in order to produce the type of elytron characteristic of *Agapete* (Pl. iii., fig. 3). *Bimia* does not particularly resemble a wasp but, compared with most beetles, the wings are rather exposed. This might well cause the insect to be occasionally suspected of being a wasp by its natural enemies and, except for the appearance of suitable variations, nothing further is required to cause natural selection to operate in such a manner as to produce forms like *Agapete*. There are few cases in which the probable steps in the evolution of a mimetic form is shown as clearly as in this case, and it illustrates the fact that, in order that a mimetic pattern may be built up by natural selection operating on variations, it is necessary for the insect first to resemble some suitable model sufficiently closely in order to be occasionally mistaken for it. This first step must therefore be purely accidental, but it is probable that quite a vague approximation to the appearance of a suitable model is all that is necessary in order to commence the process. The occurrence of a similar type of reduced elytron in such beetles as *Sitarida* (Cantharidae), which are apparently not wasp mimics, indicates that this type of reduction of the elytron is not necessarily due to selection on account of the appearance of the insect exhibiting it. Necessarily the reduction of the elytron is due to some innate power of the insect of varying in that direction, but it is reasonable to suppose that the variation is preserved by natural selection and in *Agapete* the probable instruments of selection are the natural enemies of the insect.

This is another case in which I have not had the opportunity of viewing the insect in its natural environment. It appears probable, however, that it resembles large braconids, and possibly megalynids, rather than vespoid and sphecoïd wasps, which serve as models for *Hesthesis*. The wings have a much softer and more membranous appearance than those of *Hesthesis*, and the colouration is also closer to that of certain braconids.

In the genus *Macrones* (Pl. iii., fig. 7) a very different type of wasp mimic is found. In this genus the models appear to be common ichneumonids, such as *Paniscus* and *Henicospilus* (Pl. iii., fig. 8), the outstanding characteristics of which are extreme tenuity of body, a thorax noticeably more robust than the abdomen, long antennae, often with white tips, and a "floating" type of flight, progression being slow and direction indeterminate. *Macrones* has all these characteristics and it will be seen from the photographs that length and narrowness are extreme even for a cerambycid, while the elytra are so narrow that they are almost like long spines. The colour in each species is some shade of brown, usually rather pale, which is characteristic of many ichneumonids to be found

visiting flowers, and the tips of the antennae of some of the smaller species are white, a characteristic form of colouration in many ichneumons. When flying these insects are often indistinguishable from ichneumons, the long antennae being most noticeable, appearing like floating threads above a vague cloud formed by the rapidly vibrating transparent wings, while the body is usually inconspicuous.

There are many other flower-visiting cerambycids which possess some resemblance to wasps, such, for example, as *Arideus thoracicus* Don. In these the mimetic resemblance is less perfect and less complex than in the genera I have mentioned, but the general wasp-like effect is unmistakable.

Cerambycid ant-mimics occur in several different genera, and the resemblance is produced in different manners in different species. I have reason to believe that these insects are typically to be found on tree-trunks and branches, in which situations ants would form very suitable models. *Pseudocephalus mirus* Pascoe (Pl. iii., fig. 5) is a mimic of this type and it will be noticed that this species exhibits a most abnormal development of the head and prothorax for a beetle. The head is large, prominent and globular, and the prothorax long and narrow. There is a slight bulbous development of the terminal portions of the elytra, which produces a considerable resemblance to the globular abdomen of an ant, and the sides of the basal portions of the elytra are so coloured that the insect appears to have a waist in this region when on a brown background. These characters, together with the abnormally long legs, cause the insect to have a particularly ant-like appearance. In *Ochyra coarctata* Pascoe (Pl. iii., fig. 6) the resemblance to an ant depends principally on the peculiar, and very considerable, dilatation of the terminal portions of the elytra. In this species, also, the basal portions of the elytra are so coloured as to give the impression that the insect has a narrow waist, when it is on a dark background.

Scarcely less remarkable than the Cerambycids for the variety of their models are the mimetic species belonging to the dipterous family Stratiomyidae. *Syndipnomyia* sp. (Pl. i., fig. 7) is a particularly perfect mimic; brilliant orange bands of pubescence on the abdomen, yellow legs, black costal borders to the wings and extremely long antennae, giving the insect an almost incredibly wasp-like appearance. In *Massicyta picta* Brauer (Pl. i., fig. 28) the resemblance is less striking but is still very perfect. It will be seen from the illustrations that it possesses a considerable resemblance to the thynnid figured (Pl. i., fig. 27), but it is probable that its actual model is a large mimetic group of small hymenopterous insects, consisting of numerous species of solitary bees, and vespoid and sphecoid wasps. The colouration consists of yellow and brown in rather vague bands, there is a distinct waist to the abdomen, the antennae are very long and there is a dark costal border to each wing.

The species of *Ellissoma* illustrated in Pl. ii., fig. 18, is, I think, quite as remarkable as the species of *Syndipnomyia* already referred to. The amazing development of the antennae for a brachycerous fly is perhaps the most remarkable character. White bands on the long antennae of many ichneumons (Pl. ii., fig. 17) are most characteristic, and are often the first thing to attract attention in the field. The antennae are waved rapidly while the ichneumon moves, and the flickering white spots first call attention to it. From experience with other mimetic insects, I feel sure that this stratiomyiid will be found to wave its antennae in a similar manner, though there are unfortunately no records of its habits. In addition to the antennae, however, resemblance to certain ichneumons is shown in other characters. The long legs are banded with

black and yellow-white, the thorax bears a number of bluish-white spots and the wings are hyaline, with a spot on the anterior border resembling the stigma characteristic of many Hymenoptera. The anterior borders of the wings are not dark, the model not being dipterous. Though I have been unable to figure it, *Ellissoma lauta* White is scarcely less perfect as a mimic than the preceding species, and again the model is different. One of the commonest types of braconid in this country is that with a general black colouration and a large pale pink area on each side of the base of the abdomen, and narrow pink or white lines separate the dorsal segments of the abdomen. *E. lauta* has exactly this colouration and very long black antennae. Pale pink is a most unusual colour for any insect, and the braconids mentioned are the only insects I know which normally exhibit it. That such an unusual colour as pink should be found in a mimetic insect is remarkable in itself, but that it should be of the same shade as that exhibited by the braconids and yet have a different chemical basis is still more remarkable. There can be little doubt, however, but that this is so, as the pink of the stratiomyiid faded almost immediately after death, while that of the braconids persists after many years.

E. lauta is the only stratiomyiid mimic I have seen alive, and unfortunately I only saw this after capture. The student who caught it did not suspect that it was a fly, and both in the net and in the glass-topped box to which the fly was transferred, it had a most wasp-like appearance. It exhibited the characteristically agitated and rapid movements of a wasp, and held the body far from the surface on which it moved. When at rest, however, it had a fairly normal fly-like appearance, the body being held close to the surface on which it rested, and the wings flat on the back and immobile. This appears to be characteristic of flies which mimic Hymenoptera, the wasp-attitudes only being in evidence when the mimic is active.

The family Syrphidae contains some of the best known examples of mimetic insects. The extremely bee-like species belonging to the genus *Volucella* attracted the attention of the earliest workers, and can be considered as classical examples of mimicry. Unfortunately this genus does not occur in Australia, and we have nothing which resembles it, but, on the other hand, amongst our syrphids are some species which show an even more perfect resemblance to other insects.

The resemblance of *Ceroides breviscapa* Saund. (Pl. i, fig. 13), to common species of *Odynerus*, for example, is so perfect that it would be difficult to suggest any improvement, even in detail. The bright yellow bands on the abdomen, and yellow spots on the antero-lateral portions of the thorax, and the general black and dark brown colour of the rest of the body, exactly correspond to the colouration of *Odynerus*. The very narrow waist-like basal portion of the abdomen, together with the sub-spherical terminal portion, forms an almost exact replica of the petiolate abdomen of the model. The wings have the usual dark costal border characteristic of mimics of dipterous wasps, and the antennae are extremely long for a syrphid, the length being due principally to a very long first segment. In addition, the chitinous covering of the body gives the impression of hardness and strength, this being characteristic of the appearance of wasps, while in the Diptera the body covering usually appears more or less membranous and soft. In habit this insect is amazingly wasp-like and is scarcely distinguishable from the wasps in company with which it is found. The specimen illustrated was taken while sipping water at the edge of a small pool, and it was accompanied by quite a large number of *Odynerus*, of several species. It exhibited the agitated manner characteristic of wasps and in every way conveyed the impression that it was a wasp.

A number of other species of *Cerioides* also resemble *Odynerus* very closely, but in many of these the strong basal constriction of the abdomen is lacking. Also the appearance of long antennae is largely due to a curious column-like process arising from the head capsule, at the end of which the antennae are borne; these in themselves being distinctly longer than is usual (Pl. i., figs. 15, 18 and 32).

The genus *Microdon* contains some equally fine mimetic species, though the majority of the species of this genus are very typical flies, without the remotest resemblance to wasps. *M. variegatus* Walk. is a comparatively common and well known species. It varies rather considerably in appearance, as will be seen from the figures (Pl. i., figs. 20 and 26). The abdomen bears yellow bands on a dark background and is distinctly constricted at the base. It is noteworthy that while in *Cerioides*, as in *Odynerus*, the yellow bands are due to pigment in the chitinous exoskeleton, in *Microdon* they are due to a golden pubescence. The antennae are very long, due in this case principally to an extremely elongated third segment, though the first segment is also unusually long, and the costal border of the wing is rather vaguely pigmented. A comparison of the antennae of the mimetic and non-mimetic species of *Microdon* is instructive. These appear to be very variable structures in this genus, and in the non-mimetic species are surprisingly varied in size and shape, some being very large for a syrphid, but the longest antennae occur in the two mimetic species, *M. variegatus* and *M. waterhousei*.

Like *C. breviscapa*, *M. variegatus* mimics *Odynerus* in habit as perfectly as in superficial structure. This is well shown by the series of flashlight photographs of the living insect (Pl. iv.). These were necessarily taken under laboratory conditions, the insect being inclosed in a special glass box; but the attitudes taken up by the insect under these unnatural conditions were not observed to differ from those of the insect in its natural environment, nor is there any reason to suspect that they would. In fig. 2 the insect is at rest, while in the remaining photographs it is active. This illustrates the fact that when the insect is at rest its attitude is definitely dipterous, while when disturbed it assumes wasp-like attitudes. When one considers the different functional requirements of flies and wasps, it necessarily follows that in habit, as in structure, resemblance can only be due to superficial appearance; the normal fundamental habits must be different. One must distinguish between these fundamental habits of the mimic, evolved principally for purposes of nutrition and reproduction, which cannot differ greatly from those of closely related non-mimetic species, and superficial or mimetic habits, which supplement these. The latter are principally in the nature of special attitudes and manner of movement, which can only be of significance to the mimic in so far as they affect its appearance and increase its resemblance to a wasp; for they serve no useful functional purpose and cannot be an expression of an underlying structural similarity of wasp and mimic, as there is no such similarity.

The photographs illustrate a number of distinct wasp-like characteristics of attitude and behaviour of *M. variegatus*. The insect stands, as it were, on tip-toe, holding the thorax far from the supporting surface, it has a distinct tendency to stand on its head, it often flexes the abdomen so that the tip of this tends to pass under the thorax and the wings are erected somewhat so that they are considerably separated from the abdomen. The walking movements are very rapid and jerky, often being accompanied by rapid vibration of the wings and quick waving motions of the front legs and long antennae. This is well shown in fig. 5, the blurring of the wings, antennae and front legs being due to ex-

tremely rapid movement while the flashlight photograph was being taken. In captivity the behaviour of the disturbed insect was exactly that of a wasp. It hurtled from side to side of the breeding cage, hitting the sides with such force as to produce a distinctly audible dull thud. These hurtling movements were repeated in rapid succession, usually with a short interval intervening during which the insect made a few rapid, jerky walking movements, accompanied by vibrating wings and antennae. Commonly when undisturbed, however, the insect assumed a normal fly attitude, with the body held close to the supporting surface, the legs spread out, and the wings held flat and closely applied to the dorsal surface of the body, and it would remain motionless in this position for considerable periods.

The mimetic habits of *M. variegatus* are no more perfect than those of many of the other insects I have described. It is illustrated, not as a very exceptional case, but because it is the only species of which I have so far had an opportunity of taking photographs of this nature.

A specimen of *M. waterhousei* Ferg. appears much more convincingly wasp-like than one of the preceding species. It has broad bands of brilliant orange pubescence on the abdomen, the wings possess dark anterior borders and the antennae are long; these characters causing the insect to resemble a species of *Odynerus* very closely indeed. The perfect correlation existing between this colouration and form and the mimetic habits of this insect will be appreciated from a description of the manner in which Dr. G. A. Waterhouse captured the type, and at present only known, specimen. He saw what appeared to be a wasp running with rapid jerky movements over the bark of a tree in his garden. It appeared to be a particularly fine wasp of a species he had not previously seen, so he decided to capture it. This he did, and it was only after it had been in the killing bottle for some little time that he began to suspect a deception. Wasps normally succumb to cyanide almost immediately, much more rapidly than most insects. This insect continued to buzz about in the bottle for an unduly long time, which roused Dr. Waterhouse's suspicions. He examined more carefully and was amazed to find that the insect was a syrphid.

Some of the cristaline syrphids show considerable resemblance to other insects. The common *Eristalis tenax*, a fly with an almost world-wide distribution, is referred to in almost every general article on mimicry as a common example. In colour, size and shape it is somewhat like the common hive-bee and it is usually to be found visiting flowers. It is, however, one of the least convincing cases of mimicry I know, and fails to deceive the most casual observer. The resemblance of *Eristalis smaragdi* Walk. (Pl. i., fig. 101) to common species of *Lucilia* and *Chrysomyia* is much more perfect. In shape and colouration, brilliant metallic green with blackish markings, it is an almost exact replica of these blowflies, but a mimetic explanation appears to be superfluous in this case, though it may really apply. The Muscidae and cristaline Syrphidae are similar in shape and sufficiently closely related to have similar potencies for producing certain colours; particularly such colours as metallic green, which occurs in that the appearance produced by this colouration is without significance to the many different families of Diptera. It is not surprising, therefore, that an isolated case should occur in which a species of *Eristalis* resembles some blowfly.

The large subfamily Syrphinae contains principally yellow-banded species. In other characters they have little in common with wasps. It is possible that this type of syrphid may be a general wasp-mimic, the vague resemblance being sufficiently close to cause the insects to be occasionally mistaken for wasps. On the other hand they may exhibit simple warning colouration, as it is possible

that they have some distasteful qualities of their own. A further possibility is that the appearance produced by this colouration is without significance to the insect, it being simply an attribute of the characteristic structure of this group.

The peculiar Australian genus *Pelecorrhynchus* differs from most tabanids in the fact that neither sex sucks blood, and both sexes are commonly to be found visiting flowers or flying in a particularly active manner over marshy places. The colouration is usually brilliant and varies considerably in different species, and in a few cases approximates very closely to that of certain common psammoderids, as in *P. deueti* Hardy (Pl. ii., fig. 16) and the undescribed species I have figured (Pl. ii., fig. 22). On flowers these insects may easily be mistaken for wasps, though no special mimetic habits have been observed. It is possible, however, that greater familiarity with these rather scarce insects may reveal such habits, these often not being in evidence when an insect is busy sucking nectar, as has been shown to be the case in *Hesthesis*.

A different type of possible mimetic resemblance is shown by certain more normal tabanids. Several species possess a considerable resemblance to blowflies. Thus *Scaptia violacea* (Pl. i., fig. 99) is metallic blue like many blowflies, such as species of *Chrysomyia*, and *Scaptia* sp. (near *gibbula* Walk. Pl. i., fig. 97) closely resembles the common *Calliphora stygia* Fabr. (Pl. i., fig. 96) in its dull brown colour and golden pubescence. Both species are rather abnormal in shape for tabanids, this approximating very closely to that typical of blowflies. It is possible that the same explanation applies here as has been suggested for the resemblance of *Eristalis smaragdi* to blowflies. That mimicry is involved in the resemblance, however, is indicated by the habits of *Scaptia* sp. (Pl. i., fig. 97). Tabanids and blowflies each have very characteristic habits, and an experienced entomologist can readily distinguish one from the other, either by the sound it makes or its movements when flying. Each produces a different sound and, while tabanids exhibit a certain purposefulness in their manner of settling on an animal, settling as soon as an opportunity is presented, blowflies buzz round in an aimless fussy manner and appear to settle almost by accident. *Scaptia* sp. exhibits exactly this aimless manner of flight and the sound it produces closely resembles the note of a blowfly. Dr. I. M. Mackerras and I have been completely deceived by this insect. On one occasion a number of these tabanids buzzed round us for several minutes before we discovered the deception. It is possible that blowflies enjoy a certain immunity from attack by certain predaceous animals, as observations pointing to this have been made; so that under certain circumstances it might benefit an insect to be mistaken for a blowfly. Dr. Mackerras has suggested another possible explanation. Animals, particularly horses, exhibit great fear of tabanids, and will do all in their power to prevent these insects from settling on them, while blowflies, in small numbers, are practically ignored. The blowfly-like habits of *Scaptia* sp. may therefore make it easier for the insect to obtain a meal of blood, and so the resemblance to a blowfly would give a certain survival value to the insect possessing it.

Several excellent examples of mimetic insects have come under my notice, belonging to groups which do not contain other mimetic forms, as far as I am aware. It is not improbable that other mimetic forms belonging to the same groups may be found in the future, so that these would then be placed in one or other of the groups with which I have already dealt. For the present, however, it is convenient to deal with these as examples of the random occurrence of mimetic forms in non-mimetic groups.

One of the best of these is a bombyliid, the undescribed species of *Systropus* figured (Pl. ii., fig. 5) which exhibits a remarkable resemblance to the common *Sceliphron laetum* Sm. (Pl. ii., fig. 6). Mr. Burns, who captured the insect,

was struck by its remarkable resemblance to *S. laetum* when alive. A long narrow abdomen is characteristic of the genus *Systropus*, giving a suitable basis for the development of a mimetic resemblance to a sphecoid wasp. The perfection in detail of the mimetic pattern superimposed on this favourable normal basis, however, is little less than amazing. The colour markings of thorax, abdomen, legs and antennae are extremely similar to those of the model, and the abdomen, in addition to being long and slender, is dilated at the tip, as in the model, and the antennae are extremely long for a bombyliid.

The cyrtid fly, *Leucopsina odyneroides* Wwd. (Pl. i., fig. 14) is almost as perfect a mimic of *Odynerus* as *Cerioides breviscapa*. The bright yellow bands on a dark background and narrow constriction of the abdomen, together with the long antennae, dark costal borders of the wings and yellowish legs, make the resemblance almost complete.

One would not expect to find a wasp-mimic in a family of such delicate midge-like flies as the Mycetophilidae, yet one came under my notice under rather startling circumstances. I was collecting in thick brush country when I became annoyed by the persistent attentions of what I took to be a wasp. The insect kept buzzing round my head apparently with intent to sting when opportunity offered. To remove the menace I netted the insect and placed it in a killing bottle as the easiest manner of disposing of it. My astonishment in discovering that this "venomous" insect was a harmless mycetophilid may be imagined. This insect, *Platyura* sp. (Pl. iii., fig. 16), has a dull reddish brown colour with vague yellowish bands on the abdomen, exactly the colouration characteristic of the vespidae genus *Polistes* and related genera. The insect is surprisingly large and robust, and the body covering has an extremely hard and strong appearance for a mycetophilid. The shape, also, as will be seen from the illustration, is very similar to that of *Polistes*. A well marked waist is present, the body is robust and pointed at its posterior extremity, the antennae are prominent and thick, and the wings are strong and very shiny with a pale brown pigmentation. In this case the mimic appears to have departed considerably from the normal structure of the group to which it belongs.

Before dealing with mimetic insects belonging to other orders I must deal in a more comprehensive manner with certain structural developments which take a prominent part in the production of mimetic resemblance in many mimetic flies, though these developments have already been mentioned in connection with the descriptions of the different mimetic species.

One of the most extraordinary features of dipterous wasp-mimics is the common occurrence in such mimics of long antennae, comparable in length with those of their models, in spite of the fact that all these mimics figured and described belong to the Brachycera, with the solitary exception of, *Platyura* sp. One of the outstanding features of the Brachycera is that the antennae are normally very short, and they are usually so small that they are only evident on fairly careful examination. Conspicuously long antennae are exceptional in the extreme in this suborder, yet they appear to be the rule in the mimetic species. It will be seen from an examination of the illustrations that, if the asilids be omitted, practically all the brachycerous wasp-mimics have exceptionally long antennae. The species illustrated were selected entirely without any special reference to this particular character, and I believe that they form a perfectly representative series of mimetic Diptera. Another point of interest is that in those groups of Diptera in which long antennae are the rule, the longest antennae, with the closest resemblance to those of wasps, are developed in those species which show the greatest mimetic resemblance in other characters. This feature

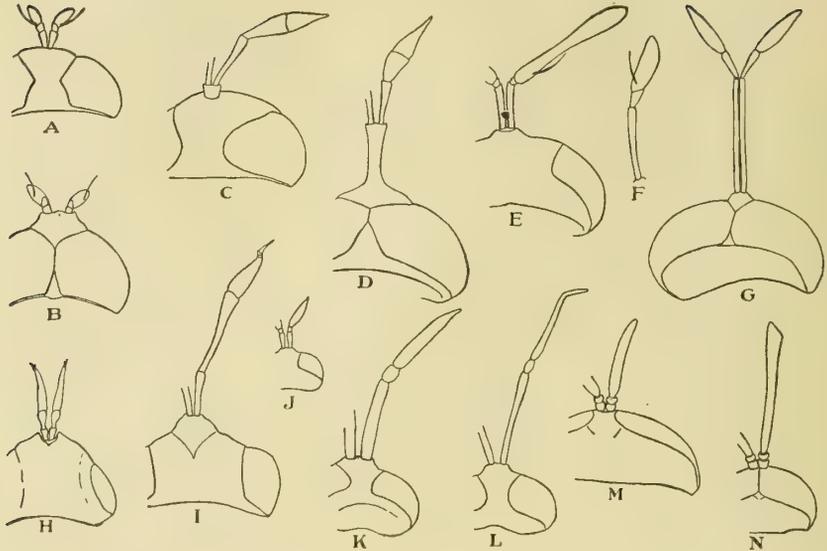
is often very marked, as, for example in the Stratiomyiidae, Therevidae, Conopidae and Syrphidae. It is scarcely credible that the close association of such an abnormal brachycerous character as long antennae with the mimetic species of many different groups of this suborder can be purely accidental, and it would appear probable that long antennae have definitely been produced in many species as a mimetic character.

Long antennae, however, are not entirely confined to wasp-mimics in the Brachycera. There are certain groups within this suborder in which there appears to be a definite tendency towards the production of abnormally long antennae, and it is noticeable that in these same groups there is also a tendency towards the production of mimetic resemblance. Another interesting fact is that though the non-mimetic species of such groups have long antennae, the greatest development of the antennae is to be found in those species which exhibit the most perfect resemblance in other characters, and, between these two extremes, there is often a number of species which show a more or less vague mimetic resemblance, in which the antennae are usually developed to an intermediate degree. It seems probable, therefore, that abnormally long antennae have taken an important part in the production of the primary fortuitous resemblance of many species to wasps, which has served as a basis on which the more perfect mimetic resemblance has later been developed by the action of natural selection. To account for the fact that the most perfectly mimetic species usually have by far the longest antennae it is necessary to consider that a further lengthening of the antennae has been produced by natural selection as a definitely mimetic character, and the colouration of the antennae in many such mimics appears to be almost certainly a mimetic adaptation. Another important point is that, though most brachycerous wasp-mimics have very long antennae, length is produced by different structural modifications in different mimics, sometimes even when these are quite closely related. A brief survey of the mimetic groups of brachycerous Diptera will illustrate the foregoing considerations.

In the Mydidae (Pl. ii., figs. 8 and 10, and Pl. vi., fig. 2) great length of antennae appears to be a normal characteristic of the family, but it is noticeable that the antennae of the more perfectly mimetic species are longer than those of the non-mimetic or slightly mimetic species. In some groups of the Cyrtidae long antennae also appear to be normal and in the very perfectly mimetic *Leucopsina odyneroides* (Text-fig. 1.N., and Pl. i., fig. 14), though the antennae are very long they are equalled in length by those of some species of *Panops*. It should be noticed, however, that the species of *Panops*, such as *P. flavipes*, which have the longest antennae also show some indications of being mimetic. In both the foregoing families the elongation of the antennae is due almost entirely to the great length of the fused series of segments which follow after the second segment. Though the portion of the antennae which follows after the second segment consists actually of a number of more or less fused segments in the Brachycera it will be convenient for present purposes to refer to the whole of this as the "terminal segment," for the fusion between the constituent segments is often so great that it is practically impossible to determine their limits.

The long antennae of the mimetic Therevidae, such as *Agapophytus australasiae* (Text-fig. 1.L., and Pl. i., fig. 45) and *Phycus* sp. (Text-fig. 1.K., and Pl. i., fig. 39) have very long first and terminal segments, which is also characteristic of the related non-mimetic species, though in these the antennae are much shorter (Text-fig. 1.J.).

Long antennae are also characteristic of the subfamily Hermetiinae of the Stratiomyiidae, practically the whole of the elongation being due to the great



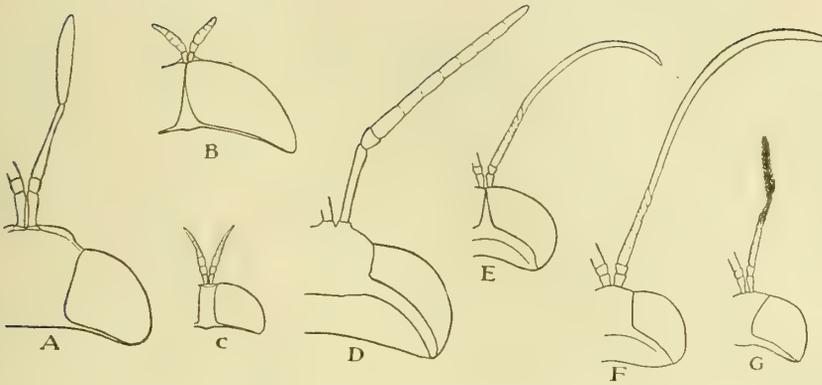
Text-fig. 1. Antennae of Mimetic and related Diptera (x8).

A., B., H. J. and M. non-mimetic, remainder mimetic.

A. *Microdon vittatus* Macq., B. *Syrphus* sp., C. *Cerioides breviscapa* Saund., D. *Cerioides variabilis* Ferg., E. *Microdon variegatus* Walk., F. *Microdon waterhousei* Ferg., G. *Systropus* sp., H. *Conops* sp., I. *Conops* sp., J. *Phycus* sp., K. *Phycus* sp., L. *Agapophytus australasiae* Guer., M. *Panops baudini* Lam., N. *Leucopsina odyneroides* Westw.

A.-F., Syrphidae, G., Bombyliidae, H. and I., Conopidae, J.-L., Therevidae, M. and N., Cyrtidae. (F., after Ferguson).

development of the terminal segment, the constituent segments of which are of very irregular lengths. By far the longest antennae occur in the highly mimetic species such as the remarkable species of *Elissoma* shown in Pl. ii., fig. 18, and Text-fig. 2.F., and *Elissoma lauta* (Text-fig. 2.E.). They are also very long in *Massicyta picta* (Text-fig. 2.G., and Pl. i., fig. 28) and in this species an appearance of thickness is given by the development of a dense pubescence over the terminal portion of the antennae. There is a large number of related species which also have long antennae, built on the same general plan, but most of these appear to be as yet undescribed. Most of these show mimetic resemblance to a greater or less extent, but a knowledge of the habits of the living insects would be necessary in order to decide whether the resemblance is really well developed. The introduced *Hermetia illucens* F. also has long antennae, though they are not relatively as long as in the other species mentioned. A specimen of *H. illucens* does not show any signs of mimetic resemblance, but I have noticed that some of its habits are distinctly wasp-like. It is possible that this species represents



Text-fig. 2. Antennae of Mimetic and other Stratiomyiidae (x8).

B. non-mimetic, A. and C. possibly mimetic in habit, remainder mimetic.

A. *Hermetia illucens* F., B. *Odontomyia decipiens* Guer., C. *Neoxairata spinigera* Wied., D. *Syndipnomyia* sp., E. *Elissoma lauta* White, F. *Elissoma* sp., G. *Massicyta picta* Brauer.

the normal type of this group and its slight resemblance to a wasp would permit of the commencement of the operation of natural selection in the production of mimetic resemblance. *Syndipnomyia* sp. (Text-fig. 2.D., and Pl. i., fig. 7) belongs to a widely separated subfamily, the Clitellarinae, and in this species the first, as well as the terminal, segment is very elongate, and the constituent segments of the terminal segment are uniform and of almost equal length. As far as I am aware, all other types of stratiomyiids have short normal brachycerous antennae (Text-figs. 2.B. and C.).

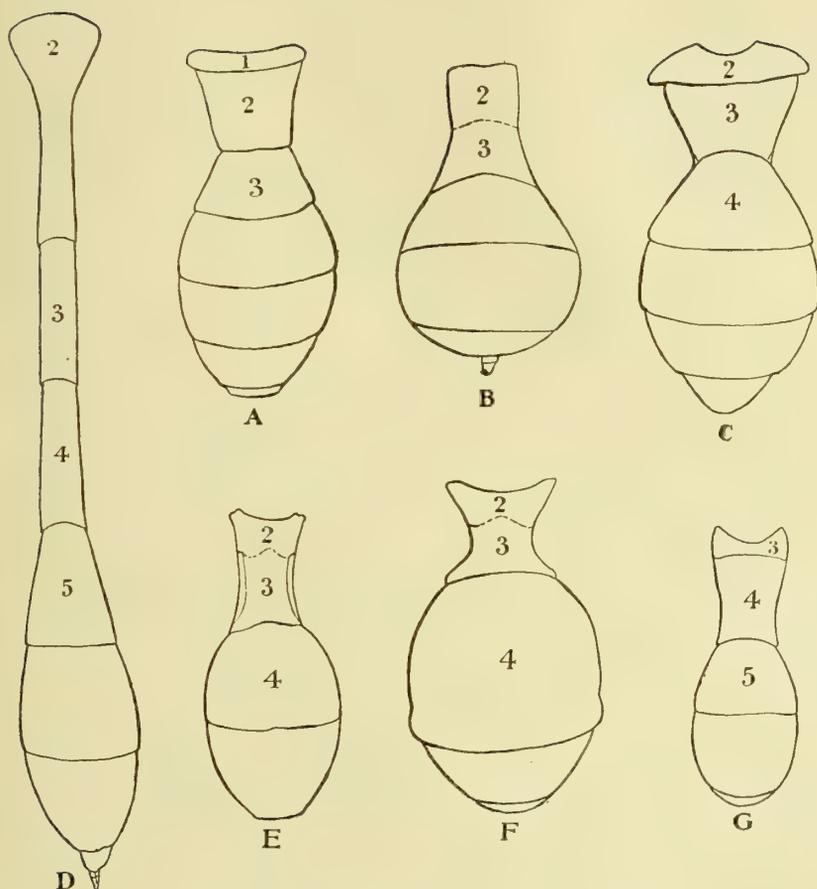
The species of *Systropus* shown in Pl. ii., fig. 5, and Text-fig. 1.G. has conspicuously long antennae, consisting of a very long first segment and moderately long second and terminal segments. This is the only truly mimetic bombyliid I know, and it is also the only bombyliid I know which has very long antennae.

In the Syrphidae long antennae are also found closely associated with those species in which mimetic resemblance is most highly developed. Most, if not all, the species of the Cerioidinae show definite mimetic resemblance and long antennae are the rule in this subfamily. In most species the antennae are borne on the end of a long frontal prominence, which gives the appearance of great length to the antennae which are otherwise quite long (Text-fig. 1.D., and Pl. i., figs. 15, 18 and 32). The length of the antennae of *Cerioides breviscapa* (Text-fig. 1.C., Pl. i., fig. 13) is due to the elongation of the first, second and terminal segments, the frontal process being very short in this species. In the Microdoninae the antennae are very variable structures and are often quite large, even in non-mimetic species, but the longest antennae occur in the two mimetic species. In *Microdon variegatus* (Text-fig. 1.E., Pl. i., figs. 20 and 26, and Pl. iv.) the terminal segment is extremely long, though the first segment is also rather long; while in *M. waterhousei* (Text-fig. 1.F.) the first segment is longest, though the second and terminal segments are also long. In the other subfamilies, such as the Syrphinae and Eristalinae, which do not contain definite wasp-mimics, the antennae are of the normal short type characteristic of the Brachycera.

Most of the Australian Conopidae appear to be more or less mimetic, but it is noticeable that in those species which exhibit mimetic resemblance most clearly the antennae are longest. In the few species which do not appear to be in any way mimetic the antennae are comparatively short, though still rather long for brachycerous insects, the elongation being due principally to the long terminal segment (Text-fig. 1.H.). In the mimetic species this segment is still longer, but the first and second segments are also very long (Text-fig. 1.L., and Pl. i., figs. 9, 19, 29, 30 and 31).

Of almost equal significance to the common occurrence of long antennae in brachycerous wasp-mimics is the almost invariable presence of black anterior borders on the wings of dipterous mimics of diplopterous wasps. It is very suggestive that this particular type of dark anterior border of the wing not only does not seem to occur amongst non-mimetic diptera, but is only found in those mimetic species which resemble diplopterous wasps. It is characteristic of diplopterous wasps, eumenids and vespids, that they fold the wings longitudinally when they are at rest. These folded wings look like narrow dark bars along the sides of the body, and the dark anterior borders of the wings of mimetic diptera have a considerable resemblance to the folded wings of their models when the wings are lying over the body in the position of rest. Such dark anterior borders of the wings occur in mimics of eumenid and vespid models belonging to the families Syrphidae, Asilidae, Stratiomyidae, Conopidae and Tachinidae of the Diptera and in the Cerambycidae of the Coleoptera; this feature in the last family being exhibited by some of the mimetic species of *Hesthesis* (see Pl. i.). There are many non-mimetic species of diptera which have dark anterior borders to the wings, this being particularly noticeable in the Bombyliidae, but these borders do not give the impression of narrow bar-like structures when the wings are placed over the back. In such insects the posterior margin of the dark anterior border is usually either very irregular or gradually shades into the posterior part of the wing.

Another common feature of dipterous wasp-mimics is the possession of a distinct waist to the abdomen just behind the thorax. This is almost a constant feature of wasps, but is extremely rare in non-mimetic Diptera. A well-marked waist occurs in many of the mimetic species belonging to the families Mycetophilidae, Asilidae, Stratiomyidae, Cyrtidae, Bombyliidae, Syrphidae and Conopidae, while in the Mydidae and Tachinidae and in the beetles *Hesthesis* and *Macrones* a waist is present, but less distinct. In the formation of such a waist it is necessary that the basal segments of the abdomen should be constricted, but it is interesting to note that in spite of this limitation there is some variation in the morphological position of the waist in different species. There is a tendency for the dorsal portion of the basal segments of the abdomen to disappear in the Diptera. Though the tergite of the first segment is developed in the Asilidae, it is lacking in most of the other families of the Brachycera, while in some of the Cyclorrhapha the tergite of the second segment also disappears. In *Brachyrhopala fenestrata* (Asilidae, Text-fig. 3.A., and Pl. i., fig. 24) the first segment is very short and the main constriction is between the second and third segments. In *Massicyta picta* (Stratiomyidae, Text-fig. 3.B., and Pl. i., fig. 28) the main constriction is between the thorax and the second segment, the second and third segments taking part in the formation of a waist. In *Leucopsina odyneroides* (Cyrtidae, Text-fig. 5.C., and Pl. i., fig. 14) the second segment is very short and the main constriction is between the third and fourth segments. The very long waist of *Systropus* sp. (Bombyliidae, Text-fig. 3.D., and Pl. ii., fig. 5) consists principally of the long narrow second, third and fourth seg-

Text-fig. 3. Abdomens of Mimetic Diptera ($\times 8$).

A. *Brachyrhopala fenestrata* Macq. (Asilidae), B. *Massicyta picta* Brauer. (Stratiomyiidae), C. *Leucopsina odyneroides* Westw. (Cyrtidae), D. *Systropus* sp. (Bombyliidae), E. *Microdon variegatus* Walk. (Syrphidae), F. *Cerioides breviscapa* Saund. (Syrphidae), G. (Tachinidae).

ments. In *Microdon variegatus* (Syrphidae, Text-fig. 3.E., Pl. i., figs. 20 and 26, and Pl. iv.) and *Cerioides breviscapa* (Syrphidae, Text-fig. 3.F., and Pl. i., fig. 13) the main constriction is between the second and third segments, and these two segments are narrow. In the wasp-like tachinid figured (Text-fig. 3.G., and Pl. i., fig. 55) the first apparent segment is probably the third mor-

phological segment, and the main constriction is between segments four and five, segment four being narrow. It appears evident, therefore, that the narrow waists of these mimetic insects must have been produced on account of their appearance, for there is little in common between them structurally.

I will now pass on to consider some other more or less isolated examples of mimetic resemblance.

One would not be impressed with the resemblance between *Trogoëdron fasciculatum* Schreib. (Cleridae, Pl. ii., fig. 20) and *Pseudagenia consociata* Turn. (Psammocharidae, Pl. ii., fig. 19) from an examination of the illustrations of these species; yet, under natural conditions, the resemblance is closer than that exhibited by a number of other mimetic insects which appear to be more perfectly mimetic according to the photographs. Large black psammocharids with conspicuous bright yellow antennae, such as *P. consociata*, are very common. They are usually to be seen on the ground or tree-trunks, and their most conspicuous characteristics are rapid movements and a rapid vibration of the antennae. *T. fasciculatum* mimics these habits to perfection. This clerid arrives within the field of vision with almost the velocity of a bullet, gives an impression of commotion when settling and proceeds to move about with rapid, jerky hunting movements, waving its conspicuous bright yellow antennae in exactly the same manner as its model. It will be observed that the resemblance in this case is almost wholly due to mimetic habits, assisted by the conspicuous bright yellow antennae. The general colouration is similar to that of *P. consociata*, but there is little in common between the forms of the two insects. This, however, does not attract attention under natural conditions, the background usually being dark coloured.

In illustrating the *Metriorrhynchus* mimetic group I have included several moths belonging to the genus *Snellenia* (Heliodinidae, Pl. i., figs. 69-72), which I did not mention when dealing with the group. The resemblance to small species of *Metriorrhynchus* is very close. The fore wings are red, though this may be obscured by black on the central area, as in the model. The rest of the insect, including the antennae, is black. An appearance similar to that of the longitudinal ridging of the elytra of the model is produced by darker scales between the main longitudinal veins. The fact that both the pure red and the black and red form of wing colouration may appear in different individuals of the same species indicates that the factors underlying the colouration in mimic and model are similar. The colour in the mimic is borne by scales and in the model by the chitinous covering of the elytra, and the two forms are so distantly related that the factor cannot be considered to be the same in each case nor to have been derived from some common ancestor. The system of colouration is so simple, however, and the colours used of such common occurrence in the Insecta that it is not difficult to believe that similar factors might easily appear in these two very different types of insects which would express themselves in a similar distribution of the same colours.

I have only seen *Snellenia* in its natural environment on two occasions and on each of these it was observed in company with *Metriorrhynchus*. One specimen was seen on the flowers of *Leptospermum*, a very common situation for *Metriorrhynchus*, and others were taken flying in the deep shade of subtropical brush. In the latter situation a small species of *Metriorrhynchus* was very common, and the only hope of securing specimens of *Snellenia* was to capture every specimen of *Metriorrhynchus* seen, and once in a while it would happen that the supposed lampyrid would turn out to be *Snellenia*.

A common form of colouration found in many Australian ants belonging

not only to different genera but to different subfamilies, is a black ground colour and brilliant golden pubescence on the abdomen. A good example of this is *Dolichoderus doriae* Em. (Pl. iii., fig. 12). Such ants are commonly to be found on tree trunks, and in association with them are found the lygaeid bug *Daerlac tricolor* Sign. (Pl. iii., figs. 11 and 13) and a black spider with golden pubescence on the abdomen. Both the bug and spider resemble the ants in colouration and also in manner of movement. A remarkable phenomenon is the fact that *D. tricolor* resembles the same model in both the larval and adult state, but the resemblance is produced in different ways in the two stages. In the larval bug (Pl. iii., fig. 13) the end of the abdomen is yellowish and convex, closely resembling the golden abdomen of the ant, and the rest of the body is black with brown markings, so arranged that the impression of a waist is conveyed when the insect is on a dark background. The adult, on the other hand, has an oval yellowish mark on the distal end of the hemelytra, shaded in such a manner with darker pigment that this flat area of the hemelytra appears convex and thus closely resembles the abdomen of its model (Pl. iii., fig. 11). As in the larva, the black and brown colouration of the rest of the body is so arranged as to convey the impression of a waist. The photographs do not do justice to this example of mimetic resemblance. It is necessary to place the insects on a dark background in order to appreciate the resemblance fully. Also, the abdomen of the soft-bodied larval specimen has collapsed considerably in drying, so obscuring the characteristic convexity of the end of the abdomen.

The remarkable resemblance to an ant of the larval coreid, *Riptortus* sp., shown in Pl. vii., fig. 2, needs little description, as it is well demonstrated by the photograph. In this case the shape of an ant is mimicked by the actual shape of the larval bug, and not by a special development of its colouration. The larva photographed appears to be in its first or second instar, and at this stage is the same size and colour, pale brown, as a common ant which was found on the same plant. The older and larger larvae are less ant-like, though the resemblance is considerable, and the adult (Pl. vii., fig. 1) does not resemble an ant in any way. It is much too large for such a resemblance to be of any conceivable use.

The mirid bug, *Eucercoris* sp. (Pl. iii., fig. 15) was taken flying in company with the braconid wasp figured (Pl. iii., fig. 14), the two insects being indistinguishable on the wing. It will be noticed that the antennae are exceptionally long and that in form and size *Eucercoris* closely corresponds to the braconid, the ample membranous wings being an unusual feature for a mirid. The resemblance in colour is even more striking. The prothorax is bright red, the head and rest of the body being black, except for the narrow white posterior borders of the abdominal segments, a type of colouration characteristic of many of our common braconids. The wings, as well as being ample and membranous, are of a semi-transparent blackish colour, just as are the wings of the braconid. In the Australian Museum there are several closely related species, each of which is unmistakably similar to some common form of braconid. One, for example, differs from the species figured in that the whole of the thorax is of a reddish brown colour, while in another there is a large pink area on the latero-basal regions of the abdomen, both these forms of colouration being noticeable characteristics of many common species of braconids.

What appears to be a very different type of deceptive resemblance from all those I have already described is exhibited by the lycaenid butterfly *Ialmenus evagoras* Don. (Pl. xiv., fig. 2). It will be observed that there is a concentration of the darker colour markings at the posterior extremity of the hind wings and that linear markings radiate from this point over the rest of the wings. Poulton

has put forward the theory that lycaenids which exhibit this type of colouration are definitely mimetic, the butterflies, as it were, mimicking themselves, backwards. The significance of this colouration, he claims, is that when a bird attempts to catch a butterfly it normally attacks the region of the head and thorax and is deceived by the colouration of such "double-ended" butterflies as *I. evagoras* and attacks the posterior end of the hind wings in mistake for the thorax. The result is that the bird simply cuts a small piece out of the hind wings and the butterfly is able to escape, but little inconvenienced by its injury. This theory has been received with considerable scepticism by many entomologists and does not appear to me to be by any means proved. On the other hand, the few observations I have been able to make certainly support the theory. On the one occasion on which I had the opportunity of studying this insect under natural conditions I caught all the butterflies I could in the few minutes at my disposal. I found that most of the older specimens of these had the posterior end of the hind wings considerably damaged, and in many of the specimens the damage appeared to have been caused by something having bitten a piece out of the hind wings. I am not convinced, however, that this would not also be found to be the case in normal butterflies, for if they are attacked when on the wing the attack would almost certainly be commonly from the rear. An examination of the plates illustrating injuries to the wings of South African butterflies given in Marshall's classical work* will show that most of the injuries are to the posterior border of the hind wings, whether the butterfly is "double-ended" or not. It is evident that this matter can only be settled by the careful observation of the manner in which *I. evagoras* and similar butterflies are attacked, and what difference, if any, there is in the nature of the attack on these "double-ended" butterflies and on related butterflies with a normal colour pattern.

The photograph (Pl. xiv., fig. 2) is of a freshly emerged butterfly, and it will be noticed that the butterfly is resting with its head pointing obliquely downwards, which is the reverse of the normal resting attitude of a butterfly. I observed a considerable number of freshly emerged specimens and they were all resting in this attitude, though the older, somewhat abraded, individuals appeared to settle indifferently with the head uppermost or pointing downwards. As the freshly emerged individuals are incapable of strong flight it is possible that this attitude takes a definite part in the mimetic resemblance of this insect.

Summary of evidence for the existence of Mimetic Resemblance and the necessity for the operation of Natural Selection.

In connection with the various types of mimetic resemblance I have described and the numerous examples I have given I have already brought forward a considerable body of evidence to show that mimetic resemblance, that is, resemblance produced as a response to the appearance of the object resembled, certainly does occur amongst insects. I have also shown that natural selection appears to be absolutely essential in order to produce, or at least preserve, mimetic resemblance and that natural selection may operate on any kind of heritable variation, whether small or large. Its operation is by no means confined to the selection of small individual variations, as some writers on the subject of mimicry appear to have assumed. Before giving a detailed account of my views on the question of the

* "Five Years' Observations and Experiments (1896-1901) on the Bionomics of South African Insects, chiefly directed to the Investigation of Mimicry and Warning Colours," by Guy A. K. Marshall.

evolution of mimetic resemblance it will be convenient first to summarise the evidence for the fact of mimetic resemblance and the necessity for natural selection to take part in its production and preservation. It will be necessary to deal separately with cryptic and deceptive resemblance, and I feel that a presentation of the evidence in tabular form will be the most satisfactory way to deal with the subject.

(a) *Cryptic Resemblance.*

1. There is an almost infinite variety of possible backgrounds for insects and of colouration, form and habit amongst insects. If, therefore, cryptic resemblance is simply a fortuitous combination of suitable colouration, form or habit with a suitable background the phenomenon should be extremely rare. Actually it is very common, so that there is little possibility that cryptic resemblance can be fortuitous.

2. The fact that cryptic resemblance in an insect is frequently due to a combination of several very distinct types of factors, such as colouration, form and habit, makes fortuitous resemblance improbable in the extreme.

3. The structural basis underlying resemblance is very different in different insects, i.e., the same end has been attained by several different means. This strongly suggests that resemblance is the actual end-product of some process which is subservient to the production of resemblance, and that it cannot be simply an attribute of some factor common to each insect exhibiting it.

4. Closely related insects in the same oecological environment have different colour patterns, but each of these makes the insect bearing it inconspicuous on its normal background. A similar colouration is therefore not produced in similar insects by the action of the same general environmental conditions. As, however, the type of resemblance produced has in each case a definite relationship to the normal environment of the insect possessing it, it appears necessary that some factor in the environment should be responsible for the production and preservation of this resemblance. The only difference in the environment of such insects is in the appearance of the background on which each is normally found. It is necessary, therefore, that the environmental factor responsible for the production of mimetic resemblance should be one capable of discrimination on account of appearance. Other animals, the natural enemies of cryptic insects, or their prey, in the case of predaceous forms, form the only conceivable discriminating factor of this nature. Only such of these as hunt by sight and attack the stage of the insect exhibiting cryptic resemblance can take any part in the production and preservation of cryptic resemblance.

5. There is every reason to suppose that the natural enemies of insects would overlook a cryptically coloured insect more frequently than a more conspicuous form, and experiments show that this is so. This is all that is necessary to cause the preservation of cryptic characters when they appear. This gives a satisfactory general explanation of the evolution of cryptic resemblance, though it does not account for the production of the original variation or series of variations involved. The latter point, however, is no objection to the theory that natural selection has been involved in the production of cryptic resemblance. In no case do we fully understand what causes the production of a variation, but, in spite of this, natural selection is generally considered to be at least one of the most potent factors in evolution in general.

6. The existence of such an adequate mechanism for the production of cryptic resemblance gives added support to the theory that cryptic resemblance is adaptive and not fortuitous.

7. To summarise. There is little possibility that cryptic resemblance can be fortuitous; it has a definite relationship to the environment of the possessor but cannot be the result of any general environmental influence; the only type of environmental factor which could operate in the production and preservation of cryptic resemblance is one capable of being affected by appearance; the only conceivable factor of this nature is that afforded by other animals, either the natural enemies or prey of the cryptic insects; there is every reason to believe that the behaviour of such enemies or prey would be modified in connection with cryptically coloured insects to the advantage of the latter, and this advantage would cause cryptic insects to have a survival value compared with other insects.

(b) *Deceptive Resemblance.*

1. The same appearance is produced in different ways by the mimics of a single model, sometimes even when the mimics are closely related. It is evident, therefore, that structural similarity is not necessary and that in a large percentage of cases similarity between mimic and model exists in appearance alone.

2. The curiously wasp-like habits and attitudes of many dipterous, coleopterous and hemipterous wasp-mimics can be of no conceivable use to the possessors unless it be on account of their resemblance to the habits and attitudes of wasps.

3. Certain apparently mimetic adaptations occur only in species which would be considered mimetic on account of other characters. The wasp-like habits, already mentioned, of many mimics of wasps do not occur in non-mimetic relatives of the mimics. Very long antennae are common in brachycerous flies which mimic wasps, the elongation of the antennae being produced in different manners, sometimes even in closely related species. This suggests that the antennae do not simply happen to be long but that length has definitely been produced as such, presumably in connection with the other mimetic characters of the insect. Antennae which even approach the length of those common amongst dipterous wasp-mimics are excessively rare amongst non-mimetic flies, and in the two or three such cases which have come under my notice there is reason to believe that when alive the insect may bear a resemblance to a wasp, the resemblance being due principally to habit and attitude. Most fly mimics of dipterous wasps have a dark anterior border to the wing, which, when the insect is at rest, look very much like the folded wings of their models. Not only are darkened anterior borders of this particular type not found amongst non-mimetic flies, but also they are not found in mimics of other types of Hymenoptera. Many different kinds of dipterous wasp-mimics have a narrow waist, always in the same apparent position as in the model but often in different morphological positions in mimic and model and even in different mimics. Mimetic adaptation appears to be the only possible explanation of these facts.

4. In most cases of resemblance between insects, and probably in all those in which the resemblance is truly mimetic, mimic and model occur in exactly the same environment at the same time. If the resemblance were fortuitous there should be no such correlation.

5. Deceptive resemblance is a comparatively rare phenomenon amongst insects, but of the few insects exhibiting it a very large proportion consists of insects each of which shows resemblance to a single model in two or more, and often in very many, independent characters. If resemblance were fortuitous, resemblance in more than one character should be excessively rare, and slightly complex resemblances due to two or three characters should form a very small proportion of the total number of cases of resemblance.

6. If resemblance were due to the operation of the same general environmental factor on mimic and model, it should operate in the same manner on related forms existing in the same environment, this being more probable than its operation in the same manner on two widely distinct forms such as a mimic and its model. Actually we find that in many cases closely related mimics resemble a series of unrelated models which differ from one another greatly in appearance, and which have only one factor in common, namely, that they are all found in the same environment. Therefore the only factor in common between such closely related mimics, other than their common environment, is resemblance to insects, of many types, which are found in the same environment. Mimics resemble their models in appearance alone, and not in structure. Therefore the only kind of environmental factor which could affect the various mimics in such a manner as to produce or preserve their respective resemblances is a factor the operation of which is in some way influenced by the appearance of other insects which exist in the same environment.

7. Deceptive resemblance, then, is not fortuitous, it is not necessarily due to any structural similarity, nor can it have been produced as the direct result of some general environmental influence, and it is evident that it has been produced in some manner as a response to the appearance of a model. The original variation, or variations, which produced the resemblance to another insect must have been due to internal factors in the first place, and the presence of a suitable model could not have influenced in any way either the production or nature of such a variation. It is evident, therefore, that suitable variations must occur amongst insects quite independently of the presence or absence of an appropriate model. As, however, mimic and model are always found together, it is evident that such variations are only preserved in the presence of a suitable model, that is, the variations only have a survival value when the appearance they produce is similar to that of a suitable model which occurs in the same situation as the mimic. The production of suitable variations, therefore, is independent of the presence of an appropriate model, but the preservation of such variations is wholly dependent on this.

8. If, as has been shown to be the case, the preservation of a variation is dependent on the similarity in appearance it produces to that of a suitable model, it is evident that the new variation must have a special survival value compared with that of the old form of the species producing it, and that this special survival value must have been conferred upon it in some manner by the presence and appearance of the model. If a suitable variation, even a complete mimetic resemblance, appears, it must have a special survival value to displace the old form of the species or to produce a new species, for the normal factors which cause the numbers of a species to remain approximately constant in relation to its normal environment would cause an individual exhibiting such a variation to have, on the average, only two descendants in each generation which might carry the factor for the variation, if the variation gave no special survival value to the possessors. The normal variation from this average from year to year would almost certainly cause the complete elimination of such small numbers sooner or later. A mimetic variation, therefore, in order to displace the original form of the species, must have a special survival value due to its similarity in appearance to that of the model, that is, natural selection must operate in its favour.

9. If natural selection is to operate in favour of the new variation on account of its similarity in appearance to that of the model, it is evident that the active agent of natural selection must be one capable of seeing, of discriminating between the appearance of the new variation and the old form of the species; its

operation must in some way be determined by the appearance of both mimic and model; and the appearance of a mimetic variation must cause it to operate less severely on the possessors than on the old form of the species. Other animals which directly affect both mimic and model form the only conceivable active agent of this nature.

10. With minor exceptions, which do not appear to have any connection with the subject under discussion, the significance of other animals to an insect can only be of two types:

- A. They eat the insect.
- B. They are eaten by the insect.

As few mimetic insects are predaceous and the deceptive resemblance of these can seldom be of any conceivable use in enabling the possessor to obtain its prey more successfully, the active agents of natural selection in mimetic insects would appear to consist almost wholly of the natural enemies of the insects.

11. If deceptive resemblance is to be of any advantage to the insect, that is, if the variations producing it have a survival value, it must:

- A. Protect the insect from its enemies; or
- B. Enable the insect to obtain its prey more effectively.

12. It follows from 8 and 11 that mimetic patterns must have been preserved by the appearance of variations deceiving other animals, on account of their similarity to suitable models, causing these to overlook or reject the mimetic forms more frequently than their non-mimetic parent forms, giving them:

- A. Comparative freedom from attack; or
- B. An advantage in catching their prey.

13. It is evident, then, that the models must enjoy a comparative freedom from attack by certain discriminating natural enemies and that this advantage is shared by other insects of similar appearance. If predaceous animals discriminate between suitable and unsuitable food on appearance, the appearance to cause rejection must be associated with the memory of some unsuitability as food of the insect exhibiting it, probably distastefulness. Young birds, for example, will eat anything which moves; discrimination comes later, after experience.

14. Mimics do not resemble any kind of insect but only models belonging to a few well defined groups, which either have known or strongly suspected distasteful characteristics. Widely distinct types of mimic resemble the same model, which, in itself, indicates that the latter must enjoy special advantages, not shared by other insects. It is reasonable, therefore, to believe that the advantage enjoyed by a model is due to a recognition of its distasteful nature by its enemies, recognition being made easy by its conspicuous colouration. As a mimetic form evidently has a special survival value due to its similarity in appearance to its model there can be but little doubt that it shares the advantage conferred on the model by its distasteful nature. The natural enemies, discriminating between suitable and unsuitable food on appearance, mistake the mimic for its distasteful model.

15. Direct experiments designed to show whether distasteful insects are rejected by predators on account of their appearance have been somewhat inconclusive, probably largely on account of the special difficulties of such experiments, but they strongly indicate that this is at least sometimes the case. It is desirable that many more such experiments should be carried out.

16. To summarise. The evidence strongly indicates that natural selection is essential to the preservation of deceptive resemblance; that the active agents of natural selection must be natural enemies of both model and mimic which are capable of discrimination; that the models are regarded as unsuitable food by

such natural enemies and are probably distasteful; and that the special survival value evidently possessed by the mimics is due to the fact that they are confused with their models, owing to their similarity in appearance.

The Nature of Variations selected in the production of Mimetic Resemblance.

As it is necessary that natural selection should have operated in order to preserve mimetic resemblance, the question arises as to what is the nature of the variations on which natural selection has operated. It has already been pointed out that the variations must have arisen in the first place quite independently of their possible use and that only those which gave a special survival value to their possessors could have survived. It is evident, then, that a variation can only be considered to be mimetic after it has commenced to be selected on account of its appearance. The factors governing the first appearance and nature of a particular variation evidently have no direct connection with mimetic resemblance.

All that is necessary in order that natural selection may operate is that a heritable variation should appear causing the insect to resemble some object or organism sufficiently well to enable the possessor to avoid attack by its natural enemies a little more frequently than it would if it did not possess the variation. So long as the variation confers this comparative immunity from attack on the possessor it is immaterial whether the variation is large or small, or quantitative or qualitative. It is well known that animals are capable of producing several different types of heritable variations, and it is unreasonable to suppose that in the production of mimetic resemblance natural selection can only have operated on a single type. Much of the criticism directed against the theory of mimicry has been due to the mistaken insistence of certain of its exponents on the supreme importance of the natural selection of small individual variations in the production of mimetic resemblance.

Two main types of variation are commonly recognised, mutations and individual variations. The conception of the nature of mutations has been modified considerably within the last few years. Previously it was considered that the outstanding characteristic of a mutation was that it was a very large inheritable variation. It was considered to be essentially different from individual variations. Further work, however, showed that size is no criterion of a mutation, for every gradation in size was found from the largest mutations to small mutations indistinguishable from individual variations. Mutationists therefore defined a mutation as any variation which can be inherited, and decided to use the term individual variation only for such small variations as cannot be inherited. In this manner they settled, in their own favour, by the expert manipulation of terminology, the rather sterile controversy as to whether evolution was due to the preservation of mutations or small variations. Actually this definition of a mutation is in every way satisfactory and, indeed, appears to be the only possible one, but it must not be permitted to blind us to the fact that there is a difference in name only between the small mutations we speak of to-day and the individual variations considered by the earlier workers, such as Darwin, to be of paramount importance in evolution. It is scarcely necessary to point out that Darwin and his followers did not consider that small non-heritable variations took any part in evolution.

Having defined what is now meant by "mutation" I shall use this term in subsequent discussions for any type of heritable variation. Previously I have purposely used the more ambiguous term "variation" in order to avoid misunderstanding; for, in spite of the modern views as to what constitutes mutation, there

are still many who are under the impression that a mutation must necessarily be a very large variation. It has been my object to show that any kind of heritable variation, whether large or small, may be selected in the production of mimetic resemblance.

Amongst the numerous forms of mimetic insects, therefore, one would expect that mutations of all degrees of magnitude should have occurred and formed the material on which natural selection could work. One would expect that in some cases the mimetic resemblance should have appeared complete as a single mutation, that in others it was built up by the selection of a series of small or moderate sized mutations and there is no reason why some should not have been built up by the selection of both large and small mutations.

I have already put forward a considerable body of evidence indicating the nature of mutations which must have been selected in order to produce particular cases of mimetic resemblance. It will now be convenient to summarise this.

In the case of many mimetic butterflies it is evident, as Punnett has shown, that the mimetic pattern must have appeared at first as a single large mutation, or in some cases, as two or three large mutations, no doubt separately selected. This is most clearly demonstrated by the results of breeding experiments carried out on butterflies with polymorphic mimetic females, such as *Papilio polytes* and *P. dardanus*. It is found that the complete colour patterns of the various forms of female are inherited as a whole and behave as Mendelian characters. If the mimetic pattern of each form of female had been built up gradually by the accumulation of a series of small variations, each of these variations ought to be inherited separately and the result of a cross should be that any combination of the numerous small characters, of which each mimetic pattern is built up, should be possible. Instead of each pattern being inherited as a whole there should be every intergrade between the two patterns and the unmodified pattern of either parent form should be of the rarest occurrence. There can be very little doubt, therefore, that in such cases the mimetic pattern must have arisen as a single mutation, complete from the time of its first appearance.

In the var. *romulus* of *P. polytes* it has been shown that two factors are necessary in order that it may appear. One of these is the factor necessary for the production of the other mimetic form, var. *polytes*, while the other is a special factor. The latter only influences the colour pattern of the possessor when it is in combination with the factor for var. *polytes*. It appears necessary to consider, therefore, that var. *romulus* appeared as a single mutation from var. *polytes*, two separate mutations being necessary to produce it from the ancestral form of the species, presumably the male-like var. *cyrus*.

It commonly happens amongst mimetic butterflies that a closely related series of mimics resemble a series of models which are also closely related, though the individual mimics or models may differ considerably in appearance from one another. This suggests that similar potencies for variation exist in the two groups to which the mimics and models belong respectively, for otherwise the mimics would be expected to resemble any kind of suitable model, quite without reference to its relationship to the models of related mimics. When one considers that in structure all butterflies are very similar and that differences of complex colour patterns may have a very simple genetical basis, as has been shown to be the case in butterflies with polymorphic females, it seems at least probable that similar potencies for variation should occur sometimes in two somewhat widely separated groups, these potencies acting on a similar structure to produce a similar effect. It is necessary that the potencies should be linked together in some manner in order that the same series of colour patterns should occur in the two groups,

otherwise similar colour patterns would be expected to occur scattered at random throughout the butterflies. That some such linkage does occur is indicated by the behaviour of the factors for the various forms of female in *Papilio polytes*. The factor for var. *polytes* together with that for var. *cyrus* determines the colouration of var. *polytes*, and the factor for var. *romulus* together with the other two determines the colouration of var. *romulus*, and is ineffective if this combination does not exist. It seems improbable that the relationship between the various colour patterns existing within a single group of mimics or models should always be of this type, but it is far from improbable that a certain basic similarity should exist between the genetical constitutions of the two groups to which the mimics and models belong respectively, relationship being fairly close and structure almost identical. Given such a basic genetical similarity one would expect that sometimes the same type of genetical variation might occur independently in the two groups, which would be expressed in the adult insects by the appearance of similar types of colouration. It is important to realise that a simple genetical variation may be expressed by a complex modification of somatic characters. The appearance of a complex colour pattern may be determined by a particular factor, but this factor is by no means the only one which takes part in the formation of the pattern. Its function is to modify already existing characters, not to completely displace them. A simile may help to make this point clearer. If a multicoloured picture be examined in a blue light it will have a special appearance which is determined by the blue light. Some parts will remain clear while others are obscured, so that a simple factor, the blue light, produces a complex modification in appearance. The appearance, however, is not wholly due to the blue light, the picture itself is equally essential, and it is a complexity existing in this which determines the apparently complex modification produced by the blue light. It is impossible to say what kind of simple factors might produce such a profound modifying effect on the colour pattern of an insect in which they appeared as mutations, but I would suggest that a factor which produced a slight modification in the normal metabolism of the insect might have such an effect. For example, if the mutation caused the deposition of pigment in the wings to occur at, say, an earlier stage than is normal, it is conceivable that this might cause a modification, both in the nature and distribution of the pigment. That slight changes in the metabolism of an insect can have a profound modifying influence on colour pattern is indicated by the well known fact that simple environmental conditions, such as temperature, humidity and food material, can modify the appearance of an insect, often to a surprising degree, as, for example, in some butterflies which have very distinct seasonal phases. It is evident that this is a secondary effect, the primary effect being some modification of the metabolism of the insect by the environmental factors.

There is another line of evidence which indicates that in many cases of mimicry there must be an underlying genetical similarity between mimic and model which causes each to develop the same appearance. In certain cases, as, for example, the *Metriorrhynchus* mimetic group (Pl. i., figs. 56-95) and the *Syntomid* group (Pl. iii., figs. 19-30) exactly the same type and degree of variation is found, either between the species contained in the various groups of mimics and models, or within single species, the variability of a particular mimic corresponding closely with that of a single species of model. If the mechanisms underlying the colouration of mimic and model were different there should be no correspondence between the variability of each, and the fact that such correspondence does exist in many cases suggests that in these cases there is an identity, or at least similarity, of mechanism. In the case of a similar range of variation existing

between the different species of mimics and of models it is possible that natural selection might have limited the variation of the mimics to the range of the models, but natural selection could not have operated to cause the variability of a single species of mimic to correspond with that of a particular model. If a mimetic mutation appeared having a variability corresponding with that of the model, natural selection might preserve it, but it is inconceivable that natural selection could either create or even modify a power of variability.

It is well known that in many widely ranging mimetic groups of butterflies the same kind of variation from the normal is to be found in the mimics and models occurring in the same country or district. This is particularly noticeable when the insects occur in a series of very isolated localities, as, for example, on different groups of islands in the Pacific. It is usually claimed that in such cases the models became modified in colouration by the action of some unknown factor and that the mimetic forms developed a similar colouration as a direct effect of natural selection. From what has already been said as to the probable fundamental similarity existing between the colouration of mimic and model in butterflies it is not improbable that both forms have been influenced by the same factors, probably environmental, which would be expected to have a similar result in each case. It is quite possible, however, that natural selection may have played an important part in preserving the resemblances when they appeared.

It appears necessary to consider that a complete mimetic resemblance could occur as a single mutation, or as a very small number of mutations, only if both mimic and model possessed a very similar structure and were sufficiently closely related to have a similar genetical constitution. In all such cases mimic and model would not only look alike but there would be a fundamentally similar mechanism underlying the appearance of each. In cases in which the same appearance is produced in mimic and model in different ways it is obvious that the mimetic resemblance must have been produced in some other manner. This is usually evident where resemblances exist between insects belonging to different orders. The one outstanding exception to this with which I am familiar is the case of the moths belonging to the genus *Snellenia* (Pl. i., figs. 69-72), which not only closely resemble some species of beetle belonging to the genus *Metriorrhynchus* (Pl. i., figs. 56-68), but have a similar range of variation. This may be an exceptional case of similar variability existing in characters which are fundamentally different, but I think that another explanation is more probable. It can scarcely be claimed that a moth and a beetle are fundamentally similar in structure or that they are closely related. The structures affected by the colouration are, however, essentially similar and I consider it probable that the factor which determines the colouration may be of a very simple type which might well occur in very different types of insect. The colouration of each insect consists of plain red front wings, the red sometimes being partially replaced by black, and the whole of the rest of the insect is black. Black is one of the commonest of the pigments which occur amongst insects, red is also very common, and it has been shown that some red pigments, at least, are closely related chemically to the dominant blacks and browns. It is not difficult to believe, therefore, that such a simple distribution of common, and probably closely related, pigments may be determined by some very simple metabolic factor which might well be expected to occur independently in very different types of insect. If the structures affected by this distribution of colour have even a superficial similarity of form and distribution a similar appearance will result, and this is the case in such moths as *Snellenia* and Lampyrid beetles such as *Metriorrhynchus*.

It may be claimed that a mimetic explanation is superfluous to account for

resemblances of the type I have been discussing, as in each case these depend on similar structure and fairly close relationship. The resemblances, however, cannot be due simply to close relationship, as this would necessitate the existence of a series of very different common ancestors of a particular mimetic group and the group to which the models belong, that is a separate ancestral type would be required for each mimic and its model, whereas only a single ancestral type can have existed. The common inheritance by mimics and models from this common ancestor of similar general structure and a similar genetical constitution, carrying potencies for similar types of mutation, is, however, not only possible, but probable. This would account for the appearance sometimes of the same type of colour pattern in the two groups, but I have already shown that it is only possible to account for all the facts of the case by considering that natural selection must have operated to preserve the resemblances when they appeared. Only in this manner is it possible to account for the fact that mimics and models are always found to occur together, as it has been shown that general environmental influences could not have caused this. It is necessary to consider, therefore, that the type of resemblance I have been dealing with is as truly mimetic as if it had been the result of the accumulation of a number of small mutations.

It appears to me that the explanation I have given agrees with the known facts concerning mimicry in butterflies much more closely than the theory that mimetic resemblance has in each case been due to the accumulation of a large number of small favourable mutations. Only in the case of butterflies with polymorphic females has it been possible to bring forward anything in the nature of direct evidence as to whether large mutations or a series of small mutations have been selected in the production of mimetic resemblance. If, however, large mutations must have been selected in such cases, as has been shown, it seems probable that the same process may have been involved in the production of other mimics with which it is impossible to carry out similar experiments, as there appears to be no essential difference between the mimetic patterns of the several forms of a polymorphic butterfly and those of a closely related series of mimetic species. It is evident, then, that the natural selection of small mutations cannot be used as an explanation for the production of certain cases of mimicry in butterflies, and that in many other cases it probably does not apply. There is no reason, however, why this explanation should not be found to apply to some cases of mimicry in butterflies, as it is the only possible explanation of many known cases of mimicry in other types of insect, but adequate evidence of this does not appear to exist at present.

There is still another important consideration which demonstrates that the natural selection of small mutations cannot account for the production of all cases of mimicry in butterflies. In many cases only the female is mimetic, that is, the mimetic pattern is sex-limited.* Sex-limited mutations are of distinctly rare occurrence and it seems incredible that all the small random favourable mutations which are considered to have been selected in building up this mimetic pattern should have been of this rare type. It is surely more probable that a single sex-limited mutation appeared and was selected. It has been claimed that natural selection would operate more effectively on the female than the male, as

* For the purposes of this discussion I am using the term "sex-limited characters" in its literal sense, that is, it signifies characters which can only appear in one sex. These may be sex-controlled or sex-linked, though not all sex-linked characters are of this type. There appears to be no evidence as to which of these categories the sex-limited characters referred to belong.

the preservation of the female is of more importance to the success of the species than that of the male. This theory appears to be due to a curious misconception of the process of natural selection. It appears to have been considered that natural selection operates with a definite end in view, the benefit of the species, and that it is capable of doing anything to attain this end. Actually, of course, it operates without reference to any ultimate object, though it commonly does benefit the species. Natural selection is an evolutionary process, which can only operate by preserving such favourable mutations as appear. It cannot produce, or even modify these. Sex-limitation of characters is a problem of genetics and obviously, therefore, has no connection with natural selection. If a mimetic mutation appeared which was not sex-limited it is immaterial whether natural selection operated in its favour on only one sex or both, in either case the mimetic pattern would be preserved in both, as a mimetic female selected would produce mimetic offspring, of both sexes. On the other hand natural selection could not cause a mutation which was sex-limited to appear in both sexes by any kind of modification of its normal action. It is obvious, therefore, that, far from being a beautiful example of the manner in which natural selection operates for the benefit of the species, as has been claimed, the occurrence of butterflies with mimetic females and non-mimetic males has no direct connection with natural selection, but is purely a genetical problem. The fact that the mimetic pattern as a whole is sex-limited strongly indicates that it is due to a single factor, and it is therefore improbable in the extreme that it should have been built up by the accumulation of small mutations. No doubt, however, the preservation of the mimetic pattern when it appeared was due to natural selection.

In the majority of cases of mimetic resemblance which have come under my notice there is no fundamental similarity between mimic and model. A similar appearance in each has been produced by the modification of different structures in different manners. There is absolutely nothing but appearance in common between mimic and model, and the only possible alternative to a purely mimetic explanation of the resemblance, that is, that appearance has been produced as a response to appearance, is that the resemblance is purely fortuitous, which I have already shown to be practically impossible.

In such cases the mechanism of the resemblance of mimic to model is of a very complex nature. Each of a series of structures in the mimic is modified in such a manner as to produce a resemblance to the model, there being nothing in common between the modifications of these various structures other than their resemblance to some part of the model, or between corresponding parts of mimic and model, these often being developed in very different manners to produce the same appearance, and not infrequently a similar appearance is produced by the development of entirely different parts in mimic and model. A large number of examples of this type of resemblance have already been given, such as wasp-like flies and beetles, and it will not be necessary to refer to these in detail here as I have already demonstrated the extreme complexity of many of these resemblances. It is evident that the series of independent characters which build up a mimetic resemblance of this nature must have had a separate origin and selection, there being no conceivable mechanism by which all could have appeared simultaneously. Natural selection must, therefore, have taken part in the construction of such resemblances, and not simply have preserved them when they appeared. It may be objected that even in these cases natural selection can only have preserved characters which had already appeared. This is so, but natural selection has itself created the resemblance by preserving a series of small suitable characters and rejecting a large number of unsuitable ones. An artist is credited with the

creation of a picture, even though it is known that all the colours he used were in his paint-box before he started.

Though it is evident that such complex mimetic resemblances must have been built up by the selection of a large number of different mutations there is no definite indication of the nature or magnitude of these. In most cases they must have been fairly small, but there is no reason for believing that they must all have been of one type. Any type of heritable variation and any combination of these may have taken part in the construction of a complex mimetic pattern.

It is often objected that if mimetic patterns are built up by the selection of a large number of small mutations it is impossible to understand how the first vague resemblance produced could have a sufficient survival value to be selected; and the same objection applies to the final stages of perfecting an already almost perfect mimetic resemblance. I must leave the detailed consideration of this question to be dealt with later, in connection with the process of natural selection, but I must point out with regard to the first objection that there is evidence that, in some cases at least, the ancestral form of the mimic had, quite accidentally, some resemblance to the insect which later served as the model. For example, it would only be necessary for an apparently non-mimetic species of *Mydaid*, such as *Miltinus viduatus* (Pl. vi., fig. 2), to develop a conspicuous yellow colouration in order to produce a considerable resemblance to certain wasps, as is the case with the fairly closely related *Dioclistis aureipennis* (Pl. ii., fig. 8). Also, an examination of the closest non-mimetic relatives of the many different types of wasp-mimic which occur within the family Asilidae will show that in each case these very definitely exhibit a basis on which the respective mimetic patterns could be built up by comparatively small mutations. As might be expected it appears that in each case the model "chosen" is the one which most closely corresponds to the normal appearance of the group to which the mimic belongs.

It is, of course, evident, that an incipient mimetic pattern must resemble some model sufficiently closely to cause the insect bearing it to be confused sometimes with the model before natural selection can commence to operate in its favour. This first "rough" resemblance must, therefore, be purely fortuitous. When one considers that comparatively few insects are mimetic, that all organisms are capable of considerable variation and of sometimes producing large mutations, and that in any particular environment there is probably quite a number of different insects which could serve as suitable models, it does not seem improbable that some insects should occasionally and accidentally produce a sufficient resemblance to some suitable model to allow natural selection to commence to operate. The small number of known mimetic insects does not appear to me to be by any means too large to be accounted for by such primary fortuitous resemblance. The mutations on which natural selection commences to operate may be very small, if the normal appearance of the species is close to that of the new model, or must be large, if the insect about to become a mimic is very unlike the model. To the former case the objection is raised that if the first small mutation be comparable in size to normal individual variations, it could not give the possessor a sufficient survival value to be selected; it being considered that the survival of the species must have depended on each mutation selected, for otherwise the normal individuals of the species would not have been eliminated. This objection I believe to be due to a misconception of the manner of operation of natural selection, but I must leave consideration of this point to a later stage. I will simply point out that all that is necessary in order that natural selection may operate is that the insect bearing the mutation should have a slightly greater survival value than the normal individuals of the same species. The margin be-

tween being seen and being overlooked must often be very slight, particularly when the insect is near the extreme range of vision of the predator, so that a slight tendency towards cryptic colouration might give the possessors a distinct, though slight, special survival value. The same would apply to a tendency towards deceptive colouration, particularly if, as must often happen, large numbers of non-mimetic and non-distasteful insects occurred together with the incipient mimic. It is at least probable that the predator would attack the obviously palatable insects by preference.

It is generally considered that birds are the most active selective agents in the production of mimetic resemblance and I think it very probable that this is so. It is commonly objected that as birds are so much more experienced as entomologists than we are, and have such superior powers of sight, they would certainly not be deceived by a "mimic" which does not deceive a human entomologist in the field. If this be so, the first vague resemblance of a mimic to its model could be of little use to it. To my mind, far too great an importance has been attached to this objection. I am ready to admit that as a field entomologist an insectivorous bird is vastly superior to me and that its sight is keener, but I do not admit that its power of perception, a mental process, is superior to mine. Experiments have proved that young birds gain experience by the process of trial and error. With some difficulty they learn to associate distastefulness with the appearance of the distasteful object. The mental processes of a bird appear to be of a relatively low type, and it is surely much more reasonable to believe that a bird will associate distastefulness with, say, bright yellow and black stripes than with a complete and detailed mental picture of the whole insect. If this be so the appearance of a simple yellow mark on a non-distasteful species might give it a distinct special survival value. This survival value would naturally be merely relative, and a more perfect resemblance would have a superior survival value and would be selected at the expense of the earlier and vaguer resemblance. In this manner a very perfect resemblance could be built up, provided that the species sometimes produced the right type of mutations. This explanation is dependent on the theory that in order to be selected a mutation need only have a survival value which is relatively superior to that of the normal form of the species. If it be considered that each mutation must have an absolute survival value on which the existence of the species would depend, the explanation would certainly be inadequate; for it would be necessary to consider that the action of the natural enemies of the insect constantly altered during the evolution of the mimetic pattern, and it is difficult to believe that such small mutations as have probably taken part in the production of the mimetic pattern could each have given a sufficiently marked survival value to permit of this explanation. I will shortly bring forward evidence to show that only a relative survival value of the mutations is necessary to account for the production of mimetic resemblance.

I have already pointed out that when the non-mimetic forms of the group to which the mimic belongs differ fundamentally in appearance from the model, it is necessary that the first step in the production of the mimetic pattern must have been in the nature of a very great change from the normal, probably a large mutation, causing the insect to resemble, accidentally, a suitable model. If the new appearance were sufficiently close to that of the model to permit natural selection to commence to operate, the final perfection of the mimetic pattern would be dependent only on time and the appearance of suitable mutations from the new normal of the species. Strong exception has been taken to this explanation on the grounds that a mutation can only be preserved, and not modified, by natural selection; and that therefore the first rough resemblance pro-

duced by a mutation cannot be trimmed into a perfect resemblance. According to our present knowledge of mutations, it is true that their nature cannot be modified in any way by any kind of selection, but it is not necessary to consider that this takes place in the perfection of such a mimetic pattern. Once the primary mutation has been selected it forms a new mean for the species and from this mean mutations of various kinds are bound to occur. Such of these as help to perfect the mimetic resemblance would be preserved. It is the mimetic resemblance which is modified, not the original mutation, and modification takes place by means of the preservation of new mutations, large or small.

There is another means by which the first general resemblance might be brought about, though, as in the previous case, the actual resemblance would be accidental. If we examine any organism we will find that two distinct kinds of structures are present, adaptive and non-adaptive. The adaptive structures may well have been preserved by natural selection, for the development of each would give the possessors a special survival value. Of the remaining structures it is probable that some have definite functions which we have not yet discovered, but there can be little doubt that many structures have no vital importance for the possessors, such, for example, as many of the "ornamentations" of many insects and their eggs. It is obvious that natural selection could not have been directly responsible for the preservation of such non-adaptive structures. The only explanation which can be given for the preservation of such structures is that, having no eliminative quality, they have been preserved along with the adaptive structures with which they occurred. We know no more of the causes which first produced them than we do of the causes which first produced adaptive structures. It appears necessary to consider that all existing organisms have been permitted to survive by the fact that natural selection has operated in their favour, that is, that the perfection of their adaptive structure has so fitted them to their natural environment that they have survived while less perfectly adapted forms have perished. Non-adaptive characters, therefore, must owe their preservation to the fact that they exist in organisms which have been preserved owing to the perfection of their adaptive structures. It seems reasonable to suppose that there must be something in common between the origin of the non-adaptive characters and that of the adaptive characters along with which they are preserved. Non-adaptive characters often show considerable elaboration such as one would expect to result from the continued action of natural selection. As direct selection of such characters is out of the question the most probable explanation seems to be that non-adaptive characters are linked in some manner to certain adaptive characters, so that elaboration produced in the latter by the direct action of natural selection results in an equivalent but dissimilar elaboration of the former. Support is given to this theory by the well known fact that certain factors are quite definitely linked in inheritance. There are two quite different types of linkage; a linkage of two distinct genes, presumably owing to their arrangement in the chromosomes, and the linkage of two or more distinct characters owing to the fact that they are actually only different expressions of a common factor. Though we are apt to think of hereditary factors in terms of the most obvious modification they produce in the structure or appearance of their bearers, it is obvious that the primary influence of the factors must be the modification of the processes of growth and metabolism of the organism, this modification causing the appearance of differences in structure. This being so there is no reason why a single factor should only affect a single structure or portion of a structure, as a slight modification of the normal metabolism may well affect a large number of different structures, and its effect

on different kinds of structures would be expected to be different. Little attention appears to have been given to this problem by geneticists but Morgan has shown that what he terms manifold effects of single factors occur in a number of different mutants of *Drosophila* and similar manifold effects of single factors have been observed in other organisms.* According to these views, therefore, if the progressive elaboration of an adaptive structure be due to the progressive modification of some process of metabolism in a definite direction, this changing metabolism might progressively modify some entirely distinct structure which might reach a considerable degree of development and complexity entirely without the direct influence of natural selection. It is evident, then, that every stage in the evolution of every structure need not, in itself, have a definite survival value. Such an indirect manner of operation of natural selection will permit of the development of non-adaptive structures to a considerable degree of complexity, and it may happen, and probably sometimes does, that such an elaborated structure accidentally serves some definite purpose. It would then be adaptive and its further perfection would be due to the direct action of natural selection. To me it seems not improbable that such highly developed non-adaptive structures may in some cases have formed the basis for selection in the production of mimetic resemblance.

In the preceding discussion I have confined attention principally to deceptive resemblance, but the same processes appear to have been involved in the production of cryptic resemblance, and the same arguments apply. It might conceivably happen that a complete cryptic resemblance should appear as a single mutation, but this would be purely accidental and is improbable. Obviously there can be no underlying genetical similarity between the mimic and its background, so that the explanation which applies, for example, to the close resemblance existing between certain mimetic butterflies and their models, cannot be used for cryptic resemblance. The natural selection of a series of mutations seems the only possible explanation. The mutations selected may be of any size or type, so long as they tend to increase resemblance. There does not appear to be any direct evidence, however, as to the nature of the mutations selected. As to the argument that birds and other predators would not be deceived by resemblances which sometimes fail to deceive even man, I can only reply that a cryptically coloured insect is less likely to be seen than a similar non-cryptic insect, even by birds, and that experiments have proved that this is so. As will be shown, it is only necessary for a slight relative survival value of this nature to operate in order to preserve a mimetic pattern, and that nothing in the nature of absolute immunity is required. Even a vague cryptic resemblance would have such a slight relative survival value.

It may be thought that the evolution of the curiously perfect mimetic habits and attitudes of many insects presents special difficulties, but I do not believe that this is so. Heritable habits must presumably be the expression of special structural peculiarities of the possessors, these probably having some connection with the nervous system. Such habits as give the bearer a special survival value would therefore be selected in the normal manner, their preservation depending on that of the structures of which they are expressions. There appears to be no essential difference between the selection of habits and of appearance. Each is but the expression of some underlying structure, itself the result of some special physiological process determined by the nature of the gene.

* See: Babcock and Clausen, "Genetics in Relation to Agriculture," pp. 133 and 134. and Morgan, "The Theory of the Gene."

The Limitation in Numbers of Animals and its Bearing on the Natural Selection of Mimetic Resemblance.

It is usually considered that the outstanding function of mimetic resemblance is protection. To explain why true mimicry, i.e., deceptive resemblance, is a comparatively rare phenomenon, the theory is put forward that natural selection must have operated more vigorously on the few forms which exhibit it than on other insects, and that the former owe their preservation solely to their great powers of variation. There is absolutely no evidence to support this theory and facts of common observation tell strongly against it. Why, for example, are mimetic insects no more successful than related non-mimetic forms? There are several other important objections to this theory, but I will leave consideration of them till after I have put forward my ideas as to the probable significance of mimetic resemblance.

As butterflies have assumed such an important position in practically all discussions of mimicry it will be convenient to use them to illustrate the considerations I am about to put forward, but practically any kind of insect would serve equally well.

It is considered, then, that the preservation of mimetic species of butterflies has depended on their production of mimetic resemblance. Obviously this can only protect them against enemies, such as birds, which attack the adult insects, and it has been a matter for frequent remark that butterflies are seldom attacked in the adult state. Anyone who has had any experience in breeding butterflies knows that the severest attack is delivered against their earlier stages, particularly the larva. It seems strange, therefore, that a beautiful and apparently complex mechanism for protection should be developed in the adult, to protect it against unimportant enemies, while the larva is unprotected or poorly protected against the most important enemies of the species. If the survival of the species depends on anything it is surely on the efficiency of its protection against its major enemies. It may be objected that efficient protection against the enemies of the earlier stages is impossible, but that these are only capable of destroying the surplus individuals produced in each generation. If this were the case a comparatively small destruction of the adults would bring about the elimination of the species in a few generations, and therefore protection of the adults would be of vital importance to the species. Before accepting such a plausible explanation it is necessary to try to find what factors determine the actual numbers of any particular insect which may exist in its normal environment.

It is well known that the numbers of a particular species existing within any given area will remain approximately the same from year to year unless the conditions change. An exact uniformity of numbers, of course, does not exist, but there is a definite mean around which the numbers fluctuate. The fluctuations may occasionally be very great, but this does not alter the fact that over a long period of years it will be found that the mean remains constant. This must be so, for if any insect had any definite tendency to increase or decrease progressively, the only alternatives, it would in the former case soon overrun the world, and in the latter become extinct. To explain this it is considered that each organism is in a definite state of equilibrium with its environment, but this state of equilibrium does not, in itself, explain what determines the actual number of a particular insect which may exist within a particular area. For example, the numbers of an insect may be considered to be so proportioned to those of its natural enemies that the surplus production of individuals in each

generation is exactly balanced by the numbers which can be destroyed by the natural enemies. This would explain, vaguely, why the numbers of the insect remain constant, that is, how an equilibrium may be established, but it gives no indication of why the equilibrium is established at any particular point. It is this that we want to know; what determines the actual numbers, not simply what causes the numbers to remain approximately constant.

If we examine the occurrence of any insect it will be found that, other conditions being equal, there is a definite relationship between the numbers of the insect and the quantity of food material available. The only manner in which food material could limit the numbers of a species directly is by starvation but, in nature, this is seldom found to happen. Take for example the case of the common wanderer butterfly, *Danaida archippus*. We know that if only two or three plants of milk-weed, its food plant, occur in a particular area we shall find only a few butterflies, while if large areas are covered with milk-weed, large numbers of butterflies will be found. In each case, however, there is a considerable surplus of food plant. The milk-weed could probably support several times as many larvae as it actually does. It appears strange that an increase in the amount of available food plant should cause a corresponding increase in the number of the insects feeding on it when in the first place, before the increase of food occurred, there was already a considerable surplus of food material. Yet this phenomenon can be observed everywhere under natural conditions. Wherever one goes in the field and whatever kind of insect be examined, it will be found that the numbers of insect under observation bear some relationship to the quantity of food material available, though the numbers are seldom directly controlled by the quantity of available food, for there is nearly always an ample surplus of food to support considerably greater numbers of the same species. Apparently the only exception to this is in the case of an exceptionally large fluctuation in numbers, but such plagues of particular species are rare and certainly abnormal, though there is evidence that some, at least, may be periodical in their appearance. It is evident, then, that the quantity of available food material must determine in some indirect manner the numbers of any species which may exist.

It is equally evident that the factors causing the destruction of the surplus numbers of individuals produced in each generation must be the active factors in the limitation of the numbers, and that these factors, therefore, must be influenced in some manner by the availability of food material, causing them to limit the numbers of the insect in some proportion to the quantity of food available.

What then are the active factors tending to destroy insects and so limiting their numbers? The quantity of food available is an obvious possible factor, but it has been shown that it evidently does not operate directly under natural conditions. Unsuitability of food might also have some effect. This would tend to reduce the average number of eggs laid, and might cause the death of certain individuals. As, however, a surplus of individuals would still be produced in each generation there is no reason why the numbers should not increase till limited directly by the amount of available food. Also, under natural conditions unsuitability of food would be an exceptional occurrence due to some change in the environment, such as adverse weather conditions, as each insect is specially adapted to its normal environment. Weather conditions, as is well known, often have a profound influence on the numbers of insects which may exist, and probably form the major factor causing the fluctuations of numbers from year to year. As they operate uniformly, however, at any particular time, they could

not have any special limiting influence governed by the quantity of food material available, and there is nothing in their action from season to season to prevent an insect from increasing in numbers till it consumed all the food material available. As neither food nor weather conditions can produce the observed effect there remain only the natural enemies of the insect, parasites, predators and diseases. Diseases are usually sporadic in their appearance, sometimes causing a very heavy mortality, but more often affecting a species but little. The outbreak of an epidemic often appears to have some connection with weather conditions, such as excessive moisture, and I strongly suspect that the sudden appearance of abnormal numbers of a single species is often the secondary effect of an epidemic disease having destroyed large numbers of some other organism, probably a natural enemy of the species observed. Diseases, then, appear to be too irregular in their action to exercise the stabilising influence on the numbers of insects for which we are trying to account. They appear rather to be one of the major factors causing the fluctuation in numbers which is observed and probably are not infrequently responsible for the largest type of fluctuations which occur, the sudden and apparently inexplicable epidemics of insects which are normally far from common. The action of parasites and predators, on the other hand, appears to be fairly uniform. Though they are subject to fluctuation in numbers like other animals, the fluctuations are normally not great and they appear to exercise a fairly constant influence on their hosts. It is conceivable, therefore, that these may exercise the stabilising influence on the numbers of other insects, the nature of which we wish to determine.

It has already been shown that the factor controlling the numbers of insects must, in some way, be governed by the quantity of food material available for these insects. Is there any manner by which the action of parasites and predators may be governed by the quantity of food material available for their hosts? It appears to me that there is. Parasites and predators have to find their hosts and if a given number of the latter are scattered over a large quantity of their food material they will be more difficult to find than if concentrated on a small quantity, and, therefore, in the former situation each host insect will have a greater chance of being overlooked than in the latter situation, provided, of course, that the number of parasites and predators is the same in the two cases. It follows, then, that the numbers of host insects would increase in each situation till a state of equilibrium was reached in which the proportion of host insects discovered and destroyed by parasites and predators equalled the proportion of the surplus number of individuals produced in each generation, that is, till on the average only one pair of host insects survived from each family in each generation. Further increase would then be impossible. Much larger numbers of insects would be produced in a large area than a small one before this equilibrium was attained, because individuals in the former situation would be more difficult to find.

It will be noticed that this argument entails the idea that the parasites and predators become more and more effective in their action as the numbers of their host increase, and do not simply maintain the same proportion in numbers to their host. This is necessary if the numbers of an insect are to be maintained at a definite level by its natural enemies. If the numbers of an insect increase beyond the normal, it is necessary that the action of the natural enemies should become more severe in order to bring them back to the normal and, on the other hand, if the numbers fall below the normal, the action of the natural enemies must be decreased. A simple proportion existing between the host and its parasites and predators would form a very unstable type of equilibrium which

would be incapable, in itself, of determining the actual numbers of the host which may exist.

If the intensity of the attack delivered by natural enemies be determined by the ease with which they find their host, it is evident that this will provide a mechanism of the required type. If there be larger numbers of the host than is normal within a given area, it is evident that each individual natural enemy should find a larger number than usual. This effect would be intensified in the next generation, for the increased number of hosts attacked would cause an increase in the numbers of the natural enemies, which would still only have to search over the same area and therefore their attack on the host would be intensified, causing further reduction in numbers. This process would continue till the equilibrium was reestablished in which the power of destruction of the natural enemies exactly balanced the power of natural increase of the host. It is obvious that in a similar manner a primary reduction in the number of the host below normal would cause a reduction in the number of parasites in the next generation, in turn causing a decreased attack and an increase in the numbers of the host till the equilibrium was reestablished. The hypothesis that the relative ease with which the host can be found determines the intensity of the attack delivered by its natural enemies therefore gives an adequate explanation as to how the numbers of an insect may be regulated so as to correspond with the abundance of its food without the numbers being actually regulated by this directly. It explains the rather puzzling phenomenon that the numbers of insects in general appear to have some definite relationship to the quantity of their food available, though there is almost invariably an abundant surplus of food which could support large numbers more of the same species. I am unable to find any other factor which could operate in the special manner required to produce this effect and, as the hypothesis I have put forward appears to explain the observed facts in an adequate manner, is at least probable, and I am unable to see any definite objection to it, I feel justified in believing it to be the true explanation of this difficult problem. It at least forms a satisfactory working hypothesis to act as a basis for further work on the subject.

The foregoing considerations apply more particularly to phytophagous insects, though it is probable that they also apply to many insects of other types. The limitation in numbers of most parasitic insects, and probably also of many predators, however, appears to be produced directly by the amount of food available. It is evident that there is not an abundant surplus of food for these insects, for they appear to be the most potent factor in limiting the numbers of other insects and, under natural conditions, normally succeed in destroying all but two of the progeny of any pair of host insects in each generation. The slight excess of food could support only a slightly increased number of parasites and predators temporarily, and could not support any more permanently. Again the actual limiting factor appears to be the "power of discovery" of the parasites and predators. The numbers of these will increase till a point is reached at which they find on the average all but two of the members of each individual family of host insect, and an equilibrium will be established at this point. A further increase in the numbers of parasites or predators would cause a decrease in the numbers of the host, which in turn would cause a subsequent decrease in the numbers of the parasites and predators, so that the equilibrium would soon be reestablished at the original point.

I am well aware that the question of the control of numbers of insects is more complex than I have indicated. The numbers are the result of the interaction of the whole of the environmental factors operating on any particular

insect. Other factors than natural enemies and food supply, however, do not appear to me to enter into the question under consideration, that is, the stabilisation of numbers at a point which has some relationship to the quantity of food material available. Other factors operate uniformly at a given time, without reference to the availability of food, and irregularly at different times and in different places, and so could scarcely be responsible for stabilisation. Such factors would appear to be of importance only in causing fluctuations in numbers from the normal. There is another point which, perhaps, requires explanation. I have been dealing only with the question of the stabilisation of numbers at some definite point and not directly with the factors which determine the actual point at which stabilisation takes place. It is evident that this depends on other factors besides the ease with which the insect can be found by its natural enemies, though this appears to be the final determining factor. The surplus numbers produced by the host in each generation, the efficiency of its concealment, either due to its own appearance or the nature of its normal situation, and the efficiency of its natural enemies in finding it, appear to be the major factors which determine the actual numbers which may exist in any particular situation. If a large surplus of individuals is produced in each generation a correspondingly large proportion must be destroyed to bring about equilibrium, that is, the insect must exist in sufficiently large numbers to cause this severe attack. A small surplus would cause the limitation of the numbers at a low point at which the natural enemies would be relatively ineffective. It is obvious that the more effectively the insect is concealed from its natural enemies the more likely it is to be overlooked, and therefore the greater the number which could exist in a given area before equilibrium could be established. It is equally obvious that the relative efficiency of its natural enemies in finding it will definitely limit the numbers of an insect which may exist. The actual numbers of an insect will be a product of the interaction of these factors, but stabilisation at the point so determined will depend on the relative ease with which the insect may be found should the numbers tend to fluctuate.

It is evident from what has been said that if the numbers of an insect are caused to vary from the normal by any cause there is a definite mechanism which will tend to bring the numbers back to normal. Suppose, then, that the major enemies, on which the numbers of a particular insect depend, attack the larval stage, and that a minor enemy attacks the adult. Does it follow that this increased attack will cause a diminution in the numbers of the insect? At first sight it would appear that the numbers would be reduced in proportion to the increased severity of attack, but a more careful examination will show that this would not be so. The effect of an increased attack on the adults would be to cause less eggs to be laid. There would, therefore, be a decrease in the number of larvae, the food of the natural enemies, causing a decrease in the numbers of parasites and predators and an increased difficulty in finding the larvae. The severity of the attack on the larvae would therefore be lessened so that a larger proportion would reach maturity. Thus the effect of an additional minor attack on the adult stage would be to lessen the effectiveness of the major attack on the larval stage, and the numbers would remain practically unaltered. A curious effect of this equilibrium is that the severer the attack on the adult stage, the larger the proportion of insects which reach maturity. Conversely, if the severity of a minor attack on the adult stage were decreased, there would be a corresponding increase in the severity of the major attack on the earlier stages, and a smaller proportion of the insects would reach maturity.

It is evident, therefore, that the numbers of an insect which may exist

under particular conditions is governed almost entirely by the action of its major enemies, and that a minor enemy only tends to interfere with the action of these and cannot appreciably affect the numbers of its host. An extreme case will, perhaps, demonstrate this most clearly. Suppose that the numbers of an insect are controlled by a single natural enemy and that a new enemy appears which, operating by itself, would be capable of limiting the numbers of the same insect to exactly the same level as the first natural enemy, because its "power of discovery" is the same. The two natural enemies have identical powers for controlling the numbers of the host. Now suppose that the two natural enemies attack the host simultaneously. It is evident that, operating on the usual number of hosts, the food supply of each natural enemy would be reduced to half the normal, owing to the action of the other, and that therefore only half the normal number of each enemy would survive. The combined action of the natural enemies under the new conditions would therefore only equal the action of either enemy acting by itself. This result would be obtained whether the enemies acted together on the same stage of the host or on different stages. In the latter case, however, a difficulty is introduced as to what is meant by equal numbers, as the numbers of the host existing at different stages would be modified. As has already been shown, an increased attack on the adult stage will cause a diminution in the numbers of adults which survive to lay eggs, but a corresponding increase in the number existing in the earlier stages and also actually an increase in the number of adults which emerge. It is evident, however, that the species is equally successful under either condition. This secondary effect of a new natural enemy in causing an increase in the numbers of the insect at stages immediately preceding the one attacked does not affect the subject under consideration, but its importance in connection with the biological control of insects is evident.

So far I have tacitly assumed the action of specific natural enemies only, the numbers of which are automatically controlled by the numbers of the particular host under consideration, the available food of the natural enemies. Many, in fact, probably most, of the natural enemies of insects are not specific in their action, but will attack many kinds of insects, so that their numbers are not directly controlled by the numbers of a particular host. In such cases the diminution in the numbers of a host insect would not cause a corresponding diminution in the numbers of its natural enemies, and it might be considered that this would cause an increased eliminative action to operate against the host, as the same number of natural enemies as before will now concentrate their attention on a reduced number of host insects. Such an effect would, of course, not tend to stabilise the numbers of the host, but would cause further disturbance of the equilibrium. The fact that the numbers of insects do tend to remain stable indicates that some other factor must operate which would cause a decreased severity of attack when the numbers of the host are reduced. Again I believe this to be due to a variation of the relative ease with which an insect can be found which corresponds to its variation in numbers. It is immaterial whether an insect exists in large or small numbers within a particular area in which a definite number of natural enemies is also found. In either case the chance of survival of any particular host insect would be the same, provided the natural enemies searched over the area equally thoroughly, whether the host was rare or common, and therefore there would be no variation in the proportion of the host destroyed dependent on its numbers. The solution of this problem lies, I believe, in the proviso I have made. It is a matter of common observation that the severest attack is delivered by, say, a bird against the insect which is

most abundant. If, for example, a particular species of caterpillar suddenly appears in exceptionally large numbers and becomes very conspicuous, birds are found to concentrate on this caterpillar, neglecting food which is difficult to find and concentrating on that which is easily obtainable. Practically everyone who has lived in the country, whether an entomologist or not, could give examples of this from personal observation. It would appear, therefore, that the increase in numbers of an insect causes an increased activity of its natural enemies against it, whether these be specific or general in their action. The mechanism of the increase in attack with an increase in numbers would appear to be that when an insect is common there is a greater chance that some individual will be seen by a natural enemy than when the species is rare, and, having found one individual, the enemy will remain to search for more. The presence of other individuals in its vicinity therefore lessens the chance of survival of any particular individual of the same species, owing to the fact that the other individuals may attract enemies to its vicinity. It follows, then, that an increase in numbers of an insect will automatically intensify the action of its natural enemies, whether specific or general. This causes an increased proportion of the insect to be destroyed, tending to reduce the numbers to normal, and when this point is reached the factors I have mentioned will operate to maintain an equilibrium.

A good example of the intensification of the attack by natural enemies caused by an abnormal increase in the numbers of an insect has been given to me by Dr. G. A. Waterhouse, an account of which will form an excellent illustration of the point under consideration. The Pierid *Anaphæis java teutonia* Fabr., sometimes known as the "travelling butterfly," does not normally breed in the Sydney district, where its food-plant, *Caparis*, is not native, but it occasionally appears there in large migratory swarms from the north or inland. Dr. Waterhouse has a bush of *Caparis* in his garden and large numbers of butterflies from one of these migratory swarms settled on this bush and laid eggs. Dr. Waterhouse and Dr. E. W. Ferguson together computed that at a conservative estimate there was at least a quarter of a million eggs on this single bush. Assuming that each female laid 100 eggs, probably a fairly accurate estimate, there must have been about 2,500 females and presumably as many males in the portion of the swarm which settled on this bush. The first enemies seen to attack these insects were neuropterous larvae, probably those of *Chrysopa*, which appeared in large numbers and sucked the juices out of many of the eggs and some of the very young larvae. This was followed by an intensive attack by the paper-wasp, *Polistes*, which destroyed large numbers of the larvae. They appeared to concentrate the whole of their energies on these larvae, but before long were seen to be flying round the bush in rather an aimless manner, seldom attacking the larvae. Evidently they had already provided as much food as their own larvae could manage and all that it was necessary for them to do now was to keep these in a state of repletion, so that they could not make further use of the abundant surplus of food provided. Later Tachinids appeared in large numbers and delivered such a heavy attack that it was difficult to find a single larva not bearing at least one Tachinid egg. By this time the whole of the leaves and all the young bark had been removed from the tree and some hundreds of larvae were seen to migrate from the tree, apparently in search of food. This they could not have obtained as another bush of *Caparis* probably did not exist within a radius of several miles. The result of this combined and heavy attack was that not more than 50 adults emerged from the whole brood and many of these were observed to be taken by blue wrens, which attacked the butterflies as soon as they emerged. Thus not more than 50 butterflies, many of

which were immediately destroyed, were produced from a number of eggs estimated at 250,000. If each female lays 100 eggs in the normal state of equilibrium an average of 2% must survive but in this case, owing to the abnormal number of individuals, only an average percentage of 0.02 emerged and few, if any, of these survived to lay eggs. This clearly indicates the proportional increase in the severity of attack brought about by abnormal increase in numbers.

We will now examine the special question of the limitation in numbers of butterflies. Anyone who has had any experience in breeding butterflies will know what an important part is played by parasites in destroying eggs, larvae and pupae; and general observations in the field show that caterpillars are heavily attacked by predators, such as birds and wasps (see Pl. vi., fig. 1). Also, one of the strongest arguments of the opponents of the theory of mimicry is that adult butterflies are seldom seen to be attacked by birds, and that therefore protection from such attack could be of little value to the insect. Again Dr. Waterhouse has provided me with concrete examples to illustrate the action of natural enemies on butterflies. Two batches of eggs, totalling 130 in number, were laid by *Delias aganippe* Don. on a native-cherry tree, *Exocarpus*, in his garden. These were left on the tree and from them only one adult resulted. Later another batch of eggs, estimated at 50 in number, was laid on the tree. These were removed to a large breeding cage of wire gauze, which excluded all the larger parasites and predators, though it was found impossible to completely eliminate spiders, which certainly destroyed some of the larvae. From this batch 26 pupae were obtained and 22 adults emerged. As the two sets of observations were unfortunately not made at exactly the same time, it is impossible to say definitely that the two cases only differed in that in one the insects were exposed to their natural enemies while in the other they were partially protected from them, but this appears to be the only difference of importance as the weather conditions appeared to be in every way favourable in each case. When exposed to natural enemies, then, considerably less than one per cent. survived and when partially protected from them there was a survival of over forty per cent. Everything indicates, therefore, that the major attack is delivered against butterflies when in the earlier stages.

From what has been said it follows that protection from attack in the adult stage can be of little, if any, importance to a species of butterfly; for reduction in the normal slight attack on the adults would only result in a slight decrease in the numbers of the earlier stages and the numbers of adults which emerged, the actual numbers of the species remaining practically unaltered. Therefore if a perfect mimetic pattern appeared suddenly in a non-mimetic species, giving complete immunity from attack, it would not increase the success of the species, which would be just as successful without the mimetic pattern. At first sight this would appear to render natural selection of the mimetic pattern impossible, but actually this is not so.

For the sake of convenience I will consider a perfect mimetic pattern which gives complete immunity from attack to the possessors, and which appears suddenly in a non-mimetic species subject to attack in the adult stage by natural enemies, such as birds, capable of discriminating between the two colour patterns. All the possessors of the mimetic pattern would survive to lay eggs, while a proportion of the non-mimetic individuals would be destroyed by their natural enemies. Therefore the proportion of the mimetic to the non-mimetic individuals would be greater when the insects laid their eggs than it was when the adults emerged. As usual an excess of eggs would be laid and the natural enemies of the earlier stages would eliminate a proportion of these, destroying,

on the average, an equal proportion of the mimetic and non-mimetic stock. As a result, the proportion of mimetic to non-mimetic individuals which would emerge would be the same as that existing between the insects which laid eggs in the previous generation, but greater than that which existed between the adult insects which emerged in the previous generation, and less than that which would later exist between the insects of the same generation when they laid their eggs. The slight selective action of the enemies of the adults is therefore cumulative from generation to generation, while elimination of surplus individuals is brought about by the enemies of the earlier stages operating completely without any selective action. It is evident, therefore, that the mimetic form of the insect would continue to increase at the expense of the non-mimetic so long as it continued to give the possessors a greater survival value than the non-mimetic form, that is, under normal conditions, till it completely replaced it. When, however, the species became completely mimetic and possessed complete immunity from attack by the natural enemies of the adult, it would be no more successful than it would be if it remained non-mimetic. The adults would certainly be free from attack, but less adults would be produced, on account of the increased severity of the attack on the earlier stages. It is therefore evident that the outstanding characteristic of mimicry is not protection, as has usually been assumed; and, on the other hand, the major objection to the theory of mimicry which is so frequently stressed, that is, that in so many cases mimetic animals evidently do not enjoy any special protection, is shown to be no argument against mimicry itself, though it remains the most important objection to the current theory as to the significance of mimicry.

It should be noticed that the foregoing considerations apply equally well to the evolution of Batesian and Müllerian mimicry. All that is necessary is that a character should appear in an incipient mimetic insect which will cause it to be mistaken occasionally by its natural enemies for some other insect which is less liable to attack. The individuals bearing this character would therefore have a slightly greater survival value than the normal individuals of the same species, and the new pattern would gradually replace the old one. The incipient mimic need not therefore be palatable; it need only be less distasteful than its model, other things being equal. If the incipient mimic be less numerous than its model it may be as distasteful, or even more distasteful than the model; for the appearance of the commoner species would be more definitely associated with distastefulness by the natural enemies than that of the rarer species, and this might more than counteract the special protection afforded by the greater distastefulness of the rarer species. On the other hand, a commoner slightly distasteful species might be caused to mimic a rarer very distasteful species because the great distastefulness of the latter more than counterbalances the effects of its rarity. The model, however, must always be the form which is least liable to attack, whether this is due to its special distastefulness or its numerical superiority. There should never be any tendency for the two insects to become mutual mimics and to develop a mimetic pattern intermediate in appearance between their two normal patterns.

As protection cannot be considered to be the outstanding characteristic of mimetic resemblance the question arises as to what is its significance. If we are to think of significance in terms of the teleological concept of ultimate purpose, mimetic resemblance has no significance to the bearers, for it does not benefit them in any way. Though the individuals in the stage which exhibits mimetic resemblance have a greater survival value than similar non-mimetic insects, neither the species nor, on the average, the individual receives any special pro-

tection resulting from mimetic resemblance; for the greater survival value of the individuals in the mimetic stage automatically brings about a correspondingly decreased survival value of the other stages. Mimetic resemblance, therefore, simply serves to fit the possessors more perfectly to their natural environment, without conferring upon them any material advantage.

The theory I have put forward with regard to the significance and probable method of evolution of mimicry in butterflies appears to apply equally well to other examples of mimetic resemblance, whether cryptic or deceptive. There are two points to which I must draw attention, however. It is not necessary that the selective and eliminative agents should always operate on different stages of the insect, though it appears evident that this happens in butterflies and probably also in many other kinds of insects; and it is probable that sometimes a single natural enemy is both the selective agent and also the major factor in controlling the numbers of the insect. I do not think the first point requires any comment as it is evident that the selective agent must operate on the stage which exhibits mimetic resemblance, while the eliminative agent may operate on any stage. With regard to the second point, it is obvious that mimetic resemblance would benefit a species if the selective and eliminative agents were actually the same natural enemy. Numbers would increase to a point at which the increased severity of attack due to increased numbers exactly balanced the value of the increased immunity due to the mimetic resemblance. There is no reason why this should not sometimes occur, but I do not think that it is a common phenomenon. It most certainly does not occur in some cases, as in the butterflies, and it is difficult to understand how, in such cases, each small mutation could have given a special survival value to the possessors; or, if this be granted, how the original non-mimetic form could have survived under what must have been a very intensive attack. It is, however, not difficult to believe that a single large mutation, or a small number of such mutations, might be preserved in this manner.

A Consideration of the More Important Criticisms of the Theory of Mimetic Resemblance.

In the light of the foregoing considerations I will now consider the main objections which have been put forward from time to time, and which are considered by many definitely to disprove that mimicry exists. These may be stated briefly as follows.

1. Why are mimetic insects apparently no more successful than closely related non-mimetic species occurring in the same environment?
2. How did the first rough pattern of an incipient mimetic form give the possessors a survival value if the tiny variations claimed to be selected in the final perfection of an already almost perfect pattern also give a special survival value? It would seem that the selective agent, such as a bird, would at first have to be very easily deceived, while later it would be required to possess very acute powers of discrimination.
3. If birds seldom attack butterflies, how can protection against them be of any importance to the species and so bring about natural selection?
4. Punnett has brought forward evidence which indicates that the proportion existing between the mimetic and non-mimetic females of *Papilio polytes* must have been much the same 150 years ago as it is to-day. If the mimetic form were specially protected its proportion to the non-mimetic form should have altered appreciably.

5. In connection with the same butterfly Punnett has shown that the range of the models does not correspond exactly with that of the mimic, but that the proportion existing between the mimetic and non-mimetic females remains apparently the same wherever the species is found in India and Ceylon.

6. Though in nearly all cases mimics are less common than their models there are some instances in which the mimic is commoner than the insect which apparently serves as its model. It is considered that a mimic must be rarer than its model if it is to receive any protection from its resemblance.

The first objection is well illustrated by Buxton's observations on the colours of desert animals. He points out that two main types of colouration occur amongst desert animals, sand colour, which has usually been considered as a particularly clear example of "protective colouration," and black. These two types of colouration are exhibited by animals inhabiting exactly the same situation and sometimes occur in quite closely related animals. The black species appear to be in every way as successful as the "protectively coloured" pale brown species, in spite of the fact that the former often move about freely and habitually in broad daylight. Also, the habits of many of the sand coloured species are such that their colour can be of very little use in concealing them as some spend almost all of their time underground, and others only come out at night. It is quite evident that any explanation which depends upon a necessity for a definite protective value of the sand colouration to account for its production and preservation will not explain the observed facts, and Buxton has tentatively put forward the theory that sand colour, and also black, may be due to some special physiological requirements common to many desert animals; that is, that the colour is simply the expression of some underlying physiological condition of the animal induced by the special environmental conditions of the desert and that the colour, in itself, is of no significance. This theory appears to me to be satisfactory in part, but it does not give an adequate explanation of the perfection of the cryptic colouration exhibited by many forms; the rather complex "counter shading," for example, which causes many bulky animals to appear flat and to be inconspicuous on a plain surface. Such colouration shows a very definite adaptation of appearance to the animal's environment, and some explanation appears to be necessary to account for this adaptation. It is evidently necessary that there should be some mechanism, by which adaptation can be evolved, which does not involve any necessity for the actual survival of the species to depend on the special protection afforded by each mutation. Such a mechanism I have already described, and I believe that this gives an adequate explanation of the observed facts concerning desert animals. What is the major factor controlling the numbers of desert animals I do not know, but it is evident from Buxton's observations that predaceous animals capable of discrimination do not constitute this factor. If, however, they exercise any selective influence, even though it be very slight, this will be cumulative and will be capable of producing a complex form of adaptive colouration, provided that the right type of mutations occur, but the mutations selected, and even the finally perfected cryptic colouration, will not in any way modify the degree of success of the species.

One further point must be mentioned. In this case, as in all others, it is necessary that the colouration of the animal should first resemble that of the background sufficiently to permit the commencement of natural selection, the primary resemblance thus being purely fortuitous. Pale brown is a common colour amongst animals, and it is not improbable that the special environmental conditions of the desert may tend to cause the appearance of this colour by some modification of the normal physiology of the animal. This alone may be the

cause of the colouration of some forms which do not show adaptation in detail, and it may have formed the basis on which natural selection operated in the production of the more perfectly adapted forms. In a similar manner black may have been induced by the altered physiological conditions of other animals; and if this black colouration, or the processes underlying it, gave the possessors even a slight advantage relative to the normal individuals of the same species, it would eventually become the normal colouration of the species. As before, this change would be brought about without any alteration in the success of the species being necessary. The advantage given by black would probably not be due to its appearance, but to some other property of the pigment, or the processes underlying its production. For example, its function is not improbably the protection of the delicate underlying tissues from the intense light characteristic of desert regions. In some animals such protection from intense light may be of more importance than protection from predaceous animals, which would cause the production of black rather than sand colour, but in neither case would the protection afforded be of vital importance to the species.

The second objection to the theory of mimicry I have put forward is very clearly stated by Punnett in his book, "Mimicry in Butterflies," in the following passage (pp. 139-140). "Even if birds are the postulated enemies it must be further shown that they exercise the postulated discrimination. It is required of them that they should do two things. In the first place they must confuse an incipient or "rough" mimic with a model sufficiently often to give it an advantage over those which have not varied in the direction of the model. In other words, they must be easily taken in. Secondly, they are expected to bring about those marvellously close resemblances that sometimes occur by confusing the exact mimicking pattern with the model, while at the same time eliminating those which vary ever so little from it. In other words, they must be endowed with the most remarkably acute powers of discrimination. Clearly one cannot ask the same enemy to play both parts. If, therefore, birds help to bring about the resemblance we must suppose that it is done by different species—that there are some which do the rough work, others which do the smoothing, and others again which put on the final polish and keep it up to the mark. This is, of course, a possibility, but before it can be accepted as a probability some evidence must be forthcoming in its favour." It is evident that the difficulty here is not to explain why birds should less frequently attack a more perfect than a less perfect mimic, but why, in the early stages of the production of a mimetic pattern, they should eliminate very imperfect forms and pass over slightly more perfect forms, and later eliminate forms whose mimetic patterns are almost, but not quite, perfect, and which are very much more perfect than those of the individuals which were previously passed over. The difficulty is due to the belief that the active principle of natural selection is the elimination of the less fit individuals, whereas, according to the views I have put forward, it is "the survival of the fittest"—a Darwinian concept which appears to have been strangely misunderstood in recent years. Thus, in his "Origin of Species," Darwin says: "As natural selection acts solely by the preservation of profitable modifications, each new form will tend in a fully stocked country to take the place of, and finally to exterminate, its own less-favoured forms with which it comes into competition." Thus he lays stress on the preservation of the fit, and not the elimination of the less fit, this elimination being a secondary result of the success of the fit. In recent years, and particularly in connection with the subject of mimicry, it appears to have been assumed that the only possible mechanism for natural selection is the exact reverse to that described by Darwin in the above passage. It has been assumed

that the fit can only survive and replace the less fit by the active elimination of the latter, and this idea has caused a number of apparently insuperable difficulties to arise, such as the one under consideration, in connection with the operation of natural selection in particular cases; difficulties which are due solely to a concentration on one possible manner of operation of natural selection. In one sense, of course, the idea of the survival of the fittest automatically entails that of the elimination of the less fit; but one is only the secondary effect of the other, and it is of the utmost importance to realise which is primary, that is, the active principle of natural selection. At first sight it would appear that the simple survival of the fittest could not in itself bring about natural selection, without a corresponding active elimination of the less fit. I have already shown, however, that it can. The survival of the fittest automatically brings about an overstocking of the environment in which they occur. This causes an intensification of the action of the normal eliminative factors which reduce the numbers to normal by an impartial destruction of fit and less fit, but the proportion of fit to less fit individuals will increase from generation to generation, owing to the cumulative action of the selective factor which gives the fit a slight survival value relative to the less fit. The last point is most important. It is not necessary that each variation should give the possessors an absolute survival value, without which they would perish; it is only necessary that each variation should give the possessors a slightly greater relative survival value than the other individuals in which the variation does not appear. Elimination of the less fit, therefore, is a direct result of the relatively greater success of the fit and would only occur in the presence of the fit.

It is evident, therefore, that the objection under consideration is not an objection to the theory of mimicry, but to a current theory as to the manner of operation of natural selection. If birds discriminate on appearance they could bring about the selection of all the stages in the production of a mimetic pattern, without modifying the nature of their discrimination, and without there being any necessity for the operation at different times of a series of different birds with different powers of discrimination. All that is necessary is that butterflies with a more perfect mimetic pattern should be slightly less frequently attacked than those with a less perfect mimetic pattern, and there can be but little doubt that birds are capable of exercising the simple type of discrimination required to bring this about.

It is often considered that some form of orthogenesis is required in order to explain the final perfection of the mimetic pattern of certain insects. The leaf-butterfly, *Kallima*, is usually taken as an example to illustrate this. It is claimed that natural selection could operate to bring about a general resemblance to a leaf, but that once the butterfly was sufficiently like a leaf to deceive its enemies, natural selection could take no further part in perfecting the resemblance. Fine details, such as the marks which look like mould spots and transparent areas of membrane which look like holes, are considered to be inexplicable as the result of natural selection. Personally I can see little force in this argument. These details are simple derivatives of structures which are not only to be found in closely related non-mimetic forms, but occur practically throughout the Nymphalidae. The "mould spots" are evidently derived from the "ocelli" which are so common on butterflies' wings, the long mark looking like the mid-rib of a leaf has its counterpart in large numbers of nymphalids, and the smaller marks which look like leaf veins are evidently only a development of marks with a similar distribution in many related non-mimetic forms. The normal system of colouration of the Nymphalidae, therefore, has

formed the basis for the evolution of the mimetic pattern in *Kallima*, and the selection of a series of simple variations from the normal is sufficient to account for the particularly perfect resemblance of this insect to a leaf. The idea that natural selection gave an inadequate explanation of this case was evidently due to the difficulty already considered; that is, it was considered that each variation must have given an absolute survival value to the possessors, so that when the insect had received the "protection" of the earlier types of pattern, further favourable variations could not give the insect a further survival value, and therefore these could not have been selected. It is evident, however, that if it is only necessary that new variations should have a slightly greater relative survival value than the normal form of the insect, new favourable variations could be selected indefinitely till complete immunity from attack is conferred upon the insect by the perfection of its resemblance. There is no evidence that this point has yet been reached by *Kallima* and certainly there is none to show that this point was reached by the insect long before the present perfection of its mimetic pattern was produced, as is postulated by those who believe that orthogenesis must have taken part in the production of this pattern. There is a further objection to this rather nebulous theory of orthogenesis. One could understand that orthogenesis might occur if it were simply the expression of the progressive development of something within the insect. A progressive increase in size, either actual or relative, or the intensification of a colour, might be explicable as the result of the progressive development of some process within the insect, but I fail to see how any conceivable type of orthogenesis could direct a progressive development towards a goal set by some factor which has no direct influence whatever on the insect. I cannot see how the appearance of a leaf could possibly direct an orthogenetic process in *Kallima* to bring about resemblance. If the leaf does not direct this process, and it be considered to be necessary that orthogenesis must have brought about the resemblance, then the resemblance must be fortuitous and orthogenesis, though responsible for the colour pattern of the insect, would not actually have produced the resemblance, as such.

As to the objection that birds seldom attack butterflies, this is but another of the difficulties manufactured by the theory that natural selection can only operate by the direct elimination of the less perfect forms. On the theory that the more perfect forms need only have a slightly greater relative survival value than the normal forms in order to be selected, this difficulty ceases to exist. Only an occasional attack by birds, provided they discriminate between mimetic and non-mimetic forms, will give the more perfectly mimetic forms a relatively greater survival value, so that in this manner a complete mimetic pattern may be built up. Protection from birds is no "object" of mimetic resemblance. Mimetic resemblance is simply a more perfect adaptation of the insect to its environment, brought about by the selective action of certain of its natural enemies, but the adaptation is not of vital importance to the species.

Papilio polytes has three types of female in India and Ceylon. Two are mimetic, apparently mimicking two other species of *Papilio*, while the third is non-mimetic and is similar in appearance to the male. Punnett brings forward evidence which indicates that the proportion existing between the mimetic and non-mimetic females must have been much the same 150 years ago as it is today. If the mimetic forms have any survival value over the non-mimetic form, there ought to have been an appreciable change in this proportion in such a long period. The fact that there has been no such change indicates that the mimetic forms have no greater survival value than the non-mimetic forms. If this be so, how can one account for the production and preservation of the mimetic forms?

The following consideration appears to me to give an adequate explanation. It is considered that birds associate the colour of a distasteful insect with its distasteful characteristics, and that a mimic of such an insect receives special freedom from attack owing to the fact that it is often mistaken for the distasteful model. Suppose, then, that such a mimetic form suddenly appears in a previously non-mimetic species. Birds will definitely associate its appearance with distastefulness, as all the insects of that appearance previously taken by the birds would be distasteful models. The mimic would therefore have a greater relative survival value than the normal non-mimetic form of the species, which it would progressively displace. When, however, the numbers of the new mimetic form approached those of the model the special survival value of the mimic would be decreased, for birds would almost as frequently associate palatability as distastefulness with the appearance common to mimic and model; for they would catch nearly as many mimics as models. The progressively decreasing special survival value of the mimetic pattern might therefore reach a point where it was no greater than the survival value of the non-mimetic form, at which point the relative proportions of the two forms would remain constant. In *Papilio polytes* the mimetic forms are actually nearly as common as their models, and, judging by the appearance of the forms of this species, I should say that the nature of the equilibrium existing between these forms is probably as follows. The mimetic forms are more conspicuous, but have a slight special survival value owing to their resemblance to their models, while the non-mimetic form is slightly less conspicuous, which probably gives it a slight special survival value. I should judge that the equilibrium has been established at a point where the eliminative value of the conspicuous colouration, together with the slight survival value of the mimetic resemblance of the mimetic forms, just equals the slight special survival value of the less conspicuous colouration of the non-mimetic form. Some of the former therefore are destroyed because they are more conspicuous, while some survive, which would not otherwise have done so, because they are confused with the model; while some of the latter escape detection because they are less conspicuous, and others are destroyed which would have escaped had they been mimetic. When the proportion destroyed of each form is the same, owing to the interaction of these factors, a position of stability is reached in which there would be no tendency for one form to increase at the expense of the other. It is easy to see that if a second mimetic form arose it would eventually be brought into a similar state of equilibrium with the other forms. The answer to this difficulty, therefore, is that the mimetic forms have lost their original special survival value as a direct consequence of their increase in numbers and they now have no greater survival value than the non-mimetic form.

Before dealing with the objection based on the slight lack of conformity between the distribution of *Papilio polytes* and its models I must briefly indicate the nature of the mimetic resemblance exhibited by this insect. There are three forms of female. One is almost identical in appearance with the male, the second, var. *polytes*, which is conveniently referred to as the A. form, resembles *Papilio aristolochiae* and the third, var. *romulus*, known as the H. form, resembles *Papilio hector*. The two mimetic forms resemble their respective models in form and general system of colouration, but the resemblance is by no means perfect. In particular the red is not as brilliant as in the models, nor is it as extensive in its distribution. Also, the two mimetic forms are not very dissimilar, and I strongly suspect that each may be considered as a general mimic of the type of butterfly represented by the two insects considered to be models, rather than as a specific mimic of a single model, though not improbably the mimetic resemblance

may be of an intermediate type between these two extremes. This would mean that either type of mimic might receive a special survival value in the presence of either model. I have already shown that there is reason to believe that birds, and other discriminating natural enemies, are more likely to associate the general appearance of an insect with distastefulness than the whole of the details which together make up that appearance.

As far as I can make out from the information given by Punnett the distribution of *P. polytes* and its models is as follows. *P. aristolochiae* has a very wide range and is found over the whole range of distribution of *P. polytes*, while *P. hector* has a more restricted range and there are some districts in which *P. polytes* occurs where *P. hector* is absent. According to the considerations I have given, in such districts the H. form of *P. polytes* may retain its special survival value owing to the presence of *P. aristolochiae*; but this, by itself, is scarcely sufficient to account for the fact that the proportion existing between the three forms of female is the same in such districts as in others in which both models exist. Districts from which *P. hector* is absent, however, are only on the fringe of the distribution of this insect. One would therefore expect that a certain amount of interbreeding should occur between individuals of *P. polytes* occurring just within the limits of distribution of *P. hector* and other individuals occurring beyond these limits. This would tend to retain the same proportion between the three forms of *P. polytes*, both within and beyond the limits of the distribution of *P. hector*. The effects of such chance interbreeding would, of course, be very slight, but they would only have to counteract a very slight tendency for the proportion of the forms to change. A slight decrease in the survival value of the H. forms, owing to the absence of its specific model, would be largely counteracted by the presence of its other possible model; and this, operated upon by a selective agent which seldom attacks the butterflies and probably does not exercise a very marked discrimination, is required to have its effects nullified by the slight stabilising influence exercised by occasional interbreeding with insects from an area in which both models occur. It does not appear to me that this is in any way beyond the limits of probability, and I certainly do not consider that any difference in the proportion of the forms to one another brought about by such conditions should be evident from a casual observation of the insects in the two areas. Before such arguments can be considered as evidence against the theory of mimicry, therefore, it will be necessary to produce much more definite data, based on careful statistical studies carried out in the different areas, or cases will have to be found in which the two types of area are completely isolated.

According to the theory that the success of a mimetic species depends wholly on the perfection of its resemblance to its model it is evident that the mimic could not exist in larger numbers than its model, for this would indicate that it had a superior survival value to its model, which could not possibly be conferred upon it by its resemblance, however perfect. Unless the resemblance be of extreme perfection it is difficult to understand how the numbers of a mimic could even closely approach those of its model. Cases are recorded, however, in which the mimic is considerably commoner than the insect considered to be its model, though these are very exceptional. Such cases can easily be explained if it be granted that the numbers of the mimic are governed by some other factor than the one which selects the resemblance, and there can be but little doubt that this is so. If a mimetic form appears which has a relatively superior survival value to that of the normal non-mimetic form, due to its resemblance to some suitable model, it will progressively displace the non-mimetic form till its survival value has been reduced to that of the latter, or till the whole of the individuals of the

species become mimetic. The mimetic form will still retain a special survival value due to its resemblance, even after its numbers have become greater than those of its model, though this will be greatly reduced. Very occasionally a bird, for example, would reject a mimetic form because it happened to have taken one or more of the distasteful model previously, but this would be a rare occurrence if the model were less common than the mimic. Still, a slight special survival value would be retained on account of the mimetic pattern, and the mimetic form would continue to displace the non-mimetic unless the non-mimetic form had some special survival value of its own which would allow an equilibrium to be produced eventually between the mimetic and non-mimetic forms. Failing this the mimetic form would ultimately completely displace the non-mimetic, even though the species existed in much larger numbers than the model.

This being so it would naturally be asked why it is a general rule that mimics are less common than their models, and usually comparatively rare. This I believe to be due to the fact that in order to form an effective model an insect must be fairly common, as discriminating enemies could only gain sufficient experience in order to associate appearance definitely with distastefulness in the case of common insects. On the other hand the average species of insect is not common, reference to any systematic collection will demonstrate this. Since, therefore, only common insects can serve as effective models while any kind of insect may become a mimic, and since most insects are not common, it follows that in most cases mimics should be scarce and models common.

In dealing with the various objections put forward to the theory of mimicry I have found it convenient to make frequent reference to the work of Punnett, as the problem appears to me to be stated more clearly in his valuable book, "Mimicry in Butterflies," than elsewhere. In order to avoid any possible misunderstanding I shall take this opportunity of stating that, far from wishing to belittle his work, I consider that it has constituted one of the greatest advances in our knowledge of this subject. He has clearly elucidated one of the most difficult problems concerning the mechanism of the production of mimetic resemblance and he has not hesitated to state clearly difficulties for which he had no adequate explanation. It is the very clarity and excellence of his work which has caused me to refer to him rather than to other authors.

Before concluding I must point out that the considerations I have given apply only to cases of true mimetic resemblance, and not necessarily to all cases of resemblance which appear to be mimetic. Amongst the large number of apparently mimetic insects there are not improbably a few in which the resemblance is purely adventitious. Also similarity in appearance may have been brought about in some cases by other factors, such as environmental conditions. I have already shown that common environmental conditions cannot have brought about resemblance in many forms, but in some others they may have done so. For example, I believe that the "mimicry rings" consisting of several species of *Euploea* which are found on various groups of islands in the Pacific are of this nature. The primary resemblance, no doubt, is simply due to close relationship, while the fact that all the species in one group of islands are similar in appearance, but differ in appearance from those in other groups of islands, is more reasonably explained as due to the action of common environmental factors operating on a series of insects with closely similar bodily structure, than as due to the direct operation of natural selection through the medium of discriminating enemies.

Summary.

The conclusions to be drawn from the evidence and considerations I have now placed before you may be briefly summarised as follows.

Of the actual fact of mimicry there can be no doubt, as there is an abundance of evidence to show that in a large number of cases of resemblance appearance can only have been produced as a response to the appearance of something else. Only the theory of natural selection will account for the preservation of all kinds of mimetic resemblance, and it is essential to the production of many kinds. The material used by natural selection is any kind of heritable variation, so that in some cases there is evidence that the complete mimetic pattern has been produced at a single step, when mimic and model are closely related, while in others the mimetic resemblance can only be considered to have arisen by the selection of a large number of smaller mutations. Natural selection has not operated by the direct elimination of the less perfectly mimetic forms, but by the special preservation of the more perfect, elimination being due to a non-selective factor. The numbers of a species are not controlled by the selective agent, but, in most cases at least, by some other agent which is non-selective; the former thus perfects mimetic resemblance by discriminating in its favour, and the latter controls the numbers of the species by a system of proportional elimination, which is regulated by the actual number of individuals existing within a particular environment in such a manner that it tends to counteract any fluctuation in the numbers from the normal. The success of a species, therefore, does not depend on its relative freedom from attack by the selective agent, but on its power of avoiding attack by the non-selective eliminative agent. It follows, then, that an adequate mechanism exists for the preservation and perfection of mimetic resemblance, causing the insect to become more and more perfectly adapted to its environment, but that the success of the species is in no way affected by this adaptation, even in its most perfect form.

If the species does not benefit from the possession of mimetic resemblance it is evident that the outstanding characteristic of such resemblance cannot be protection, as has usually been supposed. In a very special sense mimetic resemblance does, however, give protection to the possessors. An insect exhibiting mimetic resemblance is slightly less liable to attack than a closely related non-mimetic insect, but this is only a protection from the particular enemy which acts as selective agent; and the very fact of this special protection, tending as it does to cause an increase in numbers, in turn causes an increase in the severity of the attack delivered by those enemies which control the numbers of the species. Therefore neither the species nor the individual, on the average, enjoys any protection due to the possession of mimetic resemblance. Mimetic resemblance therefore simply fits an insect more perfectly to its normal environment; and in order to explain its production there is no need for any teleological concept of ultimate purpose.

The theory of the production of mimetic resemblance I have outlined appears to apply to practically all cases of true mimetic resemblance, but the possibility must not be overlooked that in a few cases the same factor may have operated both in the selection of mutations and in the limitation of the numbers of the insects. It must also be noticed that what appears to be mimetic resemblance may sometimes be produced by very different types of factors which produce similar appearance independently in two or more unrelated insects, the resulting resemblance being actually fortuitous.

Conclusion.

I am well aware that the theory I have put forward will be repugnant to many enthusiastic supporters of the theory of mimicry. The beautiful perfection of adaptation shown in many mimetic forms naturally predisposes one to consider that it must have a definite purpose, for a desire to find purpose in all things appears to be an inherent human failing. It is this very assumption of purpose which has obscured the obvious conclusions to be drawn from the known facts concerning mimetic resemblance, and this is by no means the first time that a conviction of ultimate purpose has interfered with the progress of science. Yet a simple consideration of facts with which all are familiar from personal observation will show that mimetic insects cannot have any advantage over non-mimetic insects in their normal environment. It is well known that in an undisturbed environment the numbers of any organism will remain approximately constant from year to year so that therefore, on the average, only two individuals will survive from each family in each generation. The remainder must be destroyed or the numbers of the species will progressively increase, which is impossible. It may be considered that the mimetic resemblance does give the possessors an advantage, but that this is counteracted by the more intensive eliminative action of some other factor. This, in point of fact, appears actually to be the case, but it does not alter the fact that mimetic insects can have no advantage over non-mimetic. "Purpose" and "advantage," therefore, can have no place in the true explanation of mimetic resemblance.

To my mind a mechanism which can cause the progressive perfection of the adaptation of an organism to its environment by preserving each more perfect mutation as it appears, without threatening the existence of the species should such mutation not appear, is much more worthy of our admiration than a mechanism which operates by the direct destruction of less perfect forms and constantly threatens the species with extinction. The latter mechanism exhibits a crudity such as one would not expect to find in Nature. Far more important than this, however, is the fact that a theory, simple in the extreme and based on obvious deductions from well known facts concerning the limitation in numbers of animals, when applied to the known facts concerning mimetic resemblance was found to explain them all, including those which have hitherto been considered as insuperable objections to the theory of natural selection, and did so without any recourse to supplementary and problematical hypotheses such as a special severity of the operation of natural selection on mimetic forms, orthogenesis towards some goal determined by some external object, a progressive modification of the habits of the selective agent or a constant change of selective agents during evolution. The singularly complete conformity of the theory with the known facts leads me to believe that this theory gives the true explanation of the evolution and significance of mimetic resemblance. It will be necessary, however, for the theory to explain such new facts as come to light, and it is to be hoped that every effort will be made to collect as many of these as possible in order that the theory may be proved or disproved; the ultimate object being to gain a complete understanding of the problem, which in itself would involve the solution of the greater problem of evolution.

Evidence is principally required in two directions. First, the nature of the mutations which are selected in the production of mimetic resemblance. As has been shown, we already know something of this, but this is principally by inference. More work of a purely experimental nature is required, though it is unfortunately evident that there are few forms suitable for such experimental work.

Careful search, however, should be made for suitable species. Secondly, we still have a very inadequate knowledge of the nature of the discriminating enemies which are responsible for selection. Careful observation in the field is required to determine what animals act as selective agents under natural conditions, and experiments on the same animals are required in order to determine the nature and extent of the discrimination exhibited by these animals. The collection of further cases of mimetic resemblance is of subsidiary importance, though of considerable interest. Such cases, however, as bring to light new facts may be of the greatest importance, but such facts are more likely to be found by the intensive examination of a few cases than by the enthusiastic collection of all insects which can be considered by any stretch of the imagination to show some form of mimetic resemblance.

In conclusion I should like to make a plea for the more intensive study of purely biological problems in Australia. We have special advantages for the study of such problems which few other countries possess and which will not be available to future generations in this country. Even within easy access from such a populous centre as Sydney there are hundreds of square miles of country still in practically its primeval condition, and this gives us unique opportunities for studying organisms in relation to their normal environment. I feel strongly that every possible use should be made of these opportunities while they remain, even if that has to be partly at the expense of taxonomic work. I do not wish to belittle the importance of taxonomic work. The long series of species mentioned and illustrated in this address which I have been unable to get identified clearly demonstrates the urgent necessity for further taxonomic work, as a large number of these are known to be undescribed species and probably a considerable proportion of the remainder are also undescribed. Still, I feel that the biological side of the subject is receiving less than its fair share of attention, and I hope that this address may stimulate some others to take up purely biological work who would not otherwise have done so.

Acknowledgements.

I wish to place on record my indebtedness to those friends who have so generously assisted me in the preparation of this address, for their help has been most valuable.

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The identification of the species to which I have referred, belonging as they do to many different orders, has been no mean task, and it would have been impossible for me to do this myself. It therefore gives me pleasure to acknowledge my indebtedness to the following entomologists for the trouble they have taken in the identification of specimens; to Dr. I. M. Mackerras, of the Department of Public Health, Sydney, for the identification of a long series of Diptera; to Mr. G. H. Hardy, of the Queensland Museum, Brisbane, who assisted Dr. Mackerras in the identification of some of the more troublesome species of Diptera; to Mr. H. Hacker, of the Queensland Museum, Brisbane, for the identification of the Hymenoptera; to Mr. A. M. Lea, Entomologist of the South Australian Museum,

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My thanks are also due to Miss G. Burns for the skilful and painstaking manner in which she has produced the best possible results from a series of rather indifferent negatives when making the illustrations shown in Pl. ii., fig. 23 and 24, and Pls. iv.-xiv., for the photographs of pinned specimens shown in Pls. i-iii., and for the excellent manner in which she has coloured Pls. i. and ii.

I should also like to acknowledge my indebtedness to the Trustees of the National Park. Their public spirited action in setting aside two cottages, at Gundamain and Waterfall, in the National Park, for the use of those who wish to study animals and plants in the field is deserving of the highest commendation and has been of material assistance to me. Many of my observations were made, and some of the photographs reproduced were taken while I was making use of one or other of the cottages.

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Explanation of Plates.

- Pl. i., Pl. ii., figs. 1 to 22, and Pl. iii., photographs of pinned specimens.
Pl. ii., figs. 23 and 24, and Pls. iv.-xiv., photographs of living insects.
Except in Pl. x., figs. 1 and 2, and Pl. xii., fig. 2, all the photographs shown in Pl. ii., figs. 22 and 23, and Pls. v.-xiv. were taken of insects just as they were

found in their natural environment, without interfering with them in any way. In the three exceptions mentioned the insects, in order to be photographed, were placed in situations as nearly as possible identical with those from which they were collected. No photograph has been retouched.

For the sake of brevity in the lists of species the orders are represented by the following letters:—

D.—Diptera, H.—Hymenoptera, C.—Coleoptera, L.—Lepidoptera, R.—Hemiptera (Rhynchota), N.—Neuroptera, O.—Orthoptera.

Plate I.—All Figures are Natural Size.

1. *Paralastor* sp. (H. Eumenidae).
2. *Hylaeoides concinna* Fabr. (H. Hylaeidae).
3. *Codula vespiformis* King (D. Asilidae).
4. *Leucospis* sp. (H. Chalcididae).
5. *Hesthesis variegatus* Fab. (C. Cerambycidae).
6. *Crabro tridentatus* Sm. (H. Crabronidae).
7. *Syndipnomyia* sp. (D. Stratiomyidae).
8. *Paralastor* sp. (H. Eumenidae).
9. *Conops* sp. (D. Conopidae).
10. *Odynerus bicolor* Sauss. (H. Eumenidae).
11. *Laphria* sp. (D. Asilidae).
12. *Paralastor* sp. (H. Eumenidae).
13. *Cerioides breviscapa* Saund. (D. Syrphidae).
14. *Leucopsina odyneroides* Westw. (D. Cyrtidae).
15. *Cerioides variabilis* Ferg. (D. Syrphidae).
16. *Hesthesis* sp. (C. Cerambycidae).
17. *Odynerus* sp. (H. Eumenidae).
18. *Cerioides ornatus* Ferg. (D. Syrphidae).
19. *Conops* sp. (D. Conopidae).
20. *Microdon variegatus* Walk. (D. Syrphidae).
21. *Chrysopogon* sp. near *fasciatus* Ricardo (D. Asilidae).
22. *Odynerus* sp. (H. Eumenidae).
23. *Cerceris australis* Sauss. (H. Philanthidae).
24. *Brachyrhopala fenestrata* Macq. (D. Asilidae).
25. *Cerceris opposita* Sm. (H. Philanthidae).
26. *Microdon variegatus* Walk. (D. Syrphidae).
27. (H. Thynnidae).
28. *Massicyta picta* Brauer (D. Stratiomyidae).
29. *Conops* sp. (D. Conopidae).
30. *Conops* sp. (D. Conopidae).
31. *Conops* sp. (D. Conopidae).
32. *Cerioides opuntiae* Ferg. (D. Syrphidae).
33. *Odynerus* sp. (H. Eumenidae).
34. (H. Braconidae).
35. *Brachyrhopala pulchella* Macq. (D. Asilidae).
36. *Plecia fulvicollis* Fab. (D. Bibionidae).
37. *Brachyrhopala* sp. (D. Asilidae).
38. (H. Psammocharidae).
39. *Phycus* sp. (D. Therevidae).
40. *Megachile suffusipennis* Ckll. (H. Megachilidae).
41. *Cyanonedys leucura* Herm. (D. Asilidae).
42. *Calopompilus raplor* Sm. (H. Psammocharidae).

43. *Ectinorrhynchus superbus* Sch. (D. Therevidae).
44. *Ectinorrhynchus* sp. ? *rufipes* Krob. (D. Therevidae).
45. *Agapophytus* sp. ? *australasiae* Guer. (D. Therevidae).
46. *Prionocnemis connectens* Turn. (H. Psammocharidae).
47. *Miscothyris* sp. (H. Larridae).
48. *Elimus* sp. (H. Eumenidae).
49. *Odynerus* sp. (H. Eumenidae).
50. *Brachyrhopala limbipennis* Macq. (D. Asilidae).
51. *Arpactus frenchii* Sm. (H. Arpactidae).
52. *Hesthesis* sp. ? *cingulata* Kirby (C. Cerambycidae).
53. *Arpactus bellicosus* Sm. (H. Arpactidae).
54. *Hesthesis* sp. ? *cingulata* Kirby (C. Cerambycidae).
55. (D. Tachinidae).
- 56-58. *Metriorrhynchus rhipidius* Mael. (C. Lampyridae).
- 59-61. *Metriorrhynchus irregularis* Waterh. (C. Lampyridae).
62. *Metriorrhynchus rufipennis* Fabr. (C. Lampyridae).
63. *Metriorrhynchus marginipennis* Lea (C. Lampyridae).
64. *Metriorrhynchus heterodoxus* Lea (C. Lampyridae).
65. *Metriorrhynchus marginipennis* Lea (C. Lampyridae).
66. *Trichalus ampliatus* Waterh. (C. Lampyridae).
67. *Metriorrhynchus eremitus* Fabr. (C. Lampyridae).
68. *Metriorrhynchus cryptoleucus* Lea (C. Lampyridae).
- 69-71. *Snellenia hylaea* Turn. (L. Heliodinidae).
72. *Snellenia lineata* Walk. (L. Heliodinidae).
- 73 and 74. *Eroschema poweri* Pasc. (C. Cerambycidae).
75. *Pterostenus suturalis* Oliv. (C. Cerambycidae).
76. *Chaodalis macleayi* Pasc. (C. Cerambycidae).
77. *Pterostenus suturalis* Oliv. (C. Cerambycidae).
78. *Tritocosmia roei* Hope (C. Cerambycidae).
79. *Eroschema* sp. (C. Cerambycidae).
80. *Eroschema atricolle* Pasc. (C. Cerambycidae).
81. *Rhinotia haemoptera* Kirby (C. Curculionidae).
82. *Stigmodera rufipennis* Kirby (C. Buprestidae).
83. *Stigmodera nasata* Saund. (C. Buprestidae).
84. *Stigmodera erythroptera* Boisd. (C. Buprestidae).
85. *Stigmodera praetermissa* Carter (C. Buprestidae).
86. *Palaestra assimilis* Hope (C. Cantharidae).
87. *Palaestra rubripennis* Cast. (C. Cantharidae).
- 88 and 89. *Pseudolychus haemopterus* Guer. (C. Oedemeridae).
- 90-95. *Pseudolychus haemorrhoidalis* Fabr. (C. Oedemeridae).
96. *Calliphora stygia* Fabr. (D. Muscidae).
97. *Scaptia* sp., near *gibbula* Walk. (D. Tabanidae).
98. *Onesia* sp. (D. Muscidae).
99. *Scaptia violacea* Walk. (D. Tabanidae).
100. *Pycnosoma ruffacies* Macq. (D. Muscidae).
101. *Erystalis smaragdi* Walk. (D. Syrphidae).

Plate II.—Figures 1 to 22 are Natural Size.

1. *Tragocerus formosus* Pasc. (C. Cerambycidae).
2. *Abispa ephippium* Fabr. (H. Eumenidae).
3. *Chrysopogon crabroniformis* Roder (D. Asilidae).

4. *Hesthesis ferrugineus* Boisd. (C. Cerambycidae).
5. *Systropus* sp. (D. Bombyliidae).
6. *Sceliphron laetum* Sm. (H. Sphecidae).
7. *Cryptocheilus fulvidorsalis* Turn. (H. Psammocharidae).
8. *Diochlistus aureipennis* Westw. (D. Mydidae).
9. *Lesticothynnus frauenfeldianus* Sauss. (H. Thynnidae).
10. *Diochlistus gracilis* Macq. (D. Mydidae).
11. *Exeirus lateritius* Shuck. (H. Exeiridae).
12. *Tragocerus spencei* Hope. (C. Cerambycidae).
13. *Cryptocheilus fulvidorsalis* Turn. (H. Psammocharidae).
14. *Neosarapogon princeps* Macq. (D. Asilidae).
15. *Calopompilus ornatipennis* Sm. (H. Psammocharidae).
16. *Pelecorrhynchus deuqueti* Hardy (D. Tabanidae).
17. *Suvatta* sp. (H. Ichneumonidae).
18. *Elissoma* sp. (D. Stratiomyidae).
19. *Pseudagenia consociata* Turn. (H. Psammocharidae).
20. *Trogodendron fasciculatum* Schreib. (C. Cleridae).
21. (H. Psammocharidae).
22. *Pelecorrhynchus* sp. (D. Tabanidae).
23. *Tenodera australasiae* Leach (O. Mantidae) in its natural environment and eating a larval tettigoniid. $\times \frac{1}{2}$.
24. *Hesthesis variegatus* Fab. (C. Cerambycidae) about to fly from flower of *Leptospermum*. $\times 1\frac{1}{2}$.

Plate III.

1. *Bimia bicolor* White (C. Cerambycidae). $\times 1$ 1-3.
2. *Aciptera waterhousei* Pasc. (C. Cerambycidae). $\times 1$ 1-3.
3. *Agapete carissima* Newm. (C. Cerambycidae). $\times 1$ 1-3.
4. *Erinus mimula* Pasc. (C. Cerambycidae). $\times 2\frac{1}{2}$.
5. *Pseudocephalus mirus* Pasc. (C. Cerambycidae). $\times 2\frac{1}{2}$.
6. *Ochyra coarctata* Pasc. (C. Cerambycidae). $\times 2\frac{1}{2}$.
7. *Macrones capito* Pasc. (C. Cerambycidae). $\times 1\frac{1}{2}$.
8. *Henicospilus* sp. (H. Ichneumonidae). $\times 1\frac{1}{2}$.
9. *Mantispa* sp., near *australasiae* Guer. (N. Mantispidae). $\times 1\frac{1}{2}$.
10. *Paroxyphilus* sp. (O. Mantidae). $\times 1\frac{1}{2}$.
- 9 and 10 illustrate simple convergence.
11. *Daerlae tricolor* Sign. (R. Lygaeidae). $\times 2\frac{1}{2}$.
12. *Dolichoderus doriae* Em. (H. Formicidae). $\times 2\frac{1}{2}$.
13. Larval *Daerlae tricolor* Sign. (R. Lygaeidae). $\times 2\frac{1}{2}$.
14. (H. Braconidae). $\times 2\frac{1}{2}$.
15. *Eucerocoris* sp., near *basifer* Walk. (R. Miridae). $\times 2\frac{1}{2}$.
16. *Platyura* sp. (D. Mycetophilidae). $\times 1\frac{1}{2}$.
- 17 and 18. *Systoechus vetustus* Walk. (D. Bombyliidae), in 17 viewed from in front, in 18 the same specimen is viewed from behind. $\times 1$.
- 19-22. *Syntomis phepsalotis* Meyr. (L. Syntomidae). $\times 1$.
- 23-26. *Eressa pauropila* Turn. (L. Syntomidae). $\times 1$.
- 27-30. *Trichocerosia zebrina* Hamps. (L. Arctiidae). $\times 1$.

Plates IV.-XIV.

For explanation see the Plates.

THE INCISOR TEETH OF THE MACROPODINAE.

By C. ANDERSON, M.A., D.Sc.

(By permission of the Trustees of the Australian Museum.)

Plates xv. and xvi.

While engaged in a study of the teeth of the extinct "Marsupial Lion," *Thylacoleo carnifex* Owen, I was led to examine the dentition and method of grazing and mastication in recent marsupials, and particularly the supposed scissor-like action of the lower incisors in the sub-family Macropodinae. It has long been known that the two halves of the mandible in a number of marsupials are capable of independent movement, the symphysis not being ankylosed even in the adult. Some writers have attached considerable importance to this feature, alleging that kangaroos and wallabies are thus enabled to snip the herbage by alternately separating and approximating the inner edges of the lower incisors. The first mention of this peculiarity appeared just over one hundred years ago, and it has been commented upon by several authors in the interval. It may be of interest, therefore, to summarise previous accounts, which are scattered in various works and journals; these I have supplemented by some observations and conclusions of my own.

I am indebted to Professor A. N. Burkitt, and Dr. S. Lightoller, Anatomy Department, University of Sydney, for much valuable assistance and advice, and am also under obligation to Mr. R. Rawle, third year medical student, who, under the direction of Professor Burkitt, made a fine dissection of the jaw muscles of *Macropus giganteus* (Pl. xvi., Text-figs. 1, 2).

The mandibular incisors of the Macropodinae have a peculiar form and action. They grow from persistent pulps, though they are not widely open below, and are elongated, lanceolate, and procumbent, projecting from their alveoli in an almost horizontal direction so that when the mouth is closed their long axis is inclined to that of the upper incisors at an angle of nearly ninety degrees. They are inserted in their alveoli so that the plane in which they are flattened is oblique from above inwards, only their inner (lower) edges meeting below when the teeth are unworn. The extero-inferior surface is convex, the intero-superior slightly concave near the two edges, rising to a median rounded ridge. The tooth tapers towards the root, and the greater part of the intra-alveolar portion is not lanceolate but sub-cylindrical.

The relative mobility of the mandibular incisors in the kangaroo (also exhibited by simplici-dentate rodents and Soricidae) was apparently first referred to by Mason Good (1826) who wrote:—

“The *Mus maritimus*, or African Rat, has the singular power of separating at pleasure to a considerable extent the two front teeth of the lower jaw, which are not less than an inch and a quarter long. That elegant and extraordinary creature, the kangaroo, which, from the increase that has lately taken place in His Majesty’s Gardens at Kew, we may soon hope to see naturalised in our own country, is possessed of a similar faculty.”

Waterhouse (1843) says of the lower incisors of the kangaroo:—

“I recollect to have read in the work of one of our voyagers, that the great kangaroo has the power of separating these teeth, and certainly the structure of the lower jaw would seem to permit of such movement. . . . In the skull of a kangaroo before me I find that by slightly contracting the space between the posterior portion of the rami of the lower jaw, the external cutting edges of the incisors are thus brought into contact with the cutting edges of the incisors on both sides of the upper jaw at the same time. . . .”

Murie and Bartlett (1866) investigated the movement of the symphysis of the lower jaw in the kangaroo in some detail, observing the action in the living animal and also making dissections to discover what muscles are involved. They concluded that the rami are separated by the combined action of the pterygoid, digastric, mylohyoid and geniohyoid muscles, while the transverse fibres of the *m. orbicularis oris* are the chief agents in the approximation of the anterior portion of the symphysis and the inner edges of the incisors. These authors describe how the grass was cropped or nipped off by the animals, evidently being cut through by the anterior sharp edges of the lower incisors as they pressed against the opposing concavity of the palate and the cutting edges of the upper incisors, while another portion of the food passed between the two lower incisors and seemed to be also snipped through, either by the approach of the trenchant internal lateral edges of these, or it might be by the jerking movement of the head. Murie and Bartlett, then, are of opinion that the lower incisors act in the manner of a pair of cutting forceps or short-bladed scissors, with also an occasional knife-like action.

Teutleben (1874, pp. 94-97, 110) describes a muscle, *m. transversus mandibulae*, in rodents and certain insectivores, which unites the two rami of the mandible just behind the symphysis, and by its contraction serves to separate the anterior ends of the rami. By contraction of the upper portion of the masseter the two rami are separated in the posterior part of the symphysis, bringing the lower incisors together again. He suggests that by analogy a similar muscle should exist in certain marsupials, but it does not appear that he investigated these.

Alix (1877) discusses the act of mastication in the kangaroo and points out that, while in the ruminants the lower incisors bite against a hard pad in the palate, in the kangaroos the procumbent lower incisors supply the resistance against which the upper incisors bite. He adds that the lower incisors can be separated by a slight movement of the symphysis produced by the action of the mylohyoid on the angles of the jaw, which ceases on contraction of the “symphyseal” muscle.

Blundell (1879) regards this power of separating and approximating the lower incisors as a factor contributing to the survival of the kangaroos, which by using the lower incisors as shears are enabled “to cut off any green shoots or half-buried remains spared by a scorching sun, and obtain nourishment where

any grass-feeding placental would certainly starve." He refers to a circular muscle [? *m. orbicularis oris*] embracing the two rami of the lower jaw, which by its contraction brings the inner edges of the procumbent teeth together; on its relaxation or the contraction of another muscle "placed probably at the extremities of the rami where they hinge upon the facial bones," the incisors are separated. Blundell states that the action of separating the teeth is probably connected in some measure with the action of opening the jaws.

Leche (1888) states that the lower incisors act like forceps, which grasp and sever bundles of grass, the action being rendered possible by the looseness of the symphysis and the presence of a special muscle consisting of transverse fibres which surround the anterior part of the symphysis and the alveoli of the lower incisors. Leche follows Murie and Bartlett in ascribing the separation of the teeth to the combined action of the digastric, mylohyoid and geniohyoid, but he points out that the circular muscle which brings them together is supplied by the mylohyoid nerve, and more probably belongs to the mylohyoid than to *m. orbicularis oris*.

In his great work on the rodents Tullberg (1899) described at some length the transverse mandibular muscle discovered by Teutleben, and the mode in which the lower incisors are separated and approximated in the simpliciidentata. They are brought together, he says, by contraction of the *masseter lateralis* and separated partly by the action of the *m. transversus mandibulae*, but chiefly by the internal pterygoid.

Lönnerberg (1902), one of the latest writers on the subject, follows Tullberg in his discussion of the method of mastication in some of the phalangerids in which the rami of the lower jaw are movable as in the kangaroos. He was not, however, able to detect "any trace of such a transverse muscle as that which is found in the kangaroos at the base of the mandibular incisors and which has the function of approximating the inner edges of these teeth." Lönnerberg is of opinion that in the phalangerids, as in the rodents the masseter presses the mandibular incisors together by bending the lower margin of the ramus outwards, while *m. pterygoideus internus* separates them. He also suggests that in mastication the whole mandible is moved to one side by the combined action of the masseter of the opposite side and in less degree by *m. pterygoideus internus* of the same side, the condyle of the side towards which the movement is directed serving as the pivot.

Weber (1904, p. 335) alludes to a portion of the mylohyoid which in the kangaroos as in simpliciidentate rodents plays a part in the rotation of each half of the mandible. In another place (p. 160) Weber ascribes the rotation of individual halves of the lower jaw in the Macropodidae to the action of the internal pterygoid and the masseter, and surmises that transverse fibres of the mylohyoid (*m. transversus mandibulae*) act as antagonist to this movement as in Simpliciidentata.

It will be seen therefore that there is general agreement that in the Macropodinae the two lower incisors can be separated and approximated at will, but there is divergence of opinion regarding the muscles which actuate the movement, and also regarding the purpose of the movement. Waterhouse suggests that the separation has the effect of bringing the cutting edges of the lower incisors into contact with those of the upper incisors on both sides, while Murie and Bartlett, Blundell, and Leche, are of opinion that the mandibular incisors act like a pair of scissors or forceps. This latter view has apparently been adopted by the authors of most of the standard works on the marsupials (Thomas, 1888, p. 4, Lydekker, 1894, p. 12).

I began my own investigations by a series of visits to Taronga Park Zoological Gardens, where by the courtesy of Mr. A. S. Le Souef, Director, I was able to observe a number of kangaroos and wallabies at close quarters. When not in use the points of the lower incisors rest on the pad formed by the anterior portion of the palate and do not come into contact with the inner edges of the upper incisors (Pl. xv, fig. 1). I found that the lower incisors are capable of considerable relative movement (sometimes as much as a quarter of an inch) both in a horizontal and a vertical direction (Pl. xv, fig. 2), though voluntary vertical movement seems to occur but slightly if at all. When one presents a small bundle of grass stalks to a kangaroo or wallaby, the animal opens its mouth, the mandible is at the same time thrust forward, generally slightly to one side, the lower incisors diverge and the grass is gathered in and severed by an upward jerk of the head. The action is not easy to observe, for it takes place rapidly and the teeth are quickly concealed by the lips, but in most cases it seemed that the grass was held between the points of the lower and the median upper incisors. I formed the conclusion that the lower incisors when separated act, not like scissors or forceps, but like the prongs of a fork or the teeth of a rake, and help to gather the food into the mouth. Cutting action by the inner edges of the lower incisors is quite subordinate, if it happens at all, and is not the main purpose served by the separation of the teeth. In grazing animals different methods of collecting the food are employed; in the cow, for example, the tongue serves this useful purpose, while the horse uses its mobile lips. In the ancestors of the kangaroo the dentition was adapted for an insectivorous diet, for which the procumbent, pointed lower incisors were suitable enough. But with development of the grazing habit the teeth had to be adapted to a new diet, and the separable lower incisors help by enabling the animal to grasp a larger mouthful. It is perhaps also the case that, as Waterhouse suggests, the separation of the lower incisors serves to bring their edges into contact with those of all the lateral upper incisors, thus increasing the grasping and cutting power.

I have made observations also on *Petauroides volans* and *Pseudochirus peregrinus*, and find that their lower incisors too are readily separable. These two forms are largely leaf-eating, and the separable incisors enable them to take a larger bite. The Native Bear (*Phascolarctos cinereus*), in which the mandibular incisors are not separable, habitually snips the stalks at the base of the gum leaves which form its diet, and does not seem to bite the leaves themselves as described by Lönnberg (loc. cit., p. 27).

In dissecting the jaw muscles of *Macropus giganteus*, *M. ruficollis*, and *M. rufus* I have not been able to detect any signs of the presence of *m. transversus mandibulae*, nor of transverse fibres of the mylohyoid, and Dr. Lightoller and Mr. Rawle have also failed to find evidence of these, and Parsons (1896) states that there is no transverse mandibular muscle in *Petrogale xanthopus*. In any case no such special muscle seems to be necessary for the purpose of separating the lower incisors. There is little doubt that the main factor in this separation is the internal pterygoid muscle. As is usual in grazing animals and those with a pronounced lateral (ental and ectal) movement of the mandible this muscle is strongly developed in the Macropodinae, and has a large area of insertion in the shelf formed by the inflection of the angle of the jaw. Moreover, as pointed out to me by Dr. Lightoller, the internal pterygoid in the kangaroo consists of two portions, one of which is a strong bundle of fibres arising on the anterior lateral surface of the pterygoid plate and running downwards, outwards, and backwards to be inserted in the inflected shelf close against the medial surface

of the ascending ramus (Pl. xvi., figs. 1, 2, text-fig. 1). Contraction of this anterior bundle on the left side, say, pulls the left ramus forward, and at the same time rotates its anterior end outwards. The right ramus, on account of

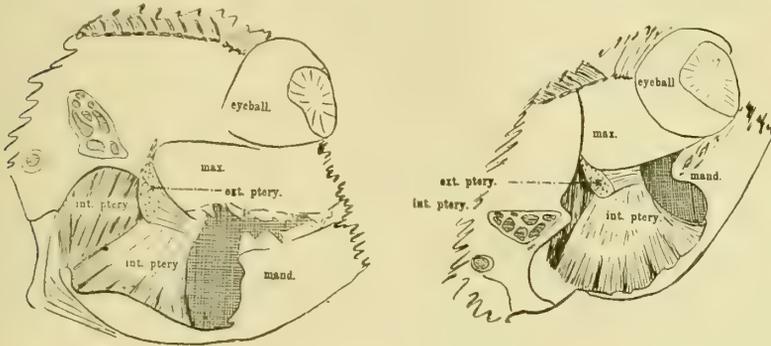


Fig. 1.

Macropus giganteus, No. M. 3914. Dissection by R. Rawle, showing the internal pterygoid muscle; on the right the dissection is viewed partly from above. Drawn by G. S. Lightoller from photographs shown in Pl. xvi.

the looseness of the symphysis, would lag behind slightly and thus the lower incisors would diverge. The external pterygoid is much smaller than the internal, and runs backward almost horizontally to be inserted on the anterior border of the condyle and the articular meniscus, which is quite well developed at least in younger animals. Contraction of the external pterygoid would assist in drawing the ramus forward and to a slight extent in its rotation. Simultaneous contraction of the right and left anterior bundles of the internal pterygoid would cause a wider separation without rotation. The main portion of the muscle runs in a more vertical direction and its contraction simultaneously with that of the masseter and temporal closes the mouth and brings the lower incisors together again, the lower molars at the same time gliding inwards on the upper molars as the two rami are brought nearer to the middle line. The outer fibres of the masseter (*m. masseter lateralis*) may possibly, as suggested by Tullberg and Lönnberg, have some effect in twisting the lower edge of the mandible outwards, but it is more probable that they act as antagonist to the inward twist imparted by the internal pterygoid and steady the jaw.

Dr. Lightoller has kindly supplied me with some interesting details regarding the masticatory and facial musculature of macropods, and a note on *m. transversus mandibulae* in the paca (*Coelogenys paca*). He finds by dissection of *Macropus ruficollis* that what (in *M. bennettii*) is figured by Murie and Bartlett (loc. cit., pp. 31, 33) as *m. orbicularis oris* is really *m. mentalis*; also that they assign to it a more anterior position than it occupies in *M. ruficollis*. In *M. ruficollis* the anterior and posterior borders of *m. mentalis* coincide respectively with those of the symphysis itself (text-fig. 2, C.D.). It is difficult to see therefore how it can act effectively in either separating or closing the incisors. Nor does it seem that *m. orbicularis oris* can serve this purpose, for it is purely a labial muscle, with no attachment to bone.

In dissecting the jaw muscles of the paca (text-fig. 3) Dr. Lightoller

found that *m. transversus mandibulae* is quite distinct from the mylohyoid, being separated therefrom by a well marked fascia.

At the suggestion of Dr. Lightoller, Professor Stump, Department of Ana-

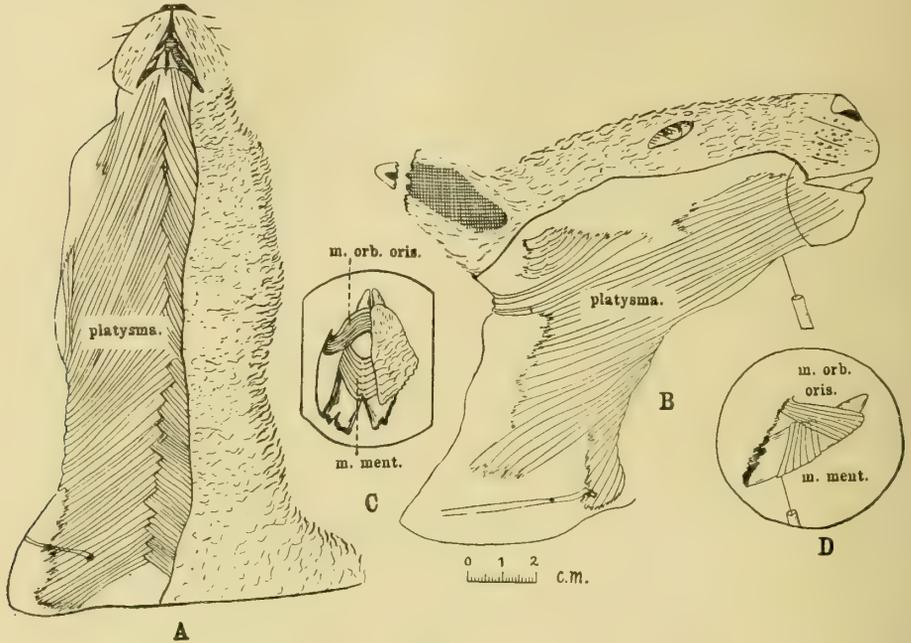


Fig. 2.

Macropus ruficollis. Dissection by G. S. Lightoller, showing the platysma, *m. orbicularis oris* and *m. mentalis*; in B. and D. the needle is inserted at the posterior end of the symphysis.

G. S. Lightoller del.

tomy, University of Sydney, sectioned the mandibular symphysis of *Macropus ruficollis* in order to examine the nature of the symphyseal joint. It was found to be very similar to the pubic symphysis in the human subject, the bone being separated by fibrous tissue, with a small median cavity in the cranial half, which possibly indicates the presence of a synovial cavity.

Mastication in the kangaroo takes place in the same manner as in ruminants, the lower jaw having a lateral movement, though this is not so pronounced as in the ruminants. It is also interesting to note that, as observed by Owen (1839-47, p. 301) in the kangaroos, the food can be regurgitated. Occasionally it can be seen that, after a few convulsive movements and gurgles, some food passes up into the mouth and is chewed over a few times and again swallowed. It is not, however, a prolonged and deliberate action which could be described as "chewing the cud."

It is instructive to compare the teeth of macropodines of different ages and to study the evidence of progressive wear exhibited by the incisors. In young

animals, as already mentioned, the two mandibular incisors make contact with one another only on their inner (lower) edges (Pl. xv., fig. 3). The two oppos-

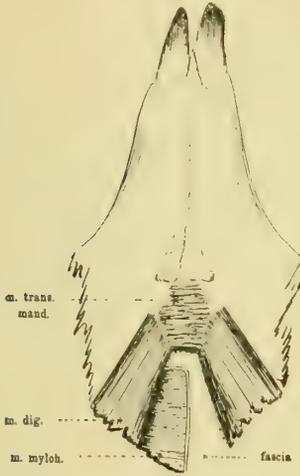


Fig. 3.

Coelogenys paca, No. M. 3918. Dissection by G. S. Lightoller, showing the mylohyoid deep to *m. transversus mandibulae*, from which it is separated by a well defined fascia. $\times 1/1$.

G. S. Lightoller del.

ing fairly sharp edges soon begin to exhibit signs of wear, which commences near the point as a narrow polished surface. This facet extends backwards and widens so that in older animals the two teeth have a considerable area of contact in the median plane. The outer (upper) edges upon which the upper incisors work wear more rapidly and first develop a facet near the point, with a slope forward, downward, and outward. This in older animals becomes a shallow undulant depression on the upper surface elongated antero-posteriorly, and forming a horizontal truncation oblique to the long axis of the tooth (Pl. xv., figs. 3, 4, 7, 8). In very old animals these two surfaces of wear meet at approximately a right angle. At the same time the tooth has moved forward in its socket and the subcylindrical base has replaced the lanceolate anterior portion. It is for this reason that in old animals a considerable space intervenes between the bases of the lower incisors, since their horizontal diameters are now smaller at that point.

In the upper incisors the earliest signs of wear appear on the inner edges (Pl. xv., fig. 5), which develop a slight slope inwards where they come into contact with the point and the outer edges of the lower incisors as these glide inwards to reach the palatal pad. In very old animals the two lateral teeth become reduced to mere stumps, while the median incisor develops a downwardly directed sharp point in front, with a worn surface behind on a level with the abraded crowns of the two lateral incisors, the whole forming a stop for the lower incisors (Pl. xv., figs. 6, 8).

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Explanation of Plate XV.

Fig. 1. *Macropus giganteus*, young. Mandible from below, showing the incisors almost in contact and falling within the upper lateral incisors. $\times 2/3$.

Fig. 2. Same specimen, the incisors separated and making contact with the crowns of the upper lateral incisors. $\times 2/3$.

Fig. 3. *Macropus giganteus*, female, nearly adult; Austr. Mus., No. S.1779. The lower incisors show but little wear and have the characteristic lanceolate shape; oclusal surface marked. $\times \frac{2}{3}$.

Fig. 4. *Macropus rufus*, old male; Austr. Mus., No. S.1758. The incisors are much worn and are sub-cylindrical in shape; oclusal surface marked. $\times 2/3$.

Fig. 5. *Macropus giganteus*. Upper jaws of S.1779. The incisors show slight wear along their inner edges. $\times 2/3$.

Fig. 6. *Macropus rufus*. Upper jaws of S.1658. Incisors are much worn; 1^2 and 1^3 are reduced to stumps and 1^1 has developed anteriorly a sharp point with a shelf behind, which, with 1^2 and 1^3 forms a stop for the lower incisors.

Fig. 7. *Macropus giganteus*. Side view of anterior part of skull and mandible of S.1779.

Fig. 8. *Macropus rufus*. Side view of anterior part of skull and mandible of S.1658.

Explanation of Plate XVI.

Dissection by Mr. R. Rawle of *Macropus giganteus*; Austr. Mus., No. M 3914.

Fig. 1. Lateral view, showing the two portions of the internal pterygoid muscle. $\times 2/3$.

Fig. 2. The same, viewed partly from above, showing the anterior portion of the internal pterygoid running backwards and outwards to its insertion on the inflection of the mandible close against the ascending ramus. $\times 2/3$.

TARONGA PARK AQUARIUM.

Plates xvii.-xix.

On July 19, 1927, the Aquarium at Taronga Park was opened to the public, and during the ensuing three months 110,344 persons paid for admission to the new attraction. This result can only be regarded as indicating what the attendances will be when the night opening has been established, and the genial summer weather lends its appeal, and visitors think of the cool grotto-like Aquarium and its finny inhabitants. Compared with the Aquarium at the Regent's Park Zoological Gardens, London, our local institution bids fair to take a leading position. The attendances at the London Aquarium for 1926 were 436,000, while our first quarter's record exceeds one-fourth of that total.

The entrance to the Aquarium is at the lower gate of the Park, near the ferry wharf, and a wide flight of steps leads through artificial rock work to the first range of tanks which surround the Shark Pool. This Pool is lighted from above by a shaft opening through the roof, as well as by electric light. All the tanks are set in concrete outwardly formed to resemble rock work, while the roof and pillars are all moulded in the form of grottos, lighted by varicolored electric globes concealed in the rock-work, and diffusing a soft and agreeable blend of shades.

Steps lead to a freshwater pool with a miniature waterfall, surrounded by a second range of tanks. The total superficial area of the glass fronts of the tanks is 684 square feet.

From the second gallery a short flight of steps leads in one direction to a beautiful rockery giving access to the Park, and in the other direction to the roof of the Aquarium, a splendid look-out giving an uninterrupted view of the Harbour with all its colours and movement. The light shaft column is concealed by a number of cosy nooks in artificial rock, furnished with tables and chairs, and refreshments are obtainable on the spot.

The Aquarium is open to the public on week days from 2 to 5 p.m., and on Sundays from 1 to 5 p.m. It is also open at night on Mondays, Wednesdays and Fridays from 7 to 10 p.m. The charges for admission are 6d. and 3d. for adults and children respectively in the daytime, and 1/- and 6d. at night.

The cost of the building and fittings was £18,000, of which £12,000 was from the Park funds, and £6,000 was contributed by the Government.

IN MEMORIAM.

EUSTACE WILLIAM FERGUSON, M.B., Ch.M., D.P.H.,

Pathologist and Naturalist.

(Portrait Plate xx.)

Born at Invercargill, New Zealand, 1884. Died at Wairoa, New South Wales, July 18, 1927.

Scientific circles of Australia are bemoaning the tragic loss, at the early age of forty-two years, of a gifted pathologist, an eminent naturalist, and a lovable personality when Eustace Ferguson, stricken with the dread nephritis, passed away after a lingering illness of nine months.

A son of the distinguished divine Rev. John Ferguson, he came to Sydney in 1894 when his father became the minister of St. Stephen's, Phillip Street. The writer's acquaintance with him began when he took the rare part of the few recorded undergraduates of Sydney University (to that date), who were interested in the natural history collections left by Sir William Macleay to the grudging care of that institution. The veteran curator of the Macleay Museum, George Masters,—a very Nestor of naturalists—at once saw unusual gifts in the young collector who was bringing rare and novel insects to his notice, and encouraged him to follow up his congenial pursuit with improved methods. Mr. Masters's room was a sort of entomological forum where amateur and professional met, so that Eustace Ferguson soon became known as an ardent coleopterist and collector. Amongst the many companions of my bush rambles in various parts of Australia I have never met his equal for close observation of natural objects; his vision apparently combining certain telescopic, as well as microscopic qualities, to which a retentive memory added the power of recalling the form of the smallest insect he had once examined.

Graduating in 1908 with Honours in Medicine, I heard incidentally that in that part of the *viva voce* examination which consisted in distinguishing and naming microbes and bacilli under the microscope, Eustace was easily first. A fellow student in his year later told me that in those subjects into which natural science or any sort of morphology entered Ferguson "set us all a terribly high standard."

He lost no time in associating with his brother naturalists, joining the Linnean Society of New South Wales in June, 1908, and contributing his first paper a year later on the Amycterinae, or ground weevils (Part 1, *Psolidura*). This interesting group of endemic beetles, with a wide range over the whole continent, had been puzzling previous systematists owing to the species tending to variation and to resemble their allies. At once his reputation was founded. Shortly after this I received a letter from the well known Commander J. J. Walker, R.N. (afterwards President of the Entomological Society of London) in

high praise of the lucid treatment of the subject, and concluding with words to the effect that *we could do with plenty more work of that kind*. But already a physical setback had occurred. His first medical appointment was to act as *locum tenens* in a practice on the South Coast (Kiama, I think) and, catching a chill during night work, endured his first attack of nephritis. For six months he lay in the Sydney Hospital whence he emerged to recuperate in that naturalists' paradise Kuranda, North Queensland. Although this had been for years the hunting ground of the famous collector Mr. F. P. Dodd, and Ferguson was an invalid, he managed to bring back several species new to science. General practice being forbidden him, he found suitable occupation in the Department of Public Health, where his ability as a pathologist made him peculiarly serviceable. In logical sequence he followed up those branches of microbiology and entomology that were related to medicine, and in addition to his other fields of work he soon acquired a wide knowledge of fleas, ticks and biting flies. Thus after completing a masterly revision of the Amycterinae (which Dr. Sharp and he showed should be correctly styled Phalidurinae) in sixteen papers—eleven published by the Linnean Society of New South Wales, three by the Royal Society of Victoria, and two by the Royal Society of South Australia—he was busily working at mosquitoes and march flies (Tabanidae). By this time he had succeeded Dr. (now Professor) Cleland as Principal Microbiologist to the Department, and had married Miss Jessie Perry, daughter of the well known squatter of the Narromine district. The details of his medical work cannot be treated here, but especially valuable were the "Tests for the Susceptibility to Diphtheria," organised by him, as well as his "Report on Dengue Fever," the latter actually concluded during his final illness.

In 1915 his unselfish patriotism led him to volunteer for medical service at the Front, and for three years he left his wife and family to serve with the A.I.F. in England, France, Egypt and Palestine. Characteristically, he was learning all the time, and finding extraordinary interest in the history and archaeology of the old world. Thus he visited Scotland, the home of his fathers, and especially profited by his time in London to work at the British museum of Natural History, where he made many friends and studied the types of Australian insects in that institution. In France he found time to study Roman remains at Nismes and Arles; in the East he became interested in Aegyptology and the Assyrian relics, and I was amazed to find how deeply he had delved in the literature and records of these lands. "Ah, but," said he to me, pointing to his shelves, "I inherited those books on Assyria from my father and had already read them as a boy." After the Armistice he managed to make a long tour of the Nile and across the Desert to a Red Sea port, besides penetrating some way into Mesopotamia. From 1919 onwards he worked steadily at the Diptera, especially on disease-carrying flies, fleas, also ticks, on which he was the accepted authority in Australia, so that he was naturally selected to lecture on this subject at the Pan-Pacific Conference of 1923. He published some half-dozen papers in the Proceedings of the Linnean Society of New South Wales on Diptera, chiefly on the Tabanidae and Syrphidae, but his work was not limited to this. His sound judgment told him that in those groups in which many Australian species had a wide distribution outside Australia he would more wisely enrol the services of world specialists to elucidate a firm basis for our knowledge; and by sending material to these he was able to communicate no less than sixteen papers on Australian Diptera to the Linnean Society between the years 1922-7; also five to Vol. iii. of the "Australian Zoologist." Of these twelve

are by J. R. Malloch, three by C. P. Alexander, five by Professor Bezzi, and one by C. H. Curran, and E. H. Bryan.

He was a member of Council and Vice-president of the Royal Zoological Society of New South Wales, of which he was President in 1922. His presidential address contained an able plea for a Biological Survey of Australia, and described in some detail the work of the Bureau of Biological Survey of the United States of America. His connection with the Linnean Society of New South Wales was of longer standing, as noted above. He was a member of its Council from 1921, later a Vice-president, and in 1926 President, in the November of which year he was stricken with his prolonged and fatal illness. He was an Associate member of the Australian Research Council, a member of the Great Barrier Reef Committee, and a member of the Royal Society of New South Wales. His Linnean presidential address was a Review of Medical and Veterinary Entomology in Australia, and is a model epitome of work that has done so much for the safety of man and of domestic animals in tropical and sub-tropical countries.

He leaves a widow and six children, five sons and a daughter, the last born during the present year.

H. J. CARTER.

26/7/'27.

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HENRY LUKE WHITE,

Pastoralist, Naturalist, and Philatelist.

(Portrait Plate xxi.)

Born at Anambah, near West Maitland, New South Wales, May 9, 1860. Died at Belltrees, New South Wales, May 29, 1927.

The State has lost a citizen of a type only too rare. Henry Luke White, who as a young man took up the profession of a surveyor, and quite early in life turned to pastoral pursuits, became one of the foremost pastoralists in New South Wales. When as the result of the strenuous work of himself and three brothers the great Belltrees and other properties in this State and Queensland were soundly established, the senior partner was able to devote more time to cultivate seriously the hobbies of his boyhood—egg and stamp collecting.

The thoroughness that characterised his pastoral pursuits was applied to his hobbies and, although he still carried on the supervising of his stations,

rising at daylight to ride for hours on business relating to sheep and cattle, he employed his too brief leisure in conducting correspondence and organising the work of accumulating what he hoped to make the greatest collections in the world of Australian birds' eggs and postage stamps. The latter hobby resolved itself largely into an intelligent and careful buying up and amalgamation of the collections of other philatelists, the result being the achievement of a representative collection of the stamps of four States, the first to be virtually completed being New South Wales. This collection he presented to the Mitchell Library in 1917, and later he added Western Australia, Queensland, and Tasmania. The present value of these gifts is approximately £50,000.

In the field of natural history, H. L. White confined his energies to the birds of Australia, and particularly to the discovery and description of the eggs of species previously undescribed. To this end he engaged the services of experienced bushmen and collectors, the first to be sent out being Sidney William Jackson, whose fine collection of eggs he had acquired. Jackson worked in Queensland amongst the jungle and forest of the Atherton district and the Macpherson Range; in South-western Australia; in the Dorrigo scrub, and other places in New South Wales. W. McLennan was despatched to Cape York, Groote Eylandt, the McArthur River, and other parts of North Queensland and the Northern Territory. F. L. Whitlock was engaged to investigate the regions of North-west, and Central Australia, and other collectors were financed, subsidised, or assisted to obtain eggs of rare or little known species. The result of this intensive investigation was the building up of a magnificent collection of Australian birds' eggs in perfect "clutches" or settings, and in series showing all the distinct variations of colour, markings, and dimensions. 143 "type" sets were obtained, and the descriptions were written and published in the "Emu," either by H. L. White himself, or by one of his collectors, to whom he most generously conceded the privilege of authorship. Some of the most interesting and informative articles that have ever been published in relation to our Australian avifauna were written by the collectors abovenamed. Another feature of the H. L. White collection was the truly amazing series of eggs of Australian cuckoos taken with the eggs of their numerous hosts. This great accumulation of eggs was from its initiation destined to become a national possession, and, although it remained at Belltrees during the life of its originator, it was bequeathed by him to the National Museum, Melbourne, together with the elaborate cabinets in which it was contained, and the valuable data books in which the history of each egg was fully recorded. This collection contained 3,754 clutches of 700 species and 140 subspecies, and totalled 10,195 eggs, exclusive of 503 cuckoo clutches containing 535 eggs of the parasitic birds, and 1,133 of the foster parents, a grand total of 11,863 eggs.

H. L. White also collected the skins of Australian birds, purchasing several collections already made, and obtaining numerous rare species through the efforts of his collectors. This collection of over 10,000 skins he presented to the National Museum, Melbourne, in 1917.

His benefactions to the Royal Australasian Ornithologists' Union were a sum of £1,000, a set of Gould's folio "Birds of Australia," valued at £300, and other contributions to the various activities of that Society.

He contributed popular articles to the "Australian Zoologist," and was a life member of the Royal Zoological Society of New South Wales, as are also his son and two daughters. He was a member of the British Ornithologists' Union, and a corresponding Fellow of the American Ornithologists' Union. In

the philatelic world his merits were recognised by the entry of his name on the Roll of Distinguished Philatelists.

The "H. L. White" collections will perpetuate the memory of a man who devoted his whole leisure, a superabundant energy, and a generous purse to the accumulation of something not already adequately represented in any Australian public institution, and this for the benefit of his fellow students in the fields of natural history and philately. The greater part of his accumulations were publicly bestowed in his lifetime, and he had the gratification of reading and hearing the commendations of press and public alike. His example is one that might well be followed by others equally favoured by fortune and opportunity to thus give while they live, and listen to the thanks of their beneficiaries, rather than have them addressed to an unresponsive grave.

A. F. BASSET HULL.

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Description of New or Rare Eggs (*Ninox humeralis*, *Acanthiza pygmaea*, *Garzetta nigripes*, *Dacelo minor*, *Pachycephala inornata*, *Aprosmictus cyanopygius*, *Lopholaemus antarcticus*, *Climacteris minor*, and *Eulabeornis castaneiventer*). *Emu*, xvi., 159-164, 2 pls., 1917.

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Description of a New Sub-species of *Malurus cyanotus*. *Emu*, xviii., 121, 1918.

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Descriptions of Two New Nests and Eggs (*Malurus leucopterus edouardi* and *Eremiornis carteri*). *Emu*, xviii., 127-8, 1918.

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Description of New Australian Eggs collected by F. Lawson Whitlock, R.A.O.U., at Dirk Hartog Island, Western Australia (*Malurus leucopterus*, *Stipiturus malachurus hartogi*, *Calamanthus campestris hartogi*, *Corvus bennetti bonhoti*, *Oreoica cristata lloydii*, and *Anthus australis hartogi*). *Emu*, xx., 186, 1921.

Notes on the Grass Wren (*Amytornis textilis*). *Emu*, xx., 190, pl., 1921.

Nests and Eggs Not Previously Described (*Atrichornis rufescens jacksoni*, *Pachycephala olivacea macphersonianus*, and *Pachycephala rufiventris maudeae*). *Emu*, xx., 193-4, 2 pls., 1921.

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Descriptions of New Nests and Eggs (*Cinclosoma alisteri*, *Acanthiza pusilla whitlocki*, *Strepera graculina robinsoni*, *Climacteris melanota*, *Geophaps scripta peninsulæ*, and *Podargus strigoides capensis*). *Emu*, xxi., 164, 1922.

Abnormal and Curious Combination Clutches. *Emu*, xxi., 167, 1922.

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An Abnormal Clutch of Blue-faced Honey-eater's Eggs. *Emu*, xxii., 3, 1922.

New sub-species of *Acanthiza nana* Vigors & Horsfield. *Emu*, xxii., 97, 1922.

Description of Eggs of the Golden-shouldered Parrot (*Psephotus chrysopygus*). *Emu*, xxii., 98, 1922.

A Collecting Trip to Cape York Peninsula. *Emu*, xxii., 99, 11 pls., 1922.

Notes on the Pied Bell-Magpie (*Strepera graculina*). *Emu*, xxii., 258, 1923.

The Wing Markings of the Black-backed Magpie. *Emu*, xxiii., 2, 1923.

The White Goshawk. *Emu*, xxiii., 3, 1923.

Description of Some New Nests and Eggs (*Amytornis purnelli*, *A. modesta*, and *Stipiturus ruficeps*). *Emu*, xxiii., 241-2, 1924.

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WILLIAM EDWARD JOHN PARADICE, M.B., Ch.M. (Syd.),

Surgeon Lieutenant-Commander, Royal Australian Navy.

(Portrait Plate xxii.)

Born at Sydney, New South Wales, February, 1897; died at Sydney, 3rd November, 1927.

Thursday, November 3rd, 1927, will always be remembered as a tragic day in the history of the Royal Zoological Society of New South Wales, for the unparalleled disaster, when the s.s. "Tabiti" struck and sank the ferry "Greycliffe" on the waters of Port Jackson, resulting in the death of one of its most prominent and capable members in the person of Surgeon Lieut.-Commander W. E. J. Paradise. This enthusiastic naturalist, so suddenly removed from our midst when on the threshold of a brilliant naval and biological career, revealed himself to his intimates as a lovable character and steadfast friend. It was he who must be credited with the inauguration of our Marine Zoological Section, which is now firmly established largely as a result of his labours.

Dr. Paradise was born in Sydney in February, 1897, and educated at the Fort Street High School. He was a promising scholar and a good sportsman, and early evinced a love of natural history, being particularly interested in fishes. He was also an excellent rifle shot and, whilst in England with the Commonwealth Coronation Cadet Contingent in 1911, took part in contests at Bisley. After studying Medicine at the University of Sydney and graduating with the degrees M.B. and Ch.M. in 1920, Dr. Paradise entered the Royal Australian Navy as a Surgeon-Lieutenant on August 1st, 1921, and was attached to H.M.A.S. "Geranium" in 1923 and 1924, when, under Commander H. T. Bennett, D.S.O., R.N., she carried on survey work in Queensland and the Northern Territory

There he was able to indulge his bent for natural history to the full, and made large collections of marine animals for the Australian Museum. He was instrumental in securing also a large fossil *Ichthyosaurus* from the Northern Territory.

Dr. Paradice was an active member of the Great Barrier Reef Investigation Committee, and wrote an important paper on the coral reefs of the Outer Barrier. In recognition of this scientific work, he was promoted to the rank of Surgeon Lieutenant-Commander on August 1st, 1926, being then Medical Officer in charge at Garden Island, Port Jackson, and of the Naval wing of the Prince of Wales Hospital, Randwick. In association with Museum zoologists, he made a hydrographic survey of the mud-flats of Gunnamatta Bay, near Sydney, a rich collecting ground for marine invertebrates, and was elected an Honorary Correspondent of the Australian Museum. He was Honorary Secretary and later Vice-President of the Marine Zoological Section of the Royal Zoological Society, of which he was a Councillor. Just prior to his death, Dr. Paradice had been engaged in working out the life-histories of the commoner fishes of Port Jackson, and was President of the Microscopical Society of New South Wales. A bryozoan, *Phylactella paradiceii*, has been named in his honour.*

His remains were interred with full Naval honours at South Head Cemetery, overlooking the Harbour whose natural history he had studied so assiduously, and in whose placid waters he had met his most untimely fate.

Surgeon Lieut.-Commander Paradice has left a widow (daughter of the late Mr. Wm. Houston) and baby son to mourn his loss, whilst his many friends in naval and scientific circles will sadly miss his company and the quiet and sincere disposition which had endeared him to them all.

A sudden demise, such as his, forcibly reminds us that we are only separated from extinction at times by a momentary hesitation or indecision, and makes us realise how paltry are our little hopes, fears, and differences of opinion.

G. P. WHITLEY and F. A. McNEILL.

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Dealt with more fully in "Reports of Three Cases," *infra*, 1924.
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- A Report on the Sir Edward Pellew Group, with Special Reference to Biology and Physical Features. (*Parl. Comm. Australia Rept.*) Govt. Printer, Melbourne, 1924. Fol., 1-20, of which 9-20 are plates; 6 maps and 2 topographical sketches.
- Injuries and Lesions caused by the bites of Animals and Insects. *Med. Journ. Austr.*, 1924, ii., 650-652, figs. 1-2.
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- Fish and other Marine Animals of Australia, of Special Interest. *Health Inspect. Assoc. Austr., Quart. Rev.*, iv., 3, July, 1926, 43-48, pls. i.-ii.
- Some Recent Natural History Observations. (A Note on the Occurrence of Burrowing Crustacean *Sphaeroma quoyana* at Cockatoo Island, Sydney;

* Livingstone, Records of the Australian Museum, xv., 1, 1926, p. 89, pl. vii. and figure 1.

A Note on the Occurrence of Albatrosses in Sydney Harbour during the Winter of 1926; A Note on the Habits and Station of *Centrostephanus rogersi* in Port Jackson; Observations on the Breeding of the Black Swan (*Chenopsis atrata*) and the Black Duck (*Anas superciliosa*) in Centennial Park, Sydney, during August, 1926). *Austr. Zool.*, iv., 5, November 30th, 1926, 319-322, pls. xlii.-liv.

Northern Territory Fishes. An Annotated List of Fishes collected from the waters of the Northern Territory of Australia during the Cruises of H.M.A.S. "Geranium," 1923-1925. *Mem. Q'ld. Mus.*, ix., 1, April 28th, 1927, 76-106, pls. xi.-xv., text-figs. 1-3, and sketch-map (with Gilbert P. Whitley).

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REVIEW.

A MONOGRAPH OF THE AUSTRALIAN LORICATES.

(*Phylum Mollusca—Order Loricata*).

By Tom Iredale and A. F. Basset Hull. 4to., pp. i.-xiii. + 1-168, pls. i.-xxi., figs. 1-12 and frontispiece. Published 20th July, 1927, by the Royal Zoological Society of New South Wales. Price, Five Shillings.

Students of natural history in Australia frequently feel the need for well-illustrated books dealing authoritatively with its fauna and flora. Of late, several fine works on Australian animals, notably vertebrates and insects, have appeared to help in filling this need, and now a Monograph of Australian Loricates can be added to their number.

The Loricates, Chitons, or Mail Shells are remarkable molluscs which are found quite commonly on all Australian coasts. Their beautiful shells, made up of eight plates, have been utilised in making jewellery, whilst an increasing number of naturalists now collect them for cabinet purposes, because, apart from their scientific interest, they make a fine display when mounted.

Messrs. T. Iredale and A. F. Basset Hull have written on the Loricates in such detail in their Monograph that any known Australian species may be named from their work, and all that has been discovered about its distribution and habits learned. Fossils and freaks are also dealt with, and interesting notes and pictures are given of the conchologists and collectors who have studied our Loricata fauna. The Monograph contains well over four hundred fine figures, some of them being coloured, and all specially prepared by expert artists. No naturalist interested in our marine fauna should be without this model monograph, which was wholly compiled and printed in Australia.

G. P. W.

NOTES AND NOTICES.

New Members: The following have been elected since publication of the last list (18 May, 1927):—

Associate Benefactor: The Walter and Eliza Hall Trust.

Life Members: Frank Buckle, W. C. Cormack.

Ordinary Members: F. Black, A. Bailey, H. V. Carter, K. G. Childers, Mrs.

D. Fels, W. Hannam, W. H. Hannam, E. Judd, M. C. Faviell, E. H. Lindquist, H. S. Mort, H. D. McLachlan, W. J. McMaster, R. McLean, E. A. Palmer, K. C. Richardson, C. Thackeray.

Life Associate Member: Phillip A. Wright.

Associate Members: R. F. Bailey, Mrs. C. A. Ferguson, H. H. Finlayson, W. M. Gower, Miss E. Harnett, Mr. and Mrs. J. Castle Harris, R. S. Hackett, G. G. Kelly, W. A. MacDougall, A. Probsthain, D. H. Stuart, Miss. V. Taylor, H. Tanner, C. Walton.

Honorary Associate Member: Gregory M. Mathews.

MEETINGS OF SECTIONS.

Entomological Section:

Wednesday—8 February, 1928.	Wednesday—9 May, 1928.
14 March,	13 June,
11 April,	

Marine Zoological Section:

Monday—5 December, 1927.	Monday—2 April, 1928.
2 January, 1928.	7 May,
6 February,	4 June,
5 March,	

Ornithological Section:

Friday—16 December, 1927.	Friday—13 April, 1928.
20 January, 1928.	18 May,
17 February,	15 June,
16 March,	

Sectional meetings are held in the Society's room, Bull's Chambers, 28 Martin Place, Sydney, at 7.30 p.m.

A NEW RULE.

Rule 6.—Endowment Members, Benefactors, and Associate Benefactors shall be elected by the Council upon nomination by a member of Council.

Every Endowment Member, Benefactor, and Associate Benefactor shall be entitled to receive an annual pass and tickets of admission to Taronga Park as in the case of an ordinary member. In the case of a corporation or trust the pass shall be issued in the name of some person nominated by such corporation or trust.

INTENSIVE BIRD OBSERVING.

We have read very many "Observations" contributed to our contemporaries, but few have equalled the following article, which we extract from *The Victorian Naturalist*, vol. xliii., 1926, 216:—

BLUE WRENS IN MELBOURNE GARDENS.

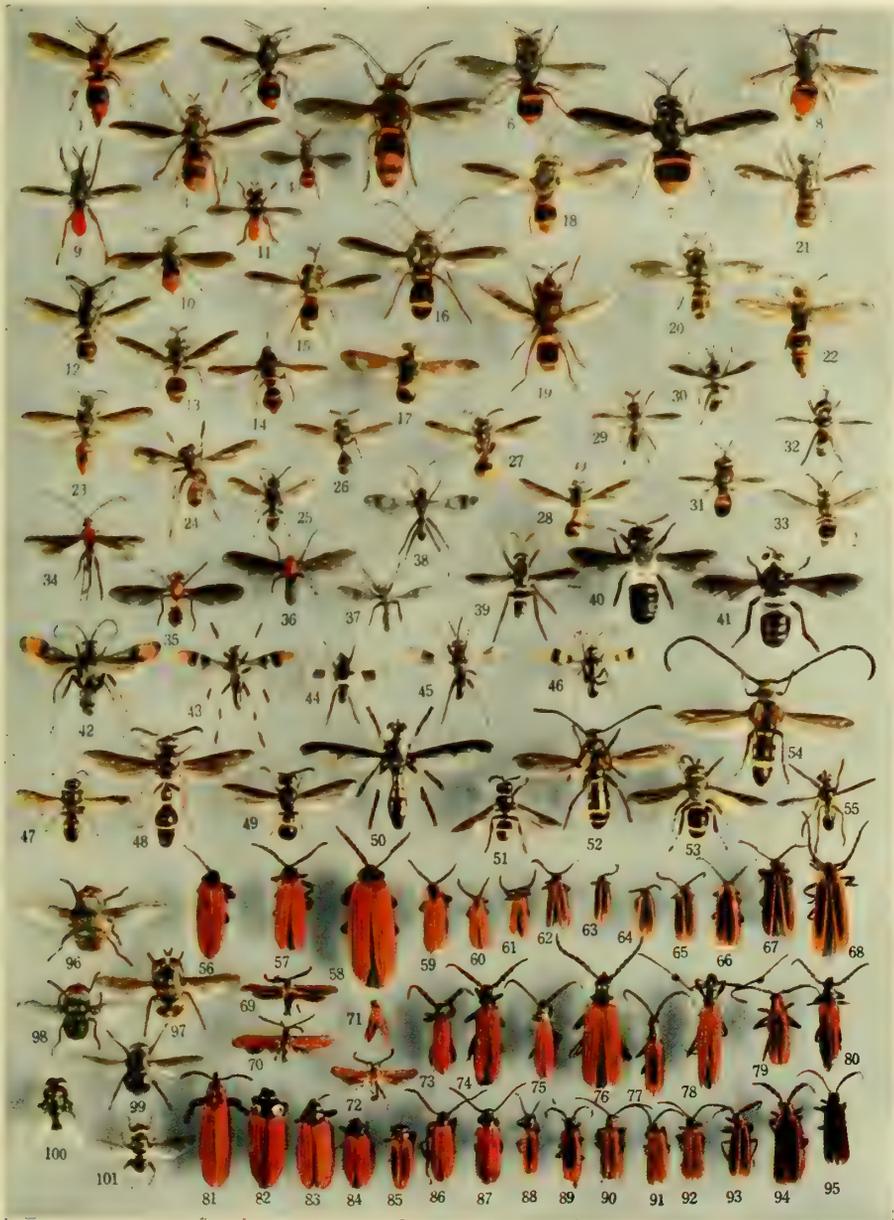
Writing on Blue Wrens in the "Naturalist" of August last, D. Dickison says—"few, if any of the males lose their bright plumage during winter." My experience is of nine pairs of birds about the Treasury and Fitzroy Gardens, Melbourne, some of which have been observed for three years. Seven of the nine males went out of colour last winter. Two appeared to keep their blue plumage all the year. Three that I have watched for three winters were out of colour this year. All are very careful to keep to their own particular localities. If one crossed a path into another's flower bed, it was at once chased out by one or other of the pair occupying it. One pair, behind the Treasury, has its domain separated by quite an imaginary line from that of the neighbouring pair a few yards away. This exclusiveness is, however departed from about June, when the parent birds take the young ones out to get rid of them to would-be partners. Not all are disposed of thus, and those not mated feed the second and third broods willingly, and some even stay with their parents for three years, though in full colour.

The greatest fear the Blue Wrens have is of the White-naped Honeyeaters (*Ptilotis penicillata*) swooping down on them, and if feeding in the open they watch carefully for these assaults. On windy days, too, the noise seems to prevent them ever leaving the shelter of the bushes.

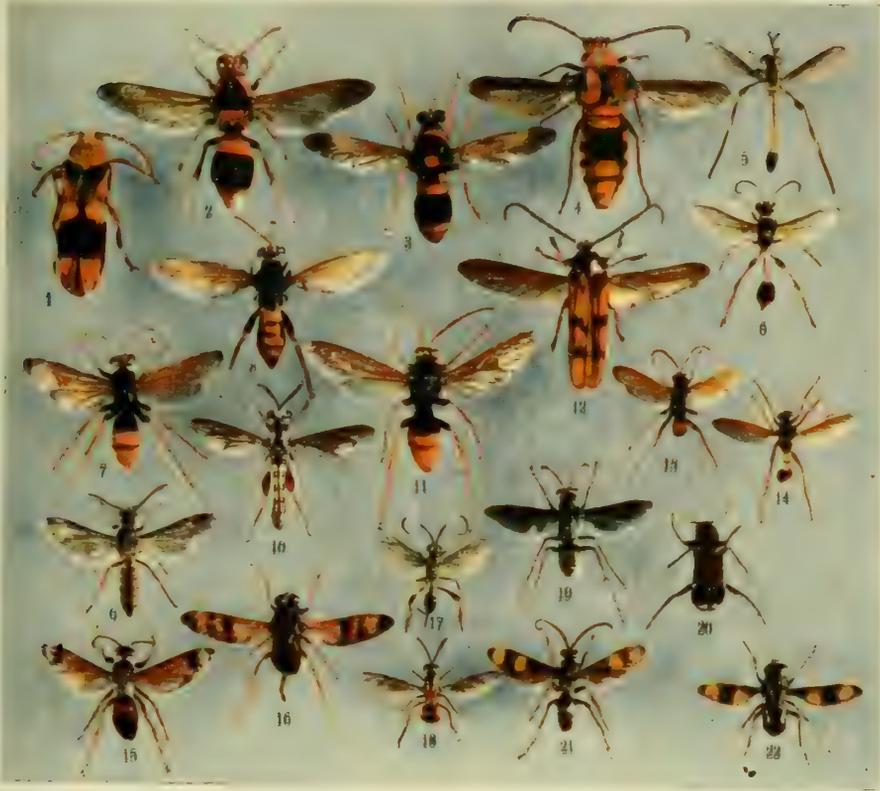
These Wrens are all known birds that come when called, to eat egg or cake, and call out complainingly if we pass without feeding them. They are as follow:—

1. The Treasury pair which has been reported to have nested near here each season for four years. The male does not change colour in the winter.
2. The pair in the old Scotch College garden. The male is from No. 3, where he fed the young ones for three years, although in colour.
3. The very tame pair at the arch in the Treasury Gardens in Lansdowne Street. These are so tame that they feed out of our hands. Last year a bough fell on the archway while they were nesting. In consequence they tried to nest in the rubbish below, but were driven out and re turned to the arch. They come many yards to meet us when called.
4. The pair in the left hand bed in the Fitzroy Gardens. The female, who is white-eyed, is from No. 3. She wandered over to the left, where she mated with a lone male. They then frequented the gully for a time, but finally returned, and are now (September) nesting in the pine tree.
5. The pair on the right hand side of the path in the small cypress. Last year they built in a palm. The cock, specially, fed the young ones. This year they have already hatched out. A different pair built in the same place before, but were disturbed.
6. The pair in the rubbish tip beside the gully. The female is an albino. These have a very wide range.
7. The pair in the hedge round the gardener's house. This male has two white shoulders. The female comes from as far as 100 yards to meet us.
8. The pair nesting just outside the work-shop.
9. A white-eyed female and her mate living just behind No. 1.

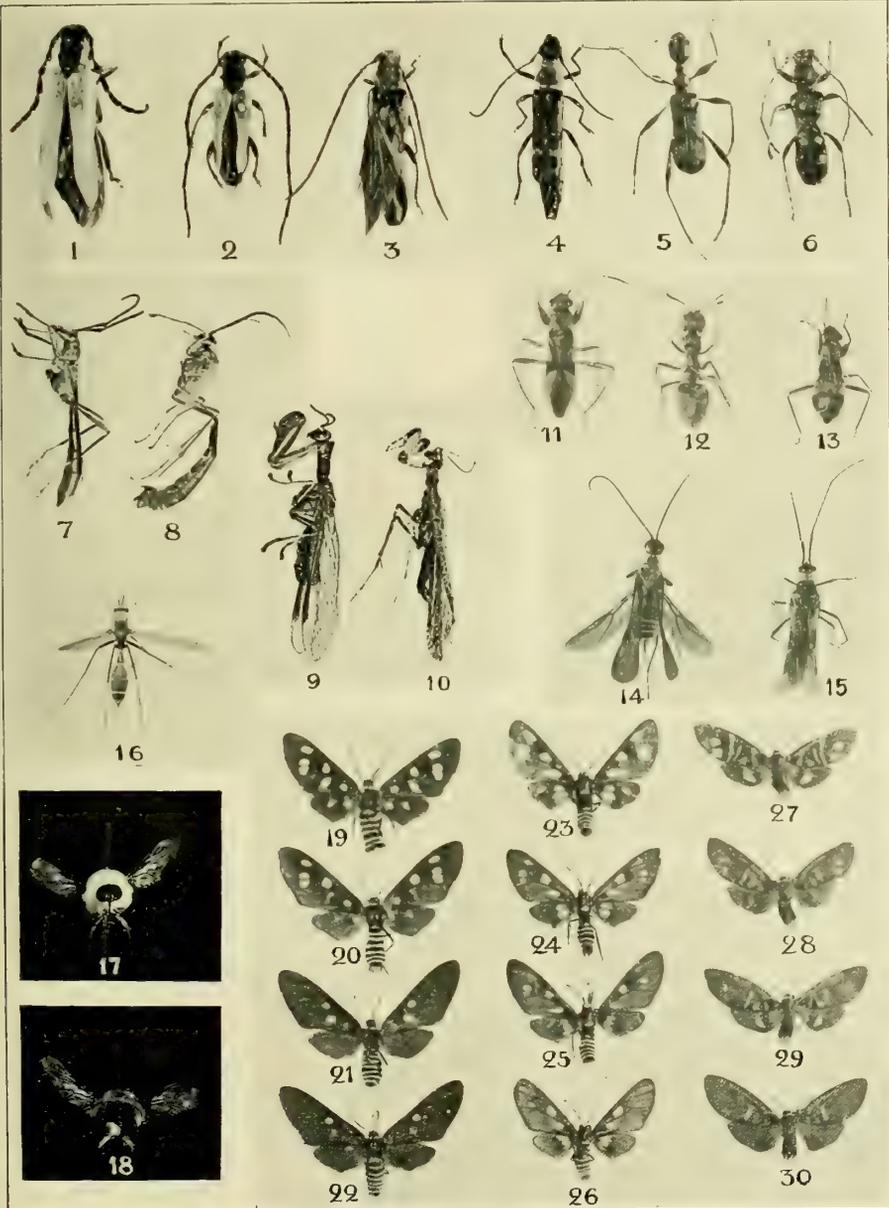
—G. HORNE.



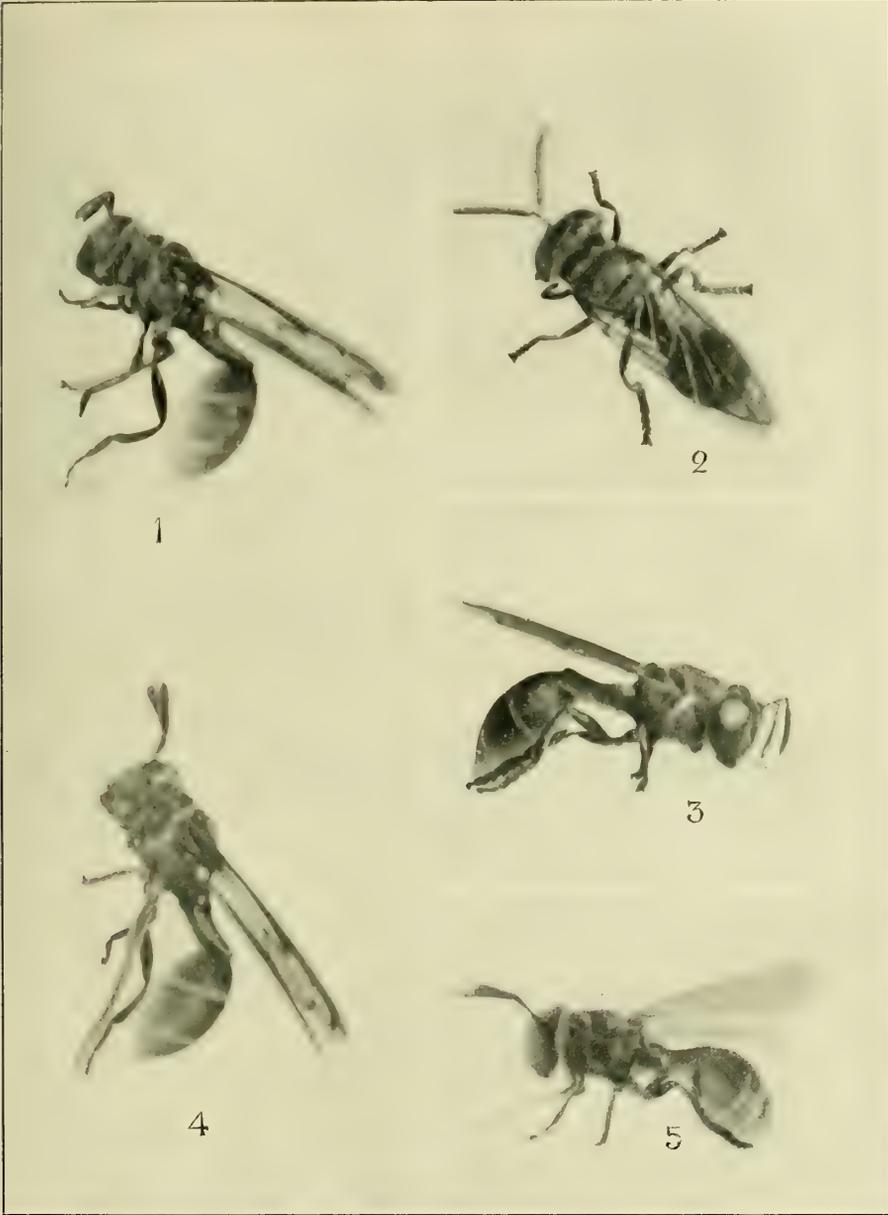
See explanation of Plate on p. 102.



See explanation of Plate on p. 103.



See explanation of Plate on p. 104.



Photographs of a living wasp-like syrphid fly, *Microdon variegatus* Walk. Fig. 2 shows the normal fly-attitude of the resting insect and the remaining figures the wasp-like attitudes assumed by the active insect. Notice the vibrating wings and antennae in Fig. 5. x5.



Fig. 2.

Fig. 2. *Hesthesia ferruginea* Bd., visiting flowers of *Leptospermum*. x14.



Fig. 1.

Fig. 1. *Hesthesia cingulata* Kly., a wasp-like longicorn beetle, visiting flowers of *Angophora*. x14.

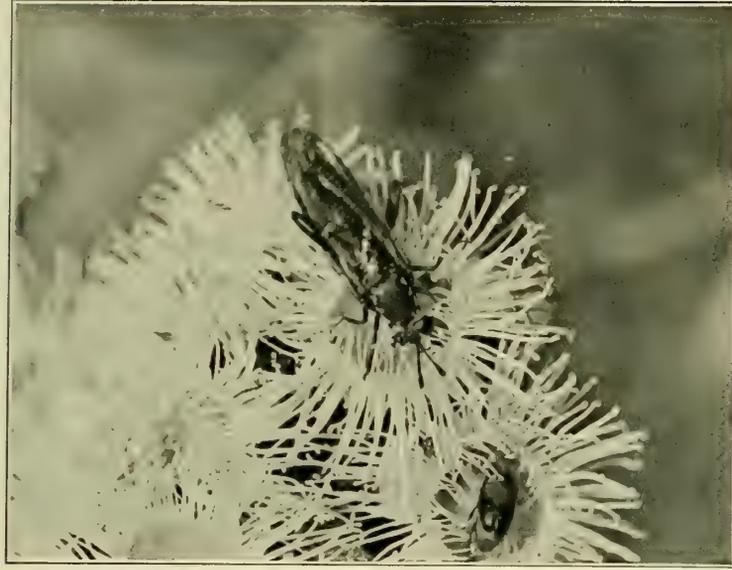


Fig. 2.

Fig. 2. A mydoid fly, *Miltinus viduatus* Wwd., visiting flowers of *Angophora*. The blurred appearance of the wings is due to their rapid vibration. x 2.



Fig. 1.

Fig. 1. A paper-wasp, *Polistes* sp. (near *tepidus* Fabr.), capturing a larva of *Danaida archippus* Fabr. Note the conspicuous "warning colouration" of the latter. x 1.



Fig. 1.



Fig. 2.

Fig. 1 adult and Fig. 2 young larva of a coreid bug, *Riptortus* sp. The young larva is very similar in appearance to a species of ant found in the same situation. Adult $\times 1\frac{1}{2}$, larva $\times 2\frac{1}{2}$.



Fig. 1. An ant-lion lacewing fly, *Formicaleo brevisculus* Gerst. resting on a twig. x 2½.



Fig. 2. A green leaf-like longhorned grasshopper, *Caedicia olivacea* Brunn., resting amongst rose leaves. x 1½.



A stick-insect, *Acrophylla chronus* Gray., in its natural environment. The insect is in the centre of the plate, the axis of its body is almost vertical and measures $2\frac{1}{2}$ inches from the head to the end of the abdomen. $\times \frac{1}{2}$.



Fig. 1.

A larval stick-insect, *Ectatosoma tiaratum* Mael, in its natural environment. Fig. 1 shows the insect in its normal attitude with the abdomen curled over the back. In Fig. 2 the insect is in a very unnatural attitude, which clearly demonstrates the significance of its normal attitude. x1.



Fig. 2.

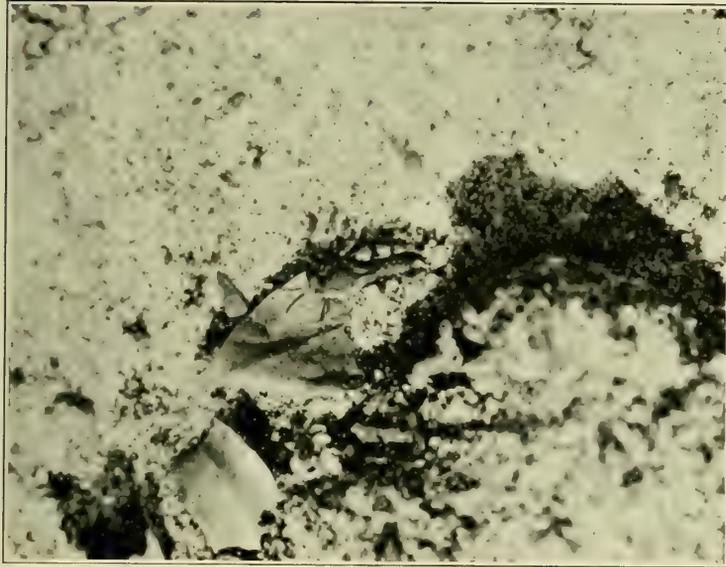


Fig. 2.
The bold silvery-grey
Urnisa erythrocnemis St.



Fig. 1.
Fig. 1 adult and Fig. 2 larva of a common sand-frequenting grasshopper, *Urnisa erythrocnemis* St. and black markings obscure the form of the insect. x 1½.

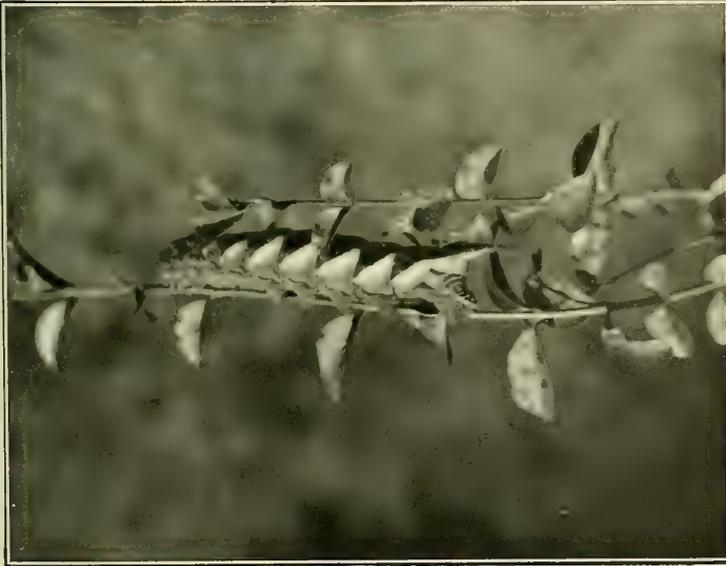


Fig. 1.

Fig. 1. The larva of a hawk-moth, *Sphinx convolvuli* L. (?) on privet. The bold markings obscure the mass of the larva. x 4.



Fig. 2.

Fig. 2. A wingless grasshopper, *Bettia* sp. Its form closely resembles that of the grass amongst which it is found, while its size is obscured by the bold white longitudinal stripe. x 1.



Fig. 2.

Fig. 2. A geometrid moth, *Syneora silicaria* Gn. (Fam. Boarmiidae), on the trunk of a paper-bark tree. The moth is in the centre of the photograph. The body is horizontal, the head is directed to the left and the out-spread wings measure $1\frac{1}{4}$ inches from tip to tip. $\times 1\frac{1}{2}$.

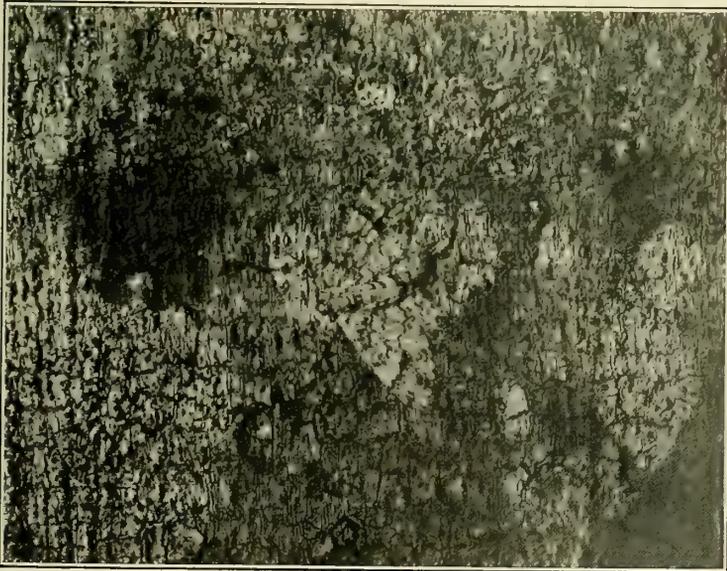


Fig. 1.

Fig. 1. A geometrid moth, *Ectropis desumpta* Wlk. (Fam. Boarmiidae), on the lichen covered trunk of a black wattle. $\times 2$.



Fig. 2.

Fig. 2. A "double-ended" butterfly, *Lalmenus evagoras* Don. at rest on a wattle. The head is pointing towards the right. x 1½.

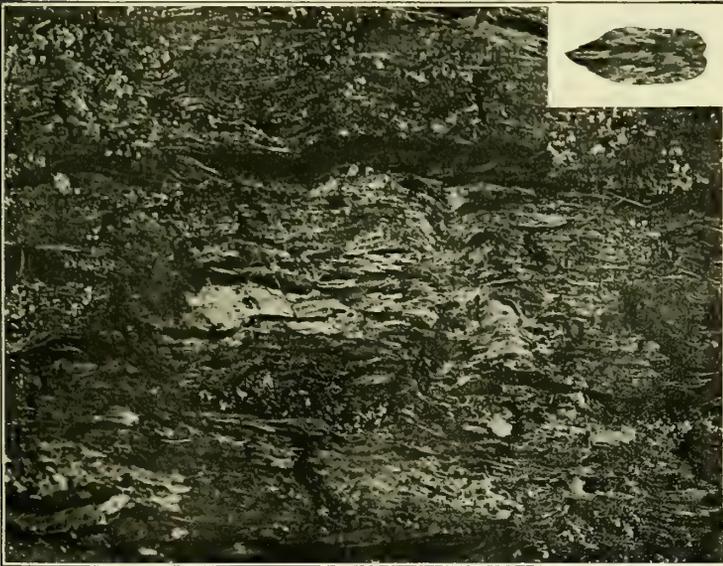


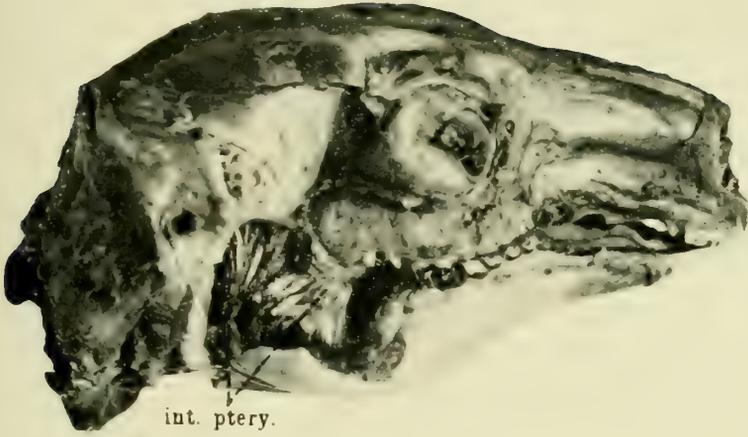
Fig. 1.

Fig. 1. A small oecophorid moth, *Cryptolechia raphidas* Turn., on the trunk of a stringy-bark gum. The moth is in the exact centre of the photograph. Inset. A second photograph of the same moth with the background painted out. x 3.



THE INCISOR TEETH OF THE MACROPODINAE.

Photographs by G. C. Clutton, Australian Museum.



INTERNAL PTERYGOID MUSCLES OF MACROPUS GIGANTEUS.

Photographs by Louis Schafer, Sydney University.



TARONGA PARK AQUARIUM.

Upper: Range of Tanks in first Gallery.

Lower: The Shark Pool. (Note Light Shaft above).

Photographs by H. Phillips.



Fig. 2.

2. The Freshwater Pool. Prussian Carp and Gold Fish.



Fig. 1.

1. Stairs to Second Gallery.

Photographs by H. Phillips.

TARONGA PARK AQUARIUM.



TARONGA PARK AQUARIUM.

Upper: Fountain and Freshwater Pool.

Lower: Range of Tanks and Stairs to Second Gallery.

Photographs by H. Phillips.



Yours sincerely
Constance M. Jackson

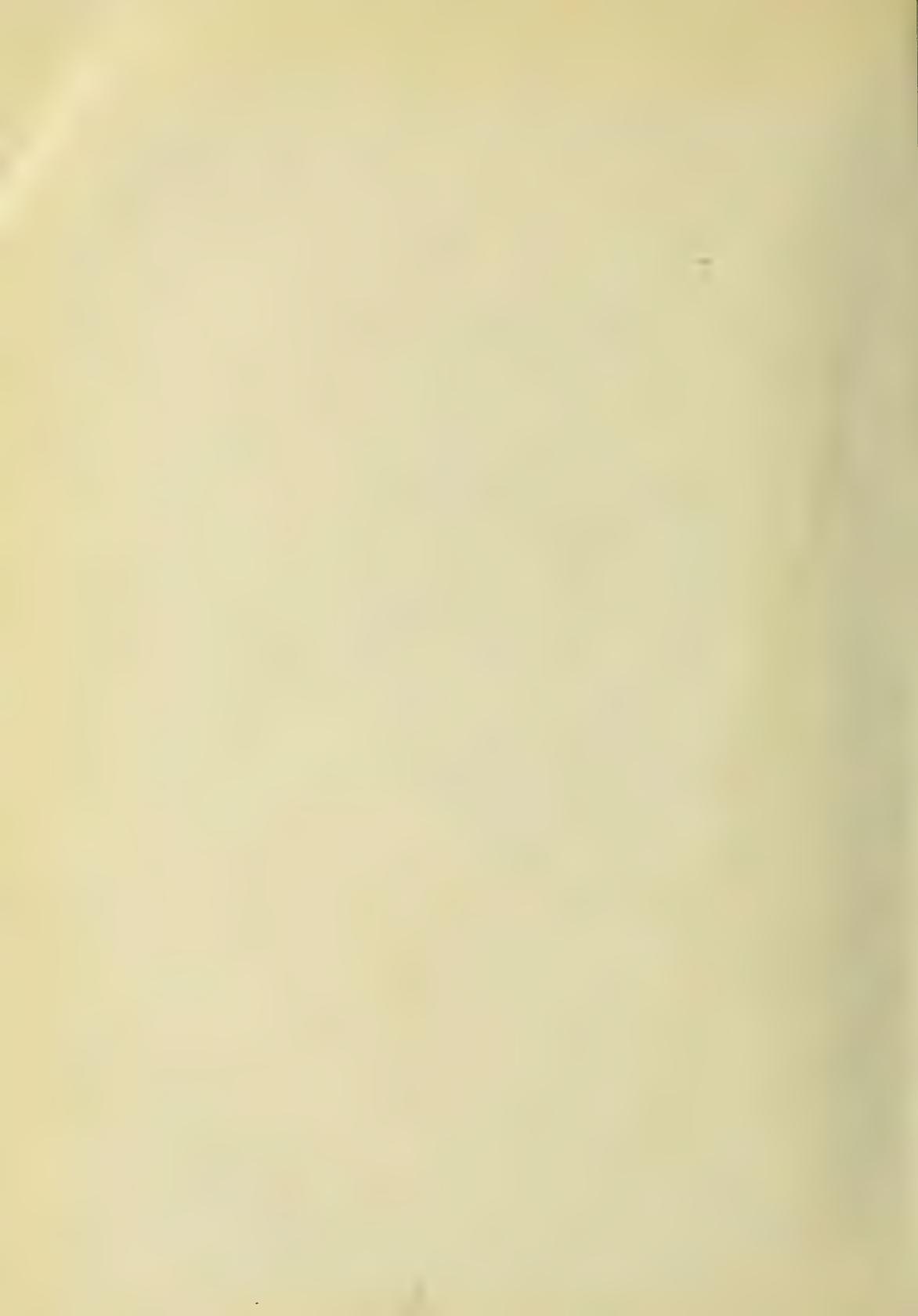


Yours very truly
A. D. White



*Yours faithfully
W. Paradise*

Portrait by courtesy of "The Sydney Morning Herald."



Royal Zoological Society of New South Wales.

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[A few copies of the first edition, bound in boards, are available. Price, 5/- Postage, 4d].

A Monograph of the Australian Loricates, by Tom Iredale and A. F. Basset Hull. 168 + xiii. pp., 21 plates and portrait. Price, 5/- Postage, 5d.

Application for Publications should be made to the Honorary Secretary, Box 2399, G.P.O., Sydney.

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Communications intended for "The Australian Zoologist" should be type-written.

Authors should state whether proofs and reprints are desired when submitting MS. Fifty reprints of any article appearing under a separate title will be supplied gratis. If more are required, terms may be ascertained on application to the Editor.

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Edited by
A. F. BASSET HULL, C.P.A.O.U.



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Royal Zoological Society of New South Wales.

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New Members.

The following new members have been elected since the publication of the last list (November 18, 1927):—

Ordinary members: W. G. Buckle, A. H. Chisholm,* J. M. Davis, J. W. Dovey, P. A. Gilbert,^o C. H. Morgan, H. N. Pope, Professor O. U. Vonwiller, S. Wynne.

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Life members: W. B. Gurney and G. P. Whitley have commuted to life membership.

* Formerly associate members.

Honorary Associate Members.

Two honorary associate members have been elected on nomination by the Entomological Section—Mr. J. R. Malloch, of the Bureau of Biological Survey, United States Department of Agriculture, for the important work he has done in describing and classifying the Flies of Australia; and Dr. T. L. Bancroft, of Eidsvold, Queensland, for the assistance he has rendered to zoologists and entomologists in particular in Australia; for his work on the diseases borne by mosquitoes, and for his important work on the life-history of *Ceratodus*.

GREAT BARRIER REEF COMMITTEE.

Preliminary steps in relation to the British Expedition to inquire into the problems of the Great Barrier Reef have now been completed, and the members are scheduled to leave London early in May, arriving at Brisbane about 9th July next.

The following memorandum on the Expedition gives details as settled up to the present date:—

(1). The personnel of the Expedition is as follows:—

Dr. C. M. Yonge (Edin.), Balfour Student of the University of Cambridge, Director. Research on the feeding and limestone formation of corals and molluscs, and economically on the growth and feeding of molluscs, especially pearl shell.

Mr. F. S. Russell, M.A. (Cantab.), D.F.C., formerly in Fisheries of Egypt, now Naturalist to the Marine Biological Association at Plymouth. In charge of all boat work, and in particular to the movements of plankton, both day and night, and in relation to currents. (Six months only).

Dr. Orr and Dr. Marshall, Naturalists at Millport Marine Laboratory. Research on varying constituents of the water such as dissolve salts, nitrates, phosphates, the pH., etc., in relation to diatoms and other marine plants and animals forming the basal food of fish and bottom living organisms.

Dr. Stephenson, Lecturer in Zoology in the University of London. In charge of all collections of animals and of faunistic work. Special research on the growth and reproduction of corals and bottom living organisms; economically sponges, etc.

Mr. Tandy, Botanist on the staff of the Natural History Museum; six months only. In charge of the collections of all marine plants and animals.

(Dr. Stephenson and Mr. Tandy propose to make together an oecological study of the bottom living animals and plants).

Mr. Steers (Cantab.), University Lecturer in Geomorphology. An experienced surveyor to assist in all the work and make a special study of the coastal regions, largely in relationship and under the advice of Professor Richards. (Pays own expenses).

Mr. G. W. Otter (Cambridge), volunteer to "devil" for the director in all matters.

(2). The following assistants are wanted from Australia in respect to the above staff:—

- (a) An assistant to Mr. Russell.
- (b) Two assistants for faunistic work under Dr. Stephenson.
- (c) An assistant to Mr. Tandy to carry on after his return to England.
- (d) Subject to the approval of Professor Richards, an assistant to Mr. Steers (six months), who will carry on service after his departure home.

Dr. Yonge would particularly like to obtain the help of one or two research workers in zoology, who would be interested in the physiological aspects of the organisms.

The above helpers would have to agree to place themselves under the Director of the Expedition, who will guarantee to give them every chance to undertake work to be published in their own names.

(3). The work of the Expedition will consist of direct research on the growth, feeding and reproduction of organisms around the camping island, to a large degree the sea forming a substitute for laboratory tanks. In addition there will have to be weekly or fortnightly examinations of the chemical constituents of the sea water, in particular the constituents which produce animal life. Furthermore, the study of the animals found there, their numbers at different seasons, will have to be undertaken, the organisms found in the plankton, as well as plants. The oecological aspects of the different reefs would require to be studied, and the animals and plants to be collected; this will entail collecting on different reefs under different circulation. Furthermore, dredging in passages in lagoons and outside the reef will have to be undertaken, so far as weather will permit, so that a proper idea may be obtained of the oecology of the organisms of the bottom in each part.

In respect to all this work, the reproduction of the organisms and their migrations will have to be studied. Pearl shell, sponges and various other organisms will have to be kept under observation.

While certain parts of this work of a systematic nature will have to be done after return to England, all experimental work, physiological or other, must be carried on on the spot.

(4). The expedition proposes to leave England on May 16th and should thus be encamped on the Low Islands by the middle of July. They will have the use of two naval launches. Obviously the naturalists in charge of the regular observations will have to remain in the Cairns region. (Mr. Russell, Mr. Tandy and Mr. Steers have to return after six months). The director, acting in conjunction with Professor Richards, will have power to visit other parts of the Reef and to undertake other work as he deems desirable. The Expedition will evacuate the camp at the end of July, 1929.

(5). The collections obtained will be worked out, so far as deemed necessary from the systematic and morphological side, as thought best by the Director, except those of the bottom living plants of all sorts which will be undertaken by the Natural History Museum. The first set of all named specimens of all groups of animals and plants to be deposited in the Natural History Museum.* The second set to be offered to the Great Barrier Reef Committee of Australia to be deposited wherever they may deem fit. All questions of economic nature to be as fully as possible reported on and discussed with the appropriate authorities in Australia before the Expedition returns to England; this, as with all matters, would be at the discretion of the Director.

(6). Professor Richards, Professor Goddard and others representing the Great Barrier Reef Committee of Australia to exercise the authority of the English Committee in all matters, so far as do not interfere with the general purposes of the Expedition.

FUR FARMING.

The Minister for Agriculture (Mr. Thorby) has appointed a Committee to inquire into the possibilities of fur production on a commercial basis in New South Wales. The personnel of the Committee is as follows:—

Mr. W. E. Taylor, Agricultural Bureau of New South Wales.

Col. E. E. Martin, Graziers' Association of New South Wales.

Mr. E. Killen, Pastures Protection Boards' Council of Advice.

Mr. E. E. Rily, Primary Producers' Union.

Mr. A. McArthur, Farmers and Settlers' Association.

Mr. A. F. Basset Hull, Taronga Park Trust.

Mr. Charles Binnie, Stockowners' Association.

Mr. F. B. Fleming, Sheepbreeders' Association.

Mr. H. W. Johnson, Chief Secretary's Department.

Mr. Max Henry, M.R.C.V.S., and Mr. Sydney Smith, junior, Department of Agriculture.

Mr. D. G. Stead, and Mr. A. S. Le Souef.

The Committee has held several meetings and taken evidence from a number of persons interested in the subject of the inquiry, and further information is sought from anyone who can give useful and practical information, especially in regard to the marsupial fauna.

* Note:—This condition is in contravention of the Commonwealth regulation which requires that types of new species shall be lodged in the Museum of the State in which they are collected.—Ed.

OBITUARY.

LAUNCELOT HARRISON.

Portrait, Plate xxiii.

Born at Wellington, New South Wales, 13th July, 1880.

Died at Narooma, New South Wales, 20th February, 1928.

The eldest son of the late Dr. Thomas Harrison, of Sydney, New South Wales, LaunceLOT Harrison was educated at King's School, Parramatta, where for two years he was head of the school and Broughton Scholar. He matriculated in 1900, but owing to the death of his father his student life came to an abrupt termination, and he entered the service of the Citizens Life Assurance Company. In 1911, however, he was enabled to resume his studies, and entered upon the science course at Sydney University, graduating in 1913 Bachelor of Science, with high distinction, first-class honours, University medal and Professor Haswell's prize in zoology, and honours in botany, after winning the Dun prize for palaeontology in 1912. In 1913-14 he was Junior Demonstrator in zoology and botany, and in 1914 he was awarded the John Coutts scholarship for distinction in science. Later in the same year he won the Exhibition of 1851 Science Research Scholarship, and proceeded to England, where he gained an open graduate exhibition for research at Emmanuel College, Cambridge. In 1916 he won the degree of Bachelor of Arts (Research), Cambridge.

Upon the outbreak of the Great War the demand for scientists to work for the War Office found Harrison engaged in laboratory work under Professor Nuttall, and in 1916 he was sent to Mesopotamia as Advisory Entomologist to the expeditionary force there, with the rank of lieutenant, and the work he accomplished in preventing the communication of insect-carried diseases to the British forces was considered of far-reaching importance. He was promoted to the rank of captain on the special list, reserve of officers.

While on active service in 1918 he was appointed Lecturer and Demonstrator in zoology at Sydney University, and he resumed duty in July, 1919. In September, 1920, he was appointed Acting Professor of Zoology during the illness of the late Professor Stephen Johnston, and after the death of the latter he was appointed to the chair, a position he occupied with distinction up to the date of his untimely death.

LaunceLOT Harrison was a born naturalist, and from his early boyhood he was noted for the keenness of his observation and the love of the fauna and flora of his native land. On the football field he was noted as an athlete and as a field naturalist he was equally noted for his powers in walking and climbing trees or cliffs in search of rare birds or plants. He was one of the foremost workers in the interests of the Wild Life Preservation Society, of which he was Honorary Secretary for some time, and he was also a keen member of the Naturalists' Society. He was a member of the Linnean Society of New South Wales, and for some years a member of Council, becoming President in 1927. He was nominated for a second time to that distinguished office, but died a few weeks before the annual meeting on which his election would have taken place. His Presidential Address for that meeting was written and the proofs corrected by him shortly before his death, and the melancholy duty of communicating that

address to the members was carried out by the Secretary. In 1924 he was elected a Trustee of the Australian Museum, to fill the vacancy caused by the death of Professor Haswell. He was a member of Council of the Royal Zoological Society of New South Wales before its incorporation, but resigned on taking up his studies at Cambridge. Upon his return to this State in 1919 he was re-elected to the Council, and was elected President for the year 1923-24. He also held the position of Honorary Editor of the *Australian Zoologist*, 1920-23.

In addition to the biological papers enumerated in the accompanying Bibliography, Harrison wrote many interesting articles of a popular nature, and during the long periods of illness which followed upon a serious attack of malaria contracted in Mesopotamia he wrote and published a charming book of verses for children, entitled "Tails and Taradiddles," illustrated by humorous sketches from his own pen.

In 1908 he married Amy Eleanor Mack, whose charming bushland stories and sketches are well known, and the influence of each on the other is discernible in the popular work of both published after their union.

That the death of Launcelet Harrison has been deeply lamented by a wide circle of friends is evidenced by the numerous personal tributes to his worth which have appeared in the Australian press. A few extracts from these tributes are here placed on record.

Professor Sir Edgeworth David, K.B.E.:—"That Professor Harrison had as much presence of mind as he had power of will and body is proved by the following episode when he was a student in my classes. At a geological excursion to the blue metal quarry at Dundas it was found necessary to descend a cliff by means of a rope. Harrison lowered himself a few feet below the top of the cliff, and placing the toe of his boot in a tiny niche of the rock, hung on to the rope with one arm, and with the other steadied the students as they slid down the rope to the bottom of the cliff. Presently one of the women students, in launching herself on the rope from the top of the cliff, lost her grip and fell, and might have been killed had not Harrison, with the herculean strength of his early inter-State football days, caught her, as she fell, with his one free arm, sustaining her weight and his own for some little time until we were able to haul her back to safety.

"The romance of his life began with his meeting with Amy E. Mack, the talented and beloved authoress of "Bushland Stories," "A Bush Calendar," and many other works, romance which led to, but did not end in, marriage.

"At the comparatively mature age of 30 Harrison entered our University, and, after graduating with very high honours in 1914, was awarded an 1851 Exhibition Research Scholarship, which took him to Cambridge. Huxley, with surely too sweeping a generalisation, described the Oxford and Cambridge students of his time as 'the host of monied, well-bred gentlemen, who do a little learning and much boating by Cam and Isis.' But when Harrison arrived in Cambridge with his wife in 1914, while he certainly was a gentleman in the highest sense of that much abused word, he was certainly not monied, nor was his wife, but 'better a mess of herbs where love is,' etc. Two ends were made to meet only by dint of the hardest work on the part of both. It was a time of storm and stress, ending in 1916 in the winning by Harrison of the much-coveted Cambridge degree, B.A., by Research.

"But even before the degree was conferred, Harrison, who had been rejected for the active military service for which he had volunteered, on account of an injury to his head, had had a call from the War Office, in response to the further

offering of his services, to go to Mesopotamia. He went promptly, and for three years worked as Entomological Adviser to the British forces, among whom at the time of his coming there was great mortality through insect-carried diseases, such as typhus and malaria. He had to fight against much inertia, prejudice, and even opposition, but in the end, working as a man among men, frequently in the front trenches, and at great personal risk, he won through.

"Professor H. M. Lefroy, one of the leading entomologists in the British Empire, has definitely stated that Harrison's splendid work reduced the mortality among our troops there by no less than 75 per cent. So that it is no exaggeration to say that Harrison was the means of saving many thousands of lives. While other men around him were bored to distraction, or plunged in despair, Harrison found the work full of interest and encouragement. His love of nature stood him in good stead, even in Mesopotamia, where his sympathies went out, not only to suffering humanity, but even to the poor little plants, struggling for existence in the burning sands of the desert, and to the little desert mice that shared his meals in his dugout. Finally he, himself, fell a victim to typhus, and a severe form of malaria, from which he would have died but for, under Providence, his own unconquerable will to live so as to finish his work. These illnesses so undermined even his robust constitution that he never recovered from their effects; and since his appointment to the Chair of Zoology at Sydney University he has suffered much from an acute, intermittent arthritis. Many men with health as impaired as was Harrison's on his return from Mesopotamia might well have been excused for becoming confirmed and pessimistic valetudinarians; but Harrison, throughout his six years' tenure of the Chair, seemed ever, like Mark Tapley, most cheerful and jolly, not without a fund of good humour.

"The cheerful optimism of the husband was no less evident in the wife, though she was tried at times by sharp illness. Thus, whether at their charming home at Gordon, or in the wider circle of University life, the Harrisons always irradiated happiness, playing no small part in the social life of the University. In the wideness of his human sympathies and interests, and unselfish service for others, Harrison helped the realisation of that ideal of a university as a goodly fellowship for mutual help and inspiration in the advancement of knowledge.

"Harrison, with the modesty of the inspired teacher, was forever planning to make good better, and was full of schemes for the betterment of his department and the University at the time of his death. To the last, in spite of bodily infirmities, he had all the freshness of outlook on nature of a boy, recalling those lines of Wordsworth:—

There was a time when meadow, grove, and stream,
The earth and every common sight
To me did seem
Apparelled in celestial light,
The glory and the freshness of a dream.

"Let us be devoutly grateful to Harrison for the glimpses he has given us of that celestial light, and rejoice that for him, as 'portion of the loveliness which he once made more lovely,' the dream has still its freshness and its glory."

Mr. H. J. Carter, B.A., F.E.S., Vice-President of the Linnean Society of New South Wales:—"I first knew Launcelot Harrison as a fellow-member of the Naturalists' Society of New South Wales, of which he was an energetic Secretary about 1906. Even then he had an extraordinary knowledge of the birds and wild flowers of the Sydney region, and this knowledge was a live thing, full of interesting personal observation—that has continued up to his untimely end. With a natural facility of speech and a wonderfully lucid way of chatting, rather than

lecturing on his subjects, I enjoyed only a year or two ago the charming series of lantern lectures he gave at Killara on the "Birds of North Sydney" more than any bird lecture I have ever heard. Later he extended his interests through a wide field, and, besides his profound general knowledge of zoology, he has become a world-known specialist on parasitology, which he treated in a strikingly original manner. He discovered, amongst other things, curious relations between various genera and their parasites.

"At Sydney University his energy and stimulating influence have been marked in the general activity of his students. Not satisfied with mere routine lectures, he initiated informal discussions on subjects of general interest—geographical distribution, theories of migration, the now seriously considered "Wegener Theory" (early adopted by him as important), and the like—and one result of his leadership is the pronounced success in research of some of his leading students. He, too, initiated and organised a University zoological expedition to Barrington Tops in January, 1925, where to the astonishment of local tourists a tent village suddenly arose where hitherto a few horsemen had struggled to an altitude of near 5,000 ft. And the expedition, as everything Harrison did, bore good fruit, in the original work, on the skink lizards, carried out by himself and Miss Weekes—a work still further developed by the latter—as also in the discoveries of many new flies, butterflies, and beetles by members of the expedition.

"Harrison was also a specialist in Australian frogs, and he could name the species by their voices from the swamp. During the 1926 winter trip to Western Australia, where he was President of the zoological section of the Australian Association for the Advancement of Science, he signalled his appreciation of the special train picnic to the south-west by discovering two new frogs, and re-discovering a rare species, all within the few hours allowed the party for exploration. Readers of the 'Sydney Morning Herald' will recall Mrs. Harrison's (Amy Mack) delightful description of this expedition. The present writer chiefly remembers the Professor's able Presidency of his section, and the almost startling interest he gave by his exposition of the Wegener Theory in relation to the distribution of animal life. One also recalls his genial and happy Chairmanship at the Linnean Society's meetings, and it is sad to recall the fact that this year, as last, the Presidential Address cannot be given in person. No trouble was too much for him when his subject, or one of them, was in question. Not only the Linnean Society felt his stimulus; he was a Trustee of the Australian Museum, and a Councillor and late President of the Royal Zoological Society of New South Wales, and to each he gave of his best. His home was peculiarly happy, and those who were privileged to enjoy those Sunday evening symposia at Gordon knew the nearest approach to the 'salon' possible, where gifted hostess and host induced that flow of soul that springs from thorough enjoyment in their guests. Harrison's versatility is shown in those delightful children's verses to which he signed himself 'Alter Ego,' most of which were thrown off during enforced inaction from zoology, when he spent many painful months with arthritic knees. These are the well known 'Tales and Tarradiddles.' I think many children will miss him. I know many men will, while scientific circles deplore the loss of valuable promised work and the University of an inspiring teacher.

"Harrison's mind had the wide horizon of the big man—music, literature, art (see, for example, his illustrations to 'Tales and Tarradiddles'), all interested him; and a small change of destiny could have made him a writer, singer, or artist. In zoology he was just as keen in helping Eustace Ferguson catch rare flies as in hunting Buprestid beetles on Kosciusko, where he discovered a new one last year. Alas! for the 'hand that can be clasp'd no more.'"

Professor R. S. Wallace, Vice-Chancellor of the Sydney University:—"All sections of the University are greatly mourning the death of Professor Harrison. He was, by common knowledge and consent, one of the most distinguished teachers in the University, and a scholar of the first rank. Starting in business, he came to academic life later than usual, but he soon made his mark, as he had a genuine love of learning. As a research worker, he was, in the subject of zoology, in the front rank. He was, besides, an excellent teacher, and, because he interested his students, he was greatly liked by them.

"The war left its mark on many men, and there can be no doubt that Professor Harrison's death was due to war service. He has been a sick man for some years, and yet, in spite of sickness, he refused to give in. He has left a memorial in the Department of Zoology, which owes much to his learning, energy, and enthusiasm."

The Council of this Society at its meeting on 15th March, 1928, carried the following resolution:—"This Society desires to place on record its deep sense of the loss sustained by Australian zoologists by the death of Professor Launcelot Harrison, who was a member of Council of this Society prior to its incorporation, re-elected upon his return from military service in Mesopotamia in December, 1919; and President for the year 1923-24. His scientific work and personal service did much to foster the interests of the Society, and his editorship of *The Australian Zoologist*, 1920-23, was conducted with conspicuous ability. The President and Council, on behalf of the members of this Society, tender their heart felt sympathy to Mrs. Harrison in her bereavement."

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ALFRED EDMUND JAUQUES.

Born at Sydney, New South Wales, in 1848.

Died at Sydney, 22nd April, 1928.

Mr. Alfred Edmund Jaques was the son of the late Mr. Charles E. Jaques, formerly a well known resident of Morpeth, on the Hunter River, who later became engaged in grazing pursuits, owning the property known as Therribri, near Narrabri. Mr. Alfred Jaques was educated at Sydney Grammar School, took up the study of Law in 1865, and five years later was admitted to practice. Eight years afterwards he entered the firm with which he was associated at the time of his death.

Apart from his profession, Mr. Jaques had many interests in the city. His close interest in Sydney Hospital lasted from 1906 until 1919, when he resigned after two years as President. Before his appointment to that office, in succession to the late Sir Matthew Harris, he had been a member of the Board and the House Committee, and also one of the Vice-Presidents of the Hospital. He was also a Director of the Royal Alexandra Hospital, Chairman of the Mercantile Mutual Insurance Company, and Chairman of the Abermain Coalmining Company.

Mr. Jaques was a member of Council of this Society prior to its incorporation, and acted as its Honorary Legal Adviser on occasions. He took much interest in the incorporation, and the Society's Memorandum and Articles of Association were prepared in the office of his firm, Messrs. Stephen, Jaques and Stephen. Although he retired from active service on the Council in 1916, he remained a member of the Society until the time of his death.

SOME FURTHER REMARKS ON *PACHYNERES AUSTRALIS* MALLOCH.

By J. R. MALLOCH.

In this magazine, Vol. 4, pt. 6, p. 337, 1927, Mr. G. H. Hardy offers some suggestions on the possible relationships of *Pachyneres australis* Malloch.

It is not clear to me from a perusal of his remarks that he has made himself acquainted with the contents of the paper in which the genus was described. If he had done so, a very necessary measure one would assume to warrant giving a full consideration to the matter he discusses, it would possibly have influenced him to the extent that his suggestion of removing the Australian species to BIBIONIDAE would not have been advanced.

Anyone conversant with the wanderings of the related genus *Mythicomyia* in North American dipterological literature might be prepared to learn that *Pachyneres* was slated for removal to EMPIDIDAE, or even to LEPTIDAE, but hardly to BIBIONIDAE, and it appears to me that a doubt in the mind of Mr. Hardy as to the accurate description of the specimen or that it was not in perfect condition to permit of a true description, has caused him to give undue weight to venational characters in making his suggestion as to its family affinities. Occasionally one is tempted to use main force in making one's conclusions accord with preconceived ideas, and it is always well to guard against giving an opinion without having the subject before one for a diagnosis.

I carefully compared the specimen of *Pachyneres crassicornis* Green with *australis* and despite the lack of an apical antennal style decided that the two species were referable to one genus, the other characters being very similar, and the characters of the pupa of the former appeared to me, as they did to Greer, to be Bombyliid in nature. Williston was in doubt as to whether the genus *Mythicomyia* belonged to LEPTIDAE or BOMBYLIIDAE, and placed it in both in his "Manual." Osten Sacken and Schiner placed the genus in LEPTIDAE, while Melander, Coquillett, and Cresson referred it to EMPIDIDAE, but no one has suggested BIBIONIDAE. Even Mr. Hardy admits that "one can readily recognise the alliance of the typical *Pachyneres* with the North American BOMBYLIIDAE," but he states that "there is no Bombyliid known in Australia that appears related even in a remote way."

He also appears to be impressed by the fact that having visited Como, the type locality of *australis*, "no Bombyliid has been found there or elsewhere to conform to any characters given by Malloch" Which argument reminds one of the prisoner who attempted to refute the evidence of two witnesses who had seen him commit the crime he was charged with by the production of a hundred witnesses who had not seen him do so.

But the incontrovertible facts are as follows: The type specimen of *Pachyneres australis* was sent to me. As stated in the original description, it is in perfect condition, and will be sent to Dr. I. M. Mackerras, in due course, so that it may be deposited in some Australian museum. Lest there may be any question of doubt as to the source of origin of the specimen, it may be of interest to state that I have a second specimen before me taken at Sydney, New South Wales,

21/9/1923, and sent to me by the late Dr. E. W. Ferguson with a lot of CHLOROPIDAE. I apprised Dr. Ferguson of the receipt of this second specimen and do not understand why, if he asked Mr. Hardy to give an opinion on the relationships of the genus, I was not requested to forward the specimens for examination, and why Mr. Hardy was unaware of the existence of the duplicate.

The foregoing appears to cover about all the points raised by Mr. Hardy that are not mere hazards in the dark, and the only suggestions I have to make are that students of insect anatomy place a little less reliance upon wing venation as guides to family relationships, and that it is wise to refrain from dogmatising upon the constituents of the fauna of any region until it has been very intensively collected. Nature is neither mathematically precise nor does she fail to produce parallelisms in certain characters in the same and different families, and many of our beliefs regarding relationships to-day may be discarded and forgotten a century hence.

Addendum: The type has been returned to Sydney by Mr. Malloch and is now in the Australian Museum. A further specimen (Sydney, 13/4/1925, E. W. Ferguson) is now in Mr. Malloch's collection, and another (same date and locality) is in the collection of the Department of Health, Sydney.—I. M. MACKERRAS.

A copy of Mr. Malloch's notes was forwarded by him to Mr. G. H. Hardy, who submits the following reply:—

"It has been intimated to me, that a reply to Mr. Malloch's further remarks on *Pachyneres australis* given above would be permissible here, and while in no way wishing to enter upon an unnecessary discussion, there are a few matters that I think should be made clear. Some few years had elapsed between my last conversation with the late Dr. E. W. Ferguson dealing with this insect, and in the meanwhile we kept each other fairly well informed in correspondence concerning outstanding developments and discoveries we made in those families of DIPTERA in which we were mutually interested. As intimated in a letter just before his death, Ferguson had intended to publish upon this fly and a new species of *Cytomorpha* from Western Australia, both acquired, I understand, shortly before his long illness and subsequent death. As no letters were received from him in the intervening period I remained in ignorance of this.

"My purpose in writing that paper was to raise a much wider interest locally in the species discussed, hoping the outcome would lead to the discovery of more specimens, but the interest aroused took one course along a line I did not expect or desire. Nevertheless one unlooked for and useful development arising from that paper is the sending of the type to Australia, which specimen I have since examined.

"Unfortunately Mr. Malloch has not in any way added information in his second paper that can be taken as conclusive in regard to the specimen under discussion being a Bombyliid. He satisfies himself with emphasising his opinion of its nature, adding much matter thereto that is quite irrelevant to the issue. I am taking this opportunity, therefore, of incorporating some necessary data that I would wish to have seen from Mr. Malloch's pen in answer to my suggestion that the species had been misplaced. I assure Mr. Malloch that these remarks, like the last, are made in good faith.

"The type is gummed to a card. The wings are much as in Malloch's drawing, but the subcostal vein, which is not illustrated, is present and does not reach the margin of the wing; also the triangular cell appears to me to be slightly smaller. The venation may not always be as entire as in the figure, for sometimes certain veins are incomplete; this is indicated on one wing of the type, as

well as on another specimen. The apical segment of one of the antennae is missing, the other shows that only two discernible segments are present, the second being apparently fused with the third, or perhaps the first. This third segment is bulbous and at the apex has what is obviously the minute remnant of the vestiture that once covered the antennae. The apical part of most of the legs is missing, the posterior ones being almost entirely gone. The two that contain the tarsi, one anterior and one intermediate, are decidedly rubbed so any vestiture including bristles that may have been there is lost, as also the pulvilli, though the claws are there. The whole insect is somewhat greasy, or perhaps only soiled by vegetable debris, and practically devoid of vestiture owing to its rubbed state. The abdomen is depressed as if squashed, but in other respects the insect is in moderate order.

"From the type, it will be noted, it is impossible to tell to which of the two superfamilies, ASILOIDEA or TABANOIDEA, the insect belongs, but fortunately another specimen is in the Ferguson collection, this one being in excellent condition. It would appear there that only the two pulvilli occur between the claws, the empodium being absent, or reduced to a bristle which I think will ultimately prove to be the case, the empodium is certainly not pulvilliform. The abdomen is definitely conical and the head is set low on the thorax, thus giving the appearance of the genus *Cyrtomorpha*. The antennae have partly collapsed on this specimen, being concave on the inner side but there is no sign whatsoever of a style, the apex being evenly rounded. The proboscis is very clear on the specimen and is Bombyliid in type, but I did not make out the palpi. It would appear that in general characters the species is not far removed from *Cyrtomorpha* which would scarcely be suspected from Mr. Malloch's account. *Cyrtomorpha* is typically Bombyliid, even in the antennae, the notable exception being wing structure, and perhaps also the proboscis is not typical, as it is slender and pointed, without discernible flaps such as are very conspicuous on the apex of that on *P. australis*. There is not so much difference between the wing venation of these two species as would at first be supposed, for a comparison of specimens shows several points in common; this is a matter that cannot be fully appreciated from the diagrams so far published.

"I think there can be no doubt but that *Pachyneres australis* will ultimately be placed in a new genus, its nearest known ally in Australia being *Cyrtomorpha*, the two being given at least tribal, if not subfamily, rank. This would in no way detract from the idea that the typical *Pachyneres* and *Mythicomyia* are related, but having no personal knowledge of these foreign types I am unable to form any exact idea of what status such a relationship may take. In the original description of *Cyrtomorpha*, the antennae are inadequately described. The two basal segments are quite discernible, the third is bulbous towards the base, but attenuated, the long fourth segment is as broad as the attenuated portion of the third, and the apex bears a minute spine. There are therefore four clearly defined segments and a minute spine; there would appear to be a gradation from *Cyrtomorpha* through *Mythicomyia*, *Pachyneres*, and this new genus wherein only two segments are discernible."

Note:—If there is any further doubt as to the correct generic status of this insect, it must be left to individual students to solve.—Ed.

FEMALE BIRDS IN PLUMAGE-DISPLAY AND SONG-MIMICRY.

By P. A. GILBERT.

Plate xxiv.

Since the publication of Darwin's famous work, the "Descent of Man," wherein the sexual dimorphism of birds is exhaustively dealt with on the basis of sexual selection controlled by females, several other important theories have been advanced to explain the divergences of secondary or morphological sex characters. Observations on Australian birds, however, disclose that Darwin's female sexual selection is at a minimum as a factor in bringing about sexual dimorphism. Natural selection as postulated by Wallace seems more potent, in so far as it holds in check, in many instances, the development of the female on the same morphological lines as the male.

The Physiological Theory of Geddes and Thomson has much to recommend it, and whose own words as expressed in the concise volume "Sex" of the Home University I will quote (page 113): "We find ourselves unable to get away from the conviction that there is no sex-determinant or factor at all, in the morphological or in the Mendelian sense, but that what settles the sex is an initial difference in the rate or rhythm of metabolism. This may also be expressed as a difference in the relation of nucleoplasm and cytoplasm, as well as in the ratio of anabolism to katabolism. According to this view, the deep constitutional difference between the male and the female organism, which makes of the one a sperm-producer and of the other an egg-producer, is due to an initial difference in the balance of chemical changes. The female seems to be relatively the more constructive, the male relatively the more disruptive. The sexes express a fundamental difference in the rhythm of metabolism."

In the realm of bird life it is commonly thought that the male possesses most of the melody of song, and all the powers of plumage display, while the female is supposed to be comparatively silent and more or less undemonstrative. Indeed, many instances will show that this has the appearance of being correct if casually considered. Popular books on bird life are so persistent in their representations that the male displays before the female for the sole purpose of enabling her to choose the most desirable partner which accords with her standard of perfection, that it now seems like sacrilege to say anything to the contrary about this long-standing dogma of ornithology. Yet I am reluctant even to suppose, and much less admit, that a female Lyrebird, for instance, is endowed with the faculty of discriminating between the degrees of perfection of this lyretail or that. It involves the assumption that the female memorises the structures of the feathers of this male and minutely compares them with the feathers of that male before coming to a decision as to which male she will espouse. It presupposes a fineness of perception which excels the critical eye of the most finished artist.

The study of female birds in relation to their environment has not received the attention which it merits, hence the tendency has been to overrate the importance of the male in working out the problem of sex-dimorphism. The female has been considered physiologically subordinate to the male, and aesthetically superior in that she is assumed to yield to the male which has the sweetest song, or the most captivating love antics. Observations on female birds in their wild

surroundings at all seasons of the year, however, reveal that they, too, when seasonably observed are also furnished with the avian refinements of plumage-display and song-mimicry, instances of which will be given in due time.

The fact that some females practise display and song-mimicry may nullify the theory that males display and sing for the delectation of the female. We must conclude then that the displays given by both sexes are reciprocal and mutual. The female is less noticeable in her outbursts on account of her energies being more closely concentrated on the functions of nidification, incubation, brooding the nestlings, and caring for the fledglings. It is not intended to lead the reader into the belief that the male does not entertain, or charm, or sing to his females. On the contrary, I maintain that the male is the dominant songster and displayer, but that the female must also possess at least the rudiments of song and display, so that the species may preserve these qualities.

Close observations prior to or during nidification are essential to enable the observer to detect the manifestations of plumage-display and song-mimicry in females where these characters exist in the corresponding males. The most fruitful period is just after daybreak, although one may expect them at any time throughout the day. These innate qualities are stirred into activity temporarily during breeding time through important changes which take place in the metabolism of the female at this period. As soon as the nesting activities begin to draw on her reservoir of energy these displays are discontinued.

It seems a gamogenetic necessity from the Mendelian standpoint that the female should display her plumage to some extent and mimic the songs of other birds if the male of the same species does so. The female by possessing the same qualities as the male will strengthen the gametes and prevent any obliteration which would probably occur through the operation of the Mendelian law, if such qualities were entirely absent in the female. That is to say, in the perpetuation of these qualities it is necessary for the inherent characters of the male and female to be alike, so that the continuity of these distinctive characters is preserved by the cumulative action of the law of heredity on the germplasm.

Instances where plumage-display and song-mimicry occur in both sexes of the same species clearly show that the difference between the performances of the male and female is one of degree and not of kind, which serves to accentuate that the only importance attaching to this difference is fundamentally one of sex. So far as mating is concerned the female is entirely submissive. She is selected by the male solely because his superior vigour helps him to overcome his less vigorous rivals. His greater vigour may have expression in beautiful plumage, persistency of display, or charming song. When occasion demands, and he has thus driven away a rival, he forces his presence on the female of his choice which acquiesces unconcernedly. This has been observed with several species, frequently with Satin Bowerbirds and occasionally with Lyrebirds. I venture to say that females, other than those enumerated of Australian birds, and possibly females in other parts of the world, will be found in every case where the male of the same species practises display or song mimicry, to show at least rudiments if not perfection in these characters.

The life-history of the Parrakeet (*Platycercus elegans*) vernacularly known as Pennant's Parrakeet, Crimson Parrot, or Crimson Rosella, affords a curious sidelight on the problem under discussion. The male and female of this species both clean out the hollow limb of the tree in which they intend to nest. Each bird takes a turn at incubation also. Under ordinary circumstances the young remain in the nest till they are able to fly well. On leaving their nest they straightway seek the shelter of thickly foliated trees. They remain perched for

hours in these hiding places, and seldom venture into the open while the adults are procuring food. The call of the parent birds is answered a long distance away by the young. The adult birds display great caution in approaching their young with food, and seldom enter the tree in which the young are hiding while there is the least sign of danger. The general colour of the young is dull olive-green: that of the adults, various shades of crimson and blue.

The young Parrakeets are, up to this point, under the influence of natural selection, the green plumage of the young harmonising with the leafy clusters in which they shelter. As soon as the young birds become full grown and begin to assume the adult garb, great changes take place in their temperament. They now join the adults in the search for food, share all their risks, and, generally, throw off the shy habits of their green-plumaged days. Increased energy is overcoming the stage where natural selection held out its protecting hand to the young birds. Previously the young escaped from their enemies by concealment, now they evade them by vigilance.

The brilliant plumage of this species makes it particularly attractive in the wilds. If bright colours are a source of attraction to enemies assuredly this blue and crimson Parrakeet should be well-nigh extinct. Not so, however.—energy, watchfulness, and mobility are attributes of the matured bird, which now greatly exceed in value the protective mimicry of its juvenile days. It is difficult to conceive of what takes place in the metabolism of this species when the change from green, with its concomitant demeanour of shyness, gives way to crimson and blue, and its accompanying feature of boldness. Here, however, the possibilities of sexual dimorphism occurring fortuitously exist, as both sexes sometimes mate in the green plumage, but more often a crimson and blue bird will pair with a green bird. As this is only a matter of age and circumstances the adult plumage is ultimately attained.

On first thought this digression on the ways of the Crimson Rosella may seem irrelevant to a discourse on female birds in plumage-display and song-mimicry, but this example was selected from a great many widely different groups of young birds to show the changes they undergo in their development to reach maturity, and then present no apparent response to external stimuli. Reason it out as one may, there is nothing in the life of the adult Crimson Rosella to suggest that either natural or sexual selection is operative so far as plumage is concerned. It seems, then, dependent on internal physiological development which is sufficient to safeguard the preservation of the species in the struggle for existence. As the moulting of this Parrakeet takes place gradually, the extraordinary colour change may be an inherited character as the feathers are shed singly, or nearly so.

To summarise the development of the Crimson Rosella we may state the position in another way:—The growth of the young bird is under the influence of protective mimicry, the metabolic processes producing green plumage and inactivity in response to external stimuli. On the approach to maturity, re-action takes place in the metabolism, which overcomes the earlier outward influences, the environment changing from external to internal, as no opposition is offered to the qualities of brilliancy and vigour.

The popular and beloved Magpie-lark (*Grallina cyanoleuca*) is an example of rudimentary sex-dimorphism. In this species the plumage of the female is similar to that of the male except that the lores, forehead, and throat of the female are white, while these parts are black in the male. As both sexes share in building the nest, incubating the eggs, and feeding the young, we may assume that this slight difference in plumage is wrapped up entirely with the qualities which distinguish sex. It has no sexual selective value. The outbursts of glad-

ness revealed in the love games of the Magpie-lark which are of a simple character, are worth brief notice. The male and female perch side by side. Then a flute-like note is emitted by the male, which bows to the female, and throws his head under her chin while she stands erect. He then flicks his tail and sways his form from side to side while he utters a series of staccato notes. The female responds with exactly the same performance. These movements are often repeated by the sexes alternately for five minutes or so, and are of daily occurrence till nidification begins. Frequently a succession of chases follow in which the male and female in turn pursue each other, darting and wheeling, as they fly, in the most graceful fashion, their shrill calls betraying feelings of intense excitement.

These performances are more frequently observed just after daybreak during August when the winter flocks are dispersing. In this simple mode of courtship there is no indication that one sex unduly stimulates the other. The actions of both are entirely reciprocal. Where sexes are alike in plumage very often their habits and calls are identical.

An interesting example of partial sex-dimorphism is afforded by the Rufous Whistler (*Pachycephala rufiventris*). The male is a voluble songster, while the female is rather limited in the utterance of call notes. The male and female share in nidification and incubation. When the male is on the nest he frequently sings, the female responding with a subdued "sweet-sweet." As both sexes incubate we find that natural selection acts on the upper parts of the male, while sexual dimorphism makes its appearance in the feathering of the under parts. Repeatedly where both male and female share in the duties of brooding little divergence is observable other than that consonant with sex differences. The Rufous Whistler is a case in point, however, where a species stands midway between sexual individualism and excessive vigour on the one hand, and the type which is the resultant of natural selective agencies on the other.

The White-shouldered Lalage (*Lalage tricolor*) is an instance of complete sex-dimorphism. Notwithstanding the fact that the male is quite distinct and more conspicuous than his female, he being white and black, while she is more or less brown, he devotes much time to nesting operations. He is also preponderantly more melodious and vigorous than his female. The male in many instances actually selects the nesting site, then by certain notes and display he entices the female to acquiesce in his selection. Generally male and female birds communicate to each other in gestures of head, wings, and body, but more particularly by call notes and song. The language of birds is a language of signs and song.

As soon as the nesting site is decided upon, the construction of the nest begins, in which the male takes an active part. The eggs also receive his fair share of attention. Indeed, the male may often be observed chasing the female when she is off the nest, but whether this is only love games, or to compel her to return to her eggs is an open question. Although the plumage of the male and female White-shouldered Lalage are widely distinct both sexes are remarkably even in their devotion to the rearing of young. They are exposed to exactly the same risks in every way. Seeing that the male passes through the same stage of plumage as the female, it is evident that the female plumage was common to both sexes in ages gone by. It is permissible to suggest, then, that the divergence in plumage colour has been more in response to internal changes, independent of, rather than as the result of either sexual or natural selection.

The defensive displays to lure intruders from their nests or young are somewhat remarkable, and common to both sexes of many birds in which the male and female share in the care of their progeny. It is particularly pronounced with the

male and female of the Yellow Robin (*Eopsaltria australis*) which often lie almost within hand's reach while feigning broken wings, or general disablement. This probably is the most vital form of plumage-display, as it involves the safety of offspring, and it is more than likely that it had its origin through the agency of natural selection, although it is difficult to suggest the precise cause which brought about this method of deception. Predatory reptiles and mammals may have largely contributed to this wonderful mode of demonstration. Defensive plumage-display undoubtedly originated before the purely aesthetic display, but whether there is any relationship between the two is a matter for speculation.

The mode of courtship of the White-browed Scrub-wren is of the simplest character, and in many respects is similar to that of the Magpie-lark. The male and female stand in front of each other on the ground. The male gives vent to a song interspersed with mimetic notes, and while he sings the female nods her head up and down. As soon as his song is finished he begins to nod back to her. If the female attempts to move away the male hops in front of her and nods vigorously. They then join in singing their own song animatedly. Early morning is the best time to observe these spasms of joy, and nuptial displays, of the White-browed Scrub-wren (*Sericornis frontalis*).

The love games of the Yellow-throated Scrub-wren (*Neosericornis lathamii*) are as pretty as any I have ever observed among small birds. It is difficult to realise the rapturous delight these feathered sprites experience as they sing to each other, then chase one another through the shadowy jungle. The handsome little male bursts into a song of excessive joy, expands his wings, and pours forth his sweet notes, every now and then inserting the calls of other birds, which he renders in rapid succession. While he thus performs the female will very often perch in the same shrub just beneath him. Suddenly he darts at her, and away they go in and out the brushwood, whistling their own song as they turn and turn about. After performing many intricate movements they return to the same shrub. Now the female takes the upper branch while the male perches in the branch she occupied. She, not quite so beautiful in appearance nor so polished in song, proceeds to charm the male with her mimetic attainments. He listens attentively, frills his plumage, and sways his form from side to side. The outbursts of the female are surprising, and if not as finished as those of her consort are, withal, very pretty when considered with her dainty form. Her song ended, she likewise darts at the male, then off they go to repeat the love chase. This performance is a forerunner to nidification, as a nest is usually found overhanging a gully or stream in the spot where this jungle wren enacts its wooing.

On the 23rd October, 1926, Mr. and Mrs. E. Nubling, well known bird observers, and I were lurching at the junction of the north and south arms of Bola Creek, Waterfall, New South Wales, when two pairs of Yellow-throated Scrub-wrens made their appearance in the branches of a fallen tree near by us, and began a combined display of song-mimicry and love games. With outspread wings the males of each pair called to the females which were perched close by. Then all four hopped from branch to branch, flew in and around the tangle, chasing each other with ecstatic fervour.

The males and females all took part in this wonderful demonstration of displaying, song mimicry, and chasing. The males were, however, more active in movements and more voluble in song than the females. During this sustained medley of song-mimicry, which lasted twenty minutes, we recognised the calls of twenty-six species of our native birds. Several weeks later two nests were noticed in this locality, which may reasonably be supposed to belong to this quartet of avian artists.

A duet by Heath Wrens (*Hylacola pyrrhopygia*) is a song worth listening to. On many occasions I have listened to a pair of birds giving forth their best in song-mimicry. The female, although not so voluble as the male, is, nevertheless, a songstress of great accomplishment. In July on the lonesome sandstone heathlands the solitude of the bush is continually punctuated by the song of the Heath Wren. During this month the Heath Wren is very actively engaged with nidification. The song of the female is a prelude to the undertaking of home life, and a sure indication that she intends to concentrate on that duty immediately. Generally her song is uttered in unison with the male. They mount a small sapling overlooking a stretch of heathland and then vie with each other in the utterance of song. As with other species the male is the dominant songster, but the great perfection of the female and the apparent satisfaction they both derive from these performances convinces one that these expressions of feeling are reciprocal and intimately associated with breeding. The Heath Wren also indulges in a love chase and as they scurry over rocks, creep through undergrowth, or flutter over the flowering heaths, they frequently pour forth their own song, or songs of mimicry.

The female Satin Bowerbird (*Ptilonorhynchus violaceus*) is both a plumage-displayer and song-mimic. She constructs a miniature bower, platform of sticks, or often a small area of ground only is cleared over which variously coloured flowers, elytra of beetles, and other fancied objects are strewn. The female resorts to it for display and recreation just prior to and during nidification. She, however, denies herself the joy and exhilaration of performing at her bower or platform as soon as the responsibility of incubation begins, but may be observed later in attendance at the bower of her male with young birds previous to the autumn flocking.

So far I have never found these miniature bowers or playgrounds at any other period than during the breeding season. Often I have located the bower by following the female from her nest, and just as frequently the reverse has been the case, for, after finding the female in the act of performing at her bower, I have been able to locate the nest by following her as soon as she quits her structure. During the spring of 1923 in the vicinity of Bola Creek, National Park, I came across a female that was particularly obliging in this respect. After playing at the bower and giving vent to her extensive repertoire of mimetic calls she quitted it and flew to a tree close by. Here she selected a leaf from the foliage and began to perform on a branch. Many quaint gestures, movements of the body and wings, and frilled plumage were accompanied with several weird notes and different mimetic calls. She terminated this little ceremony by straightway flying to her nest with the leaf still retained in her bill. After placing the leaf in her nest she returned to her bower to repeat the routine. She visited the bower of the male and he likewise paid her bower a visit. In this instance, I observed the male removing all the floral and other decorations, as well as the sticks from the walls of her bower, to that of his own after she had deserted it. In the locality where I observed this female I succeeded in finding three female bowers, two playgrounds, and two platforms. Three females were detected constructing their nests from these structures, one of which was built in a Turpentine Tree (*Syncarpia laurifolia*), where Mr. E. Nubling and I were able to watch her feeding her young. The female Satin Bowerbird undoubtedly performs exclusively for her own enjoyment when attending her own bower, as usually no other birds are in the vicinity to share in her manifestations. With closer study probably all the females of the various species of Bowerbirds will be found to build either playgrounds, platforms of sticks, or properly constructed bowers.

The female of the Newton's or Golden Bowerbird (*Prionodura newtoniana*) is also said to build a bower, the information being furnished by Mr. G. M. Sharp, who has had considerable experience with this species. In A. J. North's "Nests and Eggs," published by the Trustees of the Australian Museum, the following particulars appear on page 414, of Vol. 4, Part 5:—"The female builds a bower for herself, generally about twenty yards away from one at which the males assemble. It is in many respects similar to that constructed by the male, but is smaller, not being half the size."

The female Lyrebird (*Menura novae-hollandiae*) is a splendid song-mimic, and renders her song with the same elegance and ease as the male does. Indeed, she is often mistaken for the male, old or young, as her song is very little inferior to his, but it is generally recognised by its softer tone and less sustained volume. Truly, the female Lyrebird is the queen of female song-mimics. The female also scratches together a little mound just prior to nidification. Her mound is small in size compared with that of the male, and in many locations would not give sufficient scope for his sweeping tail. As soon as she begins the construction of her nest she forsakes the mound. When aroused her display is very little inferior to that of the male. She turns this way and that, scratches, then calls, and when her head is lowered, crest erected, wings outspread, and her tail slightly elevated and opened fanlike she presents an attitude of ornithic splendour. Apart from the very short period preceding nidification, it is difficult to say whether the female resorts to the mound at any other time of the year. It appears unlikely as nidification, incubation, and rearing and weaning the young bird, occupy approximately seven months.

Even if the female Lyrebird performs with less grandeur than the male, and if she lacks his extraordinary vigour, she, nevertheless, displays extreme delight on her mound when the male is calling on his close by. Her exultations have the appearance of being self-satisfying, and the outcome of exuberant vital force. When associated with the male in the expression of feeling, they seem to be entirely those of reciprocity and mutuality.

The evolution of mound-display probably began simultaneously with the male and female, but perfection in the female has been retarded through the abandonment by the male of nidification, incubation, and the more intimate duties associated with the successful rearing of progeny. In the case of the male surplus energy has flown towards the building up of superabundant plumage, unlimited song, and undue caution. Thus the tendency has been mainly morphological. With the female the stream of energy has been devoted chiefly to the preservation of the species, and, being subjected to the rigorous action of natural selection in performing the various stages in this process, her development has been principally physiological.

In this abstract it has been impossible to quote from the numerous authorities on sex-dimorphism, or enter into lengthy discussions on various phases of the subject. In gathering the different facts of ecology an observer is impressed with the inadequacy of existing theories in explaining certain actions. When the chemistry of cytogenesis is completely understood, we will be able to say how the internal environment affects an organism, as well as the external. We will be able to explain the origin, as well as the destiny of a species.

OVIPOSITION FOLLOWING DECAPITATION IN *PLANARIA PINGUIS*.

By DORIS A. SELBY.

From the Department of Zoology in the University of Sydney.

(Communicated by Dr. P. D. F. Murray.)

During May and June, 1927, experiments were in progress in this laboratory involving the decapitation of numbers of specimens of *Planaria pinguis*. During these two months no egg-capsules were deposited, but on July 7th two capsules were deposited by decapitated worms. On July 13th an egg-capsule was deposited by a worm in the control series, the first capsule to be laid by a worm not known to have been decapitated. In the group of worms among which this capsule was found, however, there proved to be one individual which had suffered injury in the head region. Another capsule was found on July 18th, in another group of supposedly normal worms, and again a worm with an abnormal head was found. By August 4th, six more capsules had been deposited by similar groups of control worms, four of which were in vessels found to contain injured as well as normal worms. Therefore up to this date only two egg-capsules are known to have been deposited by uninjured worms. On the other hand, no less than 76 capsules had been deposited among a group of decapitated worms numbering 158. Actually the latter number is too great, for fifty of these were worms which had been allowed to regenerate their heads after decapitation, and had then been decapitated again, so that in reality 108 worms produced these 76 capsules. Against this, only nine capsules had been deposited by several hundred "normal" worms, and there is reason for suspecting that seven of these were really produced by individuals injured or abnormal in the head region.

From August 4th onwards the percentage of normal worms which deposited capsules increased gradually, continued throughout Spring, and then decreased again, coming to zero early in November. (Sydney Spring: September and October). At all times the percentage of worms which deposited eggs after decapitation was markedly greater than that of normal worms. Unfortunately precise figures are not available, since the importance of the seasonal factor in affecting oviposition was not realised until too late. There is, however, no doubt whatever of the general truth of the statement. Finally, 40 decapitated worms deposited capsules on December 23rd. It was not thereafter possible to make further tests until March, when 40 decapitated worms produced no capsules.

From this evidence one is justified in concluding that:—

- (1). Decapitation increases the number of worms which deposit capsules.
- (2). Decapitation causes oviposition in a certain number of worms both before and after, as well as during the time throughout which normal worms deposit capsules in the laboratory.
- (3). At periods remote from this "laboratory breeding season" decapitation does not cause oviposition. No eggs were obtained from decapitated worms in May, June or March.

It is very strongly believed that the percentage of worms which deposit capsules after decapitation increases independently of the breeding season, with the

length of time the worms have been in the laboratory, up to a maximum which remains undiscovered. An experiment to test this was carried on over a period of twelve weeks, but the results were inconclusive owing to its having been performed at a time too near the end of the "laboratory breeding season," the extent of which was not then known.

The following general observations were made during the course of the experiments:—

(1). Capsules were deposited from one to five days after decapitation. There is a possibility that this period may occasionally have been as long as nine days, but such cases are based wholly upon eggs found after short periods during which observations were not made. It is very improbable that the period between decapitation and oviposition ever exceeded five days, with three days as the average.

(2). The egg-capsules vary in diameter from about 1 mm. to $1\frac{1}{2}$ mm. They are usually spherical or very bluntly oval in shape, and they have a shiny surface which becomes sticky with mucus. They are deposited attached to the floor or walls of the container by a very short, delicate, hair-like stalk which breaks at the slightest touch, without appearing to leave any scar on the capsule. The colour of the capsules is not altogether constant. Usually when first deposited they are reddish-yellow and later deepen to a dark reddish-brown, but sometimes they do not lose the original reddish-yellow shade. As a rule the capsules are opaque, but frequently the young may, in later stages, be seen through the wall, folded around each other and moving slightly.

(3). Most of the eggs deposited, whether by normal or decapitated worms, were fertile, hatching at about five weeks at laboratory temperature. The young worms are sexually mature within three months of hatching, as indicated by the fact that they may be caused to lay by decapitation. As they were not tested at earlier ages, it is possible that they may become mature when younger than this.

(4). The number of capsules deposited by a single worm varies from one to three. In the great majority of cases only one capsule is deposited, two less often than one, while three were laid only once.

(5). The number of young hatching from a single capsule varies from two to fourteen, five to nine being the usual number.

(6). The young worms vary greatly in colour at hatching, some being already of the deep brown to black colour of the adult, and others quite colourless, with all intermediate conditions.

In the present state of our knowledge of Planarian physiology it would be hazardous in the extreme to put forward any dogmatic interpretation of this remarkable phenomenon. Certain points, however, lead one to advance a working hypothesis of a purely tentative nature. In the first place it is to be noted that removal of the head results in the temporary loss to the animal of the main sense organs and of the brain. The result must be an immense decrease in the worm's sensitivity to its environment. Secondly, it is difficult to regard decapitation as a stimulus in the ordinary sense of the word; a view more likely to be correct would be to regard it as resulting in the removal of an inhibition, or at any rate in decreasing the efficiency of the animal's adjustment to its environment. Since laboratory glassware is not the animal's normal environment, the worm, when in possession of its brain and sense organs, only deposits capsules under these conditions in a relatively small percentage of cases. Hence one may regard non-oviposition as a result of normal adjustment with the environment, the deposition of capsules being the result of incorrect adjustment due to the animal's

insensitivity to the conditions under which it is living. Put into other words, the normal worm refuses to lay eggs because the environment is not suitable, and because, by virtue of its brain and sense-organs, it is "aware" of this. The headless worm lays eggs under identically the same conditions because it is not "aware" that the latter are unsuitable. That the percentage of worms which lay eggs after decapitation appears to increase with the time the worms have lived in the laboratory is in favour of this view, for it suggests that worms manufacture eggs in the laboratory, even though they do not deposit them, and hence the later the decapitations are performed the more worms there are with eggs ready to be deposited as soon as the central nervous inhibition is removed, either by removal of the main nervous organs or by removal of the conditions which bring the inhibition into existence.

Finally, the author is well aware of the incomplete condition of this work. As, however, it is not proposed to carry the investigation further, it seems well to publish this note in order to record the fact of oviposition following decapitation, and in order to give what little information is available for the benefit of future workers.

It should be stated that the author knows of no record in the literature of phenomena similar to this.

The author wishes to express her gratitude to Dr. P. D. F. Murray, of this Department, for suggestions and assistance given by him during the course of the work.

REVISIONAL NOTES ON AUSTRALIAN THEREVIDAE.

By JOHN S. MANN.

PART I.

Introduction.

This paper is the first of a series in which it is intended to prepare a revision of Australian THEREVIDAE.

The first Australian Therevid was described by Guerin in 1830 (*Agapophytus australasiae*) and in 1835 Walker described a second species (*Thereva misella*) which has remained unrecognised; others were added by Erichson in 1842, Macquart 1846-1850, Walker 1848-1857, Schiner and Thomson in 1868, Roder in 1885, Bigot in 1889 and more recently, the species of the Indo-Australian region were revised by Krober in 1912 and further species were described by the same author in 1913 and 1914; White published his revision of the Tasmanian species in 1915 and in 1916 Hardy described one species as new, and again in 1921 the same author gave some valuable notes and divided the Australian genera into two groups.

Krober in his work added greatly to our knowledge of this group, but, as pointed out by White in 1915 and by Hardy, 1921, the unsatisfactory quality of his generic conceptions has left the taxonomy of the Australian genera in a condition that cannot be regarded as satisfactory.

Unfortunately insufficient material is available at present to allow of a complete revision of the family, but such genera as are recognised will be dealt with in the series. In this part two new genera are proposed, seven species described as new and six names sunk as synonyms.

It was the late Arthur White's intention to revise the mainland species on completing those of Tasmania and he indicated in his manuscript, which was in the possession of the late Dr. E. W. Ferguson, that in classifying the genera, the form of the wing venation seemed to be of considerable importance. Mr. G. H. Hardy independently arrived at the same conclusion after examining all of the material available to him. As far as the Australian representatives of the family seen by me are concerned this character still holds good, and it is my intention to utilise this convenient grouping.

While thanking the Director of the South Australian Museum, Dr. I. M. Mackerras, Messrs. F. H. S. Roberts, A. P. Dodd, B. A. Smith and T. A. Cole for the generous loan of material, I wish to express my indebtedness to Mr. G. H. Hardy for the loan of his entire collection and for his unpublished notes, also for criticisms given during the preparation of this paper. My thanks are also due to Dr. C. H. Curran, Department of Agriculture, Ottawa, Canada, for representatives of some American genera that have been used for comparison purposes.

Characters of the Adult.

The THEREVIDAE form a well defined group of the Asiloidea and in general appearance closely resemble some of the ASILIDAE (*Dasygogoninae*), but are less heavily built, with weaker legs, no excavation between the eyes on the vertex and

with a fleshy proboscis in contrast to the more or less chitinised one found in ASILIDAE. The venation distinctly separates them from the BOMBYLIIDAE, MYDAIDAE and APIOCERIDAE, the latter differing also in the form of the palpi.

The species are mostly small to moderately sized, with the head hemispherical, semicircular or somewhat pyriform; the antennae are composed of three primary segments, the third of which bears an apical or subapical style which may be either one or two segmented and which also bears a one or two segmented apical or subapical arista, thus in all, never more than seven segments have been traced; the eyes are large, approximated, contiguous or widely separated in the male, and more or less broadly separated in the female, sometimes furrowed, never hairy; three ocelli are present and most species have distinct orbital or post-ocular bristles; the front is generally hairy; the face is short, often receding, bare or tomentose only; the cheeks are generally quite small and usually bear long thin hair; the proboscis and palpi are as a rule small, often projecting, blunt or broadened at the apex, but sometimes sharp pointed as in *Acupalpa* Krober.

The thorax is of moderate size and bears hairs and bristles. The bristles, although quite uniform in general arrangement are apparently of little systematic importance; they vary, but the variation appears to be individualistic and not specific. The scutellum bears marginal bristles, is generally semicircular and horizontal, but in the genus *Acrispisa* is triangular and raised to become perpendicular.

The abdomen is composed of eight clearly detected segments, narrowly or broadly conical or straight sided and somewhat flattened, often hairy and in the males of some genera silvery pollinose.

The legs are moderate in length, but the posterior pair are considerably longer than the others; the femora may have one or several pairs of bristles or may be bare; the tibiae and tarsi usually very bristly.

The wings are broad, hyaline, darkened, banded or spotted and with a fairly uniform venation; veins M1 and M2 may coalesce for a little beyond the median cell or may be narrowly separated at the cell or else broadly separated at their origin and coalesce before or at the margin, converge or diverge; CU1 and 1A coalesce before or at the margin of the wing; a well developed stigma is generally present and the costa is often denticulate or ciliated and is inflated to some extent in *Anabarrhynchus*, conspicuously so in *A. passus* White.

Habits of the Adult.

Little is known of the habits of adult THEREVIDAE, although some species have been regarded as being predators on other insects, especially small diptera.

An examination of the mouth parts does not indicate any special adaptations for such a mode of life. The ASILIDAE on the other hand are active and have a chitinised proboscis which enables them to pierce and kill their prey, whereas the THEREVIDAE are mostly less active and the proboscis has fleshy labella which would certainly prevent them from killing any of the more heavily chitinised insects. Although the writer has observed them flying about in numbers he has never seen them catch insects. Usually predatory insects have to be watched only for a short space of time when they will catch or endeavour to catch their prey. It has been recorded on several occasions that the adults have been bred from Lepidopterous larvae (*Sphinx*, *Aleucis*).

The males usually appear on the wing earlier than the females and may be seen hovering in the air in a manner reminiscent of some of the CHIRONOMIDAE; when hovering thus some of the species are very conspicuous owing to the silvery

pollinose of the abdomen, and, again, the posterior legs hang downward in a manner characteristic of many HYMENOPTERA. The females are generally to be found running about the ground or resting on grass stems or the leaves of low growing shrubs.

Some of the genera may be captured around flowers, particularly *Leptospermums*, others by sweeping long grass, while others frequent the damp river banks or scrubs, sand dunes along the coast or sandy patches throughout forest country.

The Early Stages.

The larvae are elongate, slender and apparently 19 segmented, tapering at both ends, amphipneustic, living in the earth, sand or rotting wood. Brunetti (Fauna of British India, Vol. 1) reports that they are "occasionally found in fungi, turnips or dung and are said to be carnivorous." Miss Vera Irwin-Smith informs me that she has frequently found them when digging in her garden and has fed them on blowfly larvae, meat and worms.

The pupae are free with two spines on the head, a rather heavy thorax and with each abdominal segment armed with a circle of reclinate bristles or spines.

Distribution.

Psilocephala is the only genus that is known from all countries of the world. *Thereva* is known from all except Australia; the remainder are more or less limited in distribution. Kroeber records 11 genera as Indo-Australian only, 9 as Palaearctic, 4 as North American, 1 as South American and 2 as African.

Ectinorrhynchus has been described from South Africa and South America, and *Anabarrhynchus* from Madagascar and Chile.

All of the other genera recognised and dealt with in these notes are confined to Australasia.

Key to the Groups.

- Cell M3 open Group 1.
 Cell M3 closed Group 2.

Group 1 includes the genera *Ectinorrhynchus*, *Evansomyia*, *Taenogera*, *Platycarenum*, *Anabarrhynchus*, *Neodialineura*, *Psilocephala*, *Belonalys* and *Eupsilocephala*.

Group 2 is represented by the genera *Agapophytus*, *Phycus*, *Actopygia*, *Acupalpa*, *Lonchorrhynchus*, *Parapsilocephala*, *Pseudoloxocera* and *Acrispisa*.

The genus *Spatulipalpa* has not been recognised but Kroeber described two species, one with the cell closed and the other with it open. It is quite probable that one of these species will later be associated with another genus, but until recognised the genus will have to be left in abeyance. It has recently been questioned if *Clethentia* White, originally placed in the family LEPTIDAE and transposed to the THEREVIDAE by Hardy in (Proc. Linn. Soc. N.S. Wales), 1921, belongs to this family owing to the absence of the female genital spines.

Key to the Genera of Group 1.

1. Metallic coloured *Eupsilocephala* Kroeber.
 Not metallic coloured 2.
2. First antennal segment greatly swollen and arising from a bilobed antennal tubercle; style one segmented; arista short; small species.
 *Neodialineura* gen. nov.
 Not such flies 3.

3. Antennae with style and arista subapical; head distinctly pyriform, but broad; front with two shining black calli. *Platycarenum* Krober. Style apical; calli if present, indistinct; head if pyriform, not broad. 4.
4. Abdomen short, robust and conical. *Anabarrhynchus* Macquart. Abdomen elongate, if conical then slender 5.
5. Antennae distinctly longer than head; style two segmented; abdomen of males silvery pollinose; antennal tubercle prominent. . *Evansomyia* gen. nov. Antennae shorter than, or at most, very slightly longer than the head. 6.
6. First segment of antennae robust and noticeably broader than the third when viewed dorsally; style one segmented; abdomen of males silvery pollinose; antennal tubercle prominent. *Ectinorrhynchus* Macquart. First segment of antennae, when viewed dorsally, not noticeably robust or broader than the third; style two segmented; abdomen of males not silvery pollinose; antennal tubercle not prominent. *Taenogera* Krober.

Note.—The number of segments in the style affords an excellent character for the separation of the genera, but it is not always convenient, therefore an attempt has been made to incorporate other distinctions in the above key.

The genera *Psilocephala* and *Belonalys* have not been recognised, therefore it has not been possible to insert them in the key; notes will be given on these genera in the ensuing pages.

Genus ECTINORRHYNCHUS.

Ectinorrhynchus Macquart, Dipt. Exot., suppl. 4, 1850. *Dimassus*, Walker, List. Dipt. Brit. Museum, suppl. 1, p. 108, 1851.

The head is broader than the thorax, flattened above and produced in front and thus appearing somewhat pyriform and forming a prominent antennal tubercle; antennae inserted below the middle of the head height, which position is in relation to the anterior curve, horizontal or sub-deflexed, approximated or contiguous at the base, composed of three primary segments with an apical style which bears a short arista; the first segment is considerably thickened and the second and third divergent; proboscis and palpi projecting prominently; eyes large and descending well down on to the cheeks; face and cheeks small.

The thorax longer than broad; scutellum semicircular and furnished with 2 marginal bristles; postscutellum convex.

The abdomen is parallel sided and somewhat flattened, in the male covered with silvery tomentum.

The anterior coxae are sometimes elongate; the femora bear a pair of apical bristles and the tibiae and tarsi are furnished with numerous bristles.

The wings are twice to three times as long as broad and banded; vein R4 meets the border well above the tip of the wing and R5 well below, M1 and M2 divergent, M3 and M4 very slightly convergent, 1A straight and coalescing with CU1 well before the border; costa ciliated.

Genotype. *Ectinorrhynchus variabilis* Macquart.

Distribution: The typical species is distributed over practically all of the southern half of the continent; and *albimanus* Krober from N.S. Wales and Southern Queensland.

Under this genus eight Australian species were placed, namely:—*variabilis* Macquart, *phyciformis* White, *terminalis* Walker, *superbus* and *viduus* Schiner, *brunneus*, *albimanus* and *rufipes* Krober; of these *terminalis* is a synonym of *variabilis*, *superbus* and *viduus* are synonymous and more readily conform to the

genus *Taenogera*, *rufipes* belongs to group 2 and *phyciformis* has been removed to a new genus. This leaves only three species conformable to the genus, two of which are described below, the third, *brunneus* not having been recognised.

Range: The genus seems to be mainly confined to Australia, but two species have been described from South Africa and one from South America; it is probable, however, that these will be associated with another genus at some subsequent date.

Key to the Species of Ectinorrhynchus Macquart.

- Antennae light brown; wings with three cross bands; slender species.
 *albimanus* Kröber.
 Antennae dark brown; wings with two cross bands; robust species.
 *variabilis* Macquart.

ECTINORRHYNCHUS VARIABILIS.

Thereva variabilis Macquart, Dipt. Exot., suppl. 1, p. 102, 1846; *Dimassus terminalis* Walker, Cat. Dipt., pt. 1, 129, 1848; *Id.*, Walker, Dipt. Saund. Ins., 1, p. 3, 1850; *Ectinorrhynchus variabilis* Macquart, Dipt. Exot., suppl. 4, p. 103, 1850; *Xylophagus variabilis* Walker, List. Dipt. Brit. Mus., suppl. 1, 1854; *Xylophagus basipunctatus* Walker, Trans. Ent. Soc. Lond., iv., p. 121, 1857; *Ectinorrhynchus variabilis* Schiner, Reise Novara. Dipt., 1868; *Id.*, Kröber, Ent. Mitt., 1, p. 155, 1912; *Id.*, White, Proc. Roy. Soc. Tasm., 1915.

Length: 10-13 mm.

Male: Head considerably broader than long; occiput greyish or brownish grey and bearing rows of black hairs and bristles; eyes separated on the vertex by the width of the ocellar tubercle, slightly convergent below this for one half of the length and from thence widely diverging; front flattened, narrower above than below, black-brown with white towards the eye margins; antennal tubercle dark-brown, circled by a narrow silvery white band and bearing numerous stiff black hairs; the antennae are dark-brown with some blackish reflections, shorter than the head, subdeflexed, closely approximated at the base, with the first segment thickened, it being one-third as wide as its greatest length, slightly tapering from base to apex and bearing numerous black bristles and stiff black hairs; the second segment is somewhat globular, narrower than the apex of the first, but similarly covered with black hairs and bristles; the third is about half the length of the first, ovoconical and bearing a few stiff black hairs at the base; the style is tholiform; the arista short; the face greyish; the cheeks silvery grey and bearing long thin whitish hairs; the proboscis is brown-black and projects in an upward direction as far forward as the apex of the second antennal segment; the palpi are yellow and two-thirds the length of the proboscis and covered with blackish hairs.

The thorax is twice as long as the head, two-thirds as broad as long and as deep as broad, covered with blackish pubescence and varying in general colour from greenish-grey to light brown and with two lateral and one dorsal broad dark-brown longitudinal stripes, the dorsal one of which extends only for two-thirds the length of the dorsal surface; humeral calli bright brown or yellow-brown; pleurae greyish or blackish but sometimes brownish; scutellum brownish black with the posterior margin dark brown and bearing two black and convergent marginal bristles; postscutellum black, almost hidden beneath the scutellum.

The abdomen is flattened, straight sided, black, the first five segments extensively covered with shining silvery white tomentum on the dorsum and with the sides brown, the remaining segments are shining brown; the second and third segments often have the hind margins white; genitalia reddish with yellow-brown extremity; venter brownish.

The legs: Coxae brown and covered with greyish tomentum; femora and posterior tibiae dark brown, the posterior femora being somewhat darker, the intermediate and anterior tibiae yellow-brown with blackish apices; tarsi black with the basal two-thirds of the first anterior and intermediate segments yellow-brown and that of the posterior, yellowish; the posterior femora bear a pair of black apical bristles and the tibiae and tarsi are furnished with numerous black bristles and hairs.

The wings are three times as long as broad, tinged brownish and with two blackish brown cross bands, one of which is narrow, irregular and indistinct and crosses at the base of the median cell, and the other broad and distinct and extends from the apex of the median cell to the tip of the wing.

Variations: The colour of the hind femora may vary from dark brown to black-brown and the basal third of the first hind tarsal segment from dirty white to yellow. The colours of the thorax are very variable.

Female differs from the male by having a slightly broader front, lighter coloured legs and by the absence of the silvery pollen on the abdomen which is either shining black with the hind margin of the fifth segment, the apical half of the sixth and the whole of the seventh and eighth, orange-brown or shining red-brown, or else orange-brown with the hind margins of the segments black.

This is the typical form of the genus and is the most common Therevid met with along the coast of Australia and Tasmania and with a range extending from Hobart (Tasmania) to Brisbane (Queensland); it is also known from West Australia. The species appears on the wing as early as July in Brisbane and continues throughout the summer months. It is readily distinguished from the other members of the genus by the wing pattern in conjunction with the colour of the legs and the thoracic stripes.

Localities: Sydney, Woy Woy, Barrington Tops, Ballina, Moss Vale (N.S.W.), Brisbane (Queensland), Georgetown, Mount Arthur, Bridport, Hobart, Triabunna (Tasmania), Warren (West Australia).

ECTINORRHYNCHUS ALBIMANUS.

Ectinorrhynchus albimanus Krober, Mitt. Naturh. Mus. Hamburg, xxxi., p. 37, 1914.

Type: K. K. Hofmuseum, Wien.

Length: Male, 9-11 mm.; female, 12-14 mm.

Male: Head with the occiput dark brown and bearing numerous black hairs and bristles; the front is dull black, somewhat grey towards the eye margins, beset with a few black hairs and the lower third ornamented with a few indistinct longitudinal striae; antennal tubercle dull black, brownish at apex and with silvery sides; the antennae are light brown with the first segments contiguous, thickened, three times as long as the greatest width which is at the base and beset with a few black bristles; the second segment is somewhat globular, flattened at both ends and bearing a few black bristles and hairs, the third is nearly three times as long as its greatest width and has the sides straight and parallel for two-thirds of their length and from thence converging, bears a few black bristles at the base and is covered throughout with fine black hairs; the style is short and conical with a rather thick arista which is slightly longer than the style; face brown; cheeks silvery grey and bearing a few long, thin, whitish and some short black, hairs; the proboscis is dark brown and projects as far forward as the middle of the first antennal segment; the palpi are light brown and two-thirds the length of the proboscis.

The thorax is greyish brown with six broad longitudinal stripes, the four median dorsal ones of which extend for two-thirds the length and the outer ones indistinct but extending for the whole length of the dorsal surface; pleurae greyish black; scutellum dark velvet brown with a chocolate brown margin and bearing two erect, divergent black marginal bristles; postscutellum black.

The abdomen is dull black and covered with silvery tomentum; venter brownish; the genitalia red-brown.

The legs: Anterior coxae elongated, light brown and the remaining coxae grey; femora and tibiae light brown, the posterior ones being sometimes dark brown; tarsi black with the basal third of the first segment dark brown.

The wings are hyaline with a narrow brown cross band at the base, one broad and irregular crossing the median cell and another crossing just prior to the wing tip. Halteres yellow-brown.

The female differs from the male in having a slightly broader front, brown halteres with pale yellow apices and a more elongate abdomen which is not silvery pollinose.

Habitat: Mosman (N.S. Wales), 1 male and 1 female, November, 1923 (Mackerras); National Park, 1 male and Mount Tambourine, 2 females (H. Hacker), and 2 females (W. H. Davidson) Queensland.

The pattern of the wings together with the colour of the antennae, legs and thorax readily separate this species from *variabilis*.

ECTINORRHYNCHUS BRUNNEUS.

Ectinorrhynchus brunneus Krober, Ent. Mitt., 1, p. 157, 1912.

The following is a translation of the original description given by Krober:—

"Female.—Cinnamon-brown throughout. Head much broader than long. Frons above the antennae shining black, the rest with bright brown tomentum. Lower face with silver white pubescence. Antennae bright orange. First segment with soft black bristles; third segment widened in the form of a leaf; style quite short. Thorax with two ill-defined longitudinal lines. Scutellum bright yellow brown, the ground colour velvet black. Abdomen shining orange; the first segment dull. Femora bright orange, the hind pair somewhat darkened at the end. Anterior tibiae whitish, the others pale yellow. Tarsi blackish, anterior metatarsi almost white. Femora bare, tibiae with a few black bristles. Wings with the tip and band blackish. Fourth posterior cell wide open. Length: 10 mm. N.S. Wales."

This species has not been recognised in any of the material examined, but I consider it advisable to give the original description as it is not easily available. The species has not been included in the key, but it should be readily recognised by the shining orange abdomen in conjunction with the banded wings and shining black front.

Genus EUPSILOCEPHALA.

Eupsilocephala Krober, Ent. Mitt., 1, p. 255, 1912.

Metallic species with the head hemispherical, considerably broader than long and slightly broader than the thorax; occiput broad, convex; eyes separated in the female by twice the width of the ocellar tubercle, large and descending well down on to the cheeks and with the facets uniform in size; the front is broad, bare, slightly raised above the antennae and ornamented with a shallow transverse furrow; antennal tubercle flattened; the antennae are longer than the head with the first segment cylindrical and furnished with numerous bristles and almost equal in length to the third which is slightly broader, oval and furnished with bristles; the second segment is very short and globular; the style is two seg-

mented and elongate; the arista apical and elongate; face and cheeks very small and the latter bearing long thin hairs; the proboscis is thickened and projects as far forward as the middle of the second antennal segment; the palpi are two-thirds the length of the proboscis and slightly enlarged at the apex.

The thorax is convex, only sparsely covered with short hairs and is furnished with but few bristles which are mainly weakly developed; scutellum semicircular and bears two marginal bristles; postscutellum convex and well hidden beneath the scutellum.

The abdomen is hardly twice as long as the thorax, broadly conical with a blunt apex and sparsely covered with short hairs.

The legs are of moderate length and the posterior femora bear two pairs of apical bristles.

The wings are almost twice as long as the abdomen and slightly more than twice as long as broad; vein R4 decumbent for half its length and from thence curving upwards to meet the border well above the wing tip; R5 decumbent and joining the border well below the wing tip; M3 and M4 slightly convergent; 1A is straight and coalesces with C_u1 just before the hind margin; the costa and hind margin ciliated; median cell rather large.

Genotype. *Eupsilocephala singula* Walker.

Krober formed this genus for Walker's *Thereva singula*, but it is evident from his description that he had not seen the species, but characterised his genus from the original description given by Walker; his description of the species contains the essential colour characters only and these are given in Walker's words. Krober states that the antennae are intermediate between *Psilocephala* and *Parapsilocephala* and allies his genus with these two and calls it *Eupsilocephala*. The antennae do not show any affinities to either of the abovementioned genera, which have the antennae shorter than the head with the third segment narrowly or broadly conical. The genus is closely allied to *Anabarrhynchus*, but differs from that genus by having the front bare, slightly raised above the antennae and ornamented with a transverse furrow and by the longer antennae and the less hairy thorax and abdomen.

This is the only known genus of Therevid with metallic colouring which makes it easily recognised.

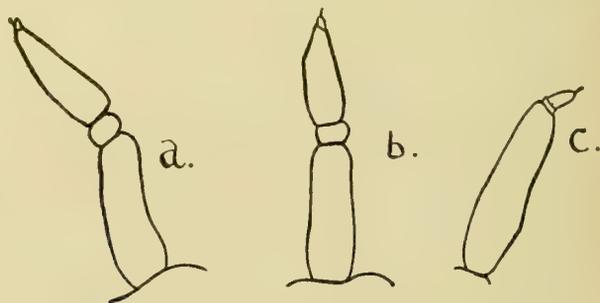


Fig. 1.

- a. Antenna of *Ectinorrhynchus variabilis* Macquart.—Profile view.
 - b. Antenna of *Ectinorrhynchus albimanus* Krober.—Profile view.
 - c. Third antennal segment of *Eupsilocephala singula* Walker.—Profile view.
- (All of same magnification.)

EUPSILOCEPHALA SINGULA.

Thereva singula Walker, List. Dipt. Brit. Mus., 1, p. 227; 1848; *Eupsilocephala singula* Krober, Ent. Mitt., 1, p. 255, 1912.

Length: 14 mm.

Female: Head with the occiput shining black in the middle, golden on the sides and furnished with rows of black hairs and bristles; front shining brown-black; antennae dull brown-black, the first two segments bearing numerous black hairs and bristles; the first segment is cylindrical with straight sides, four times as long as the second, which is somewhat globular; the third segment is oval, about the same length as the first and covered with short black hair; the style has its first segment short and its second conical and twice as long as the first; the arista is almost as long as the second segment of the style; face yellow; cheeks blackish and bearing long thin black hairs; the proboscis and palpi are black, somewhat brown at the apices and bearing blackish hair.

The thorax is dark shining blue with blackish reflections; humeral calli, reddish-purple; pteropleura dark shining blue and the remaining pleurae shining black; scutellum dark shining blue with purple reflections and bears two black marginal bristles; the postscutellum is dark black.

The first segment of the abdomen is shining purple and the remaining segments mainly shining green but with dark shining blue, black and purple reflections; the venter is very metallic, exhibiting black, purple, blue, green and red reflections, but the predominating colour is dark green; the genital spines are black.

The legs are brown-black with all bristles and hairs black.

The wings have the basal cells darkened brown, from thence to the base of the median cell, hyaline, and from thence to the tip dark brown. The halteres are dark brown.

The male is unknown.

A most beautiful species and readily recognised by the metallic colouration; it is the only known species of Therevid with metallic colouring. Walker in his original description noted that the species was allied to *Dasyomma* (STRATIOMYIIDAE) to which it does bear a superficial resemblance.

Habitat: Tasmania; no date given (A. Simson). The type locality is West Australia and the only specimen known to me is in the collection of the South Australian Museum.

Genus PLATYCARENUM.

Platycarenum Krober, Ent. Mitt., 1, p. 243, 1912.

Head broader than the thorax; when viewed from above, longer than broad and considerably flattened and drawn out in front at the base of the antennae presenting a shape distinctly pyriform; occiput broad, convex and with a slight median indentation; the eyes are small and widely separated in both sexes; front broad above and widening towards the antennae where it is generally broader than long, ornamented with two irregular shining black calli; the antennae, in relation to the frontal curve of the head are situated below half its depth, about as long as the head, composed of three primary segments; style two segmented and sub-apical; arista short; face small and tomentose; cheeks small and covered thickly with long, fine hair; proboscis and palpi projecting.

The thorax is convex above and slightly longer than broad; scutellum semi-circular and bears four convergent marginal bristles; postscutellum convex.

The abdomen is flattened above with the first three segments straight sided and the remainder slightly tapering.

The femora bear a pair of apical and a pair of intermediate bristles; the tibiae and tarsi bear numerous bristles and hairs.

The wings are twice as long as broad and considerably longer than the abdomen, hyaline with well defined venation; R4 joins the border well above and R5 well below the wing tip; 1A is straight and coalesces with Cul just before the border; M3 and M4 convergent; costa and hind margin ciliated.

Genotype. *Platycarenum quinquevittata* Macquart.

This genus is evidently allied to *Anabarrhynchus* and *Eupsilocephala* and differs from the former by the subapical style, the distinct shining frontal calli and by the more slender shape and longer and more flattened abdomen, and, from the latter, chiefly by the shape of the abdomen, the length of the antennae, position of the style and by the body being thickly clothed with hairs. As with some other of Krober's genera the genus is erected on somewhat arbitrary characters, but as it is readily distinguished from the other genera I do not consider it advisable to sink the genus as a synonym.

PLATYCARENUM QUINQUEVITTATA.

Thereva quinquevittata Macquart, Dipt. Exot., suppl. 2, p. 50, 1847; *Thereva arida* Walker, Trans. Ent. Soc. Lond., iv., p. 133, 1857; *Platycarenum porrectifrons* Krober, Ent. Mitt., 1, p. 244, 1912; *Anabarrhynchus pallidus* White, P. & P. Roy. Soc. Tasm., 1915; *Platycarenum quinquevittata* Hardy, Proc. Linn. Soc. N.S. Wales, xlvii., p. 299, 1921.

Length: 10-12 mm.

Male: Head with the occiput yellow-brown and furnished with numerous hairs of a similar colour; the eyes are separated by twice the width of the ocellar tubercle; the front is light yellow-brown and is rather thickly covered with black hair; the first two segments of the antennae are light brown and are furnished with numerous black hairs and bristles, the third segment and the style, black; the first segment is three times as long as the second and considerably broader and is, at its greatest breadth, which is the base, less than one-third as broad as long, straight sided and slightly tapering; the second segment is slightly longer than broad and somewhat globular; the third is half the length of the first, more than twice as long as its greatest width and constricted medianly; the style has the first segment short, three times as broad as long, though not as broad as the third antennal segment; the second segment is somewhat rectangular and considerably longer than broad; arista black; face and cheeks silvery grey and covered with whitish hairs; proboscis brownish and projects as far forward as the middle of the first antennal segment; palpi yellowish, two-thirds the length of the proboscis and covered with whitish hairs.

The thorax is light yellow-brown dorsally, grey laterally and with three narrow brown longitudinal dorsal stripes; scutellum yellowish-brown.

The abdomen is uniformly greyish and covered with yellowish hairs and tomentum; venter yellowish; genitalia bright yellow.

The legs are wholly yellow; the tibiae and tarsi with some brownish reflections and bearing numerous black hairs and bristles; the femora are covered with yellowish hairs.

The wings are considerably longer than the abdomen, hyaline with well defined venation; vein R4 decumbent for half its length and then curving upward to meet the wing border; R5 decumbent; M3 and M4 markedly convergent; 1A

straight and coalescing with Cu1 just before reaching the hind margin. The halteres are yellowish.

The female differs from the male by having the eyes slightly more widely separated, by the absence of the grey on the sides of the thorax and by the abdomen being uniformly light yellow-brown and slightly more pointed and elongate.

Habitat: Woy Woy, N.S.W., 3 ♀, 4th October, 1924 (Mackerras); Tasmania, 8 ♀, 2 ♂ and 2 pairs taken in copula, January-February (G. H. Hardy).

The above synonymy recorded by Hardy in 1921 is evidently correct; the original descriptions will all fit the one species and Macquart's name has priority. The species may be captured in the vicinity of sand hills along the coast and its colouring is clearly protective in such situations. It is unknown from Queensland, but should subsequently be found to occur along the coast of the southern half of that State.

Genus *EVANSOMYIA*, *gen. nov.*

The head is considerably broader than long, broader than the thorax, somewhat flattened above and slightly produced in front; occiput concave; eyes separated in both sexes, slightly more so in the female than in the male, large and descending well down on to the cheeks; front straight, flattened and almost bare; antennal tubercle prominent and bare; antennae considerably longer than the head and inserted, in relation to the anterior curve of the head, below half its depth, approximated at the base with the segments divergent; the first segment is longer than the second and third united, cylindrical, straight sided and bearing numerous bristles; the second is short and globular and the third narrowly conical, shorter than the first and bearing a few weak bristles at the base; style two segmented, the first segment being short and broad and the second tholiform; arista short, fine and subapical; face and cheeks small, the latter bearing long fine hair; proboscis short and thick and projecting as far forward as the apex of the antennal tubercle; palpi half the length of the proboscis.

The thorax is longer than broad, convex above and bears very few bristles; scutellum semicircular and bearing four divergent marginal bristles; postscutellum convex.

The abdomen is twice as long as the thorax, flattened above, tapering in the female and more or less straight sided in the male; the dorsum of the male is covered with silvery tomentum.

The legs: Coxae bear tufts of hairs; the posterior femora a pair of apical and the tibiae and tarsi numerous bristles.

The wings are more than twice as long as broad, but hardly as long as the thorax and abdomen together, tinged, banding very indistinct; R4 meets the border well above and R5 well below the tip; M3 and M4 slightly convergent; Cu1 coalesces with 1A, which is straight, well before the border; costa and hind margin ciliated.

Genotype. *Ectinorrhynchus phyciformis* White.

This genus is proposed for White's *E. phyciformis* and is apparently very closely allied to *Ectinorrhynchus* on the one hand and *Taenogera* on the other; the two segmented style would place the species in the latter genus, but the shape and length of the antennae together with the silvery pollinose abdomen of the male and the prominent antennal tubercle separates it from that genus. It more closely conforms to the characterisation of *Ectinorrhynchus*, but differs by having a two segmented style and by the elongate antennae with the first segment narrow and cylindrical.

I reluctantly propose this genus in a family which is already over burdened with genera, but the species cannot be satisfactorily placed in any of the genera which have been proposed.

There is a further species, represented by one specimen in the material before me, which may belong here, but the specimen is in too poor a condition for describing.

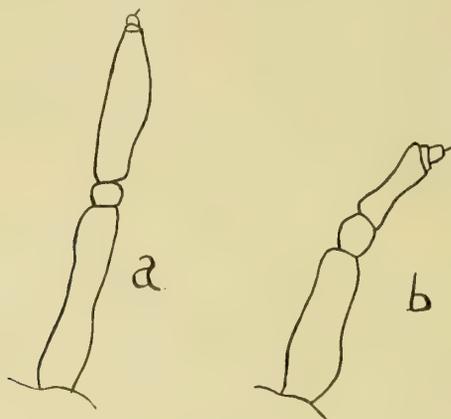


Fig. 2.

- a. Antenna of *Evansomyia phyciformis* White.—Dorsal view.
 b. Antenna of *Platycarenum quinquevittata* Macquart.—Dorsal view.
 (Both of same magnification.)

EVANSOMYIA PHYCIFORMIS.

Ectinorrhynchus phyciformis White, Proc. Roy. Soc. Tasm., 1915.

Length: 10-12 mm.

Male: Head with the occiput deep black and fringed with black hairs and with a central patch of silvery white; eyes separated on the vertex by the width of the ocellar tubercle; front flattened, shining black and with a central transverse band of silvery white which extends in two rather narrow lines down the eye margins to the cheeks; antennal tubercle shining black; antennae divergent, testaceous at the base, from thence to the tip black; the first segment longer than the others united, straight sided, cylindrical and bearing numerous black bristles and hairs; the second segment is short, rounded and flattened at the extremities; the third is straight sided at the base, the apical two-thirds conical and bearing a few black hairs at the base; the style and arista short; face shining black; cheeks very small and silvery grey; proboscis chestnut-brown and projecting only slightly; palpi brownish at the base, yellowish at the apex and about half the length of the proboscis.

The thorax is hardly twice as long as broad, about as deep as long, dull black on the dorsum and with the sides deep shining black; ornamented with two convergent yellowish longitudinal dorsal stripes which are confluent on the basal third, forming a rectangular area; the scutellum is dark orange with the apex bright yellow and furnished with four black marginal bristles; postscutellum blackish.

The abdomen is straight sided but tapers slightly towards the apex; uniformly orange-red with segments 2-6 silvery pollinose; genitalia orange-red.

The legs: Coxae light orange, covered with silvery tomentum; anterior and intermediate femora light orange, posterior femora orange red; anterior and intermediate tibiae dark yellow, the posterior ones having the basal half brown with blackish reflections and the apical half blackish; tarsi with basal half of first segment dirty white; the posterior femora bear a pair of black apical bristles.

The wings are more than twice as long as broad but hardly as long as the thorax and abdomen together, tinged brownish and with a faint trace of a darker band which crosses the apex of the median cell. Halteres bright yellow.

The female differs from the male by the slightly broader front, the absence of the silvery white transverse frontal stripe, the longer and sharper pointed abdomen which is not silvery pollinose and by the longer wings.

White's type, male and female in G. H. Hardy's collection, Brisbane.

Habitat: Tasmania, Victoria and Blackheath, N. S. Wales, January.

Genus TAENOGERA.

Taenogera Krober, Ent. Mitt., 1, p. 151, 1912.

Head broader than long, slightly broader than the thorax, subhemispherical or somewhat pyriform; occiput concave or flat and with a median indentation; eyes separated in both sexes; front broad, convex or flattened, sculptured or indented and hairy; antennal tubercle flattened; antennae, in relation to the anterior curve of the head are situated below half its depth, composed of three primary segments the third of which, when viewed in profile is broadly and evenly conical, but when viewed dorsally is often straight sided and tapering and is longer than the first and second segments united; face and cheeks small, the former tomentose or bare and the latter furnished with long thin hair; proboscis and palpi projecting slightly.

The thorax is convex above, considerably longer than broad; scutellum semi-circular and bearing from 2-6 marginal bristles; postscutellum convex.

The abdomen is attenuated or narrowly conical, constricted in the middle or straight sided, flattened or cylindrical.

The wings are considerably longer than broad, banded or clouded with a distinct stigma; R4 joins the border well above or slightly above the tip and may be wholly decumbent or for part of its length only and then curving upward; R5 joins the border well below the wing tip; M3 and M4 slightly convergent; Cu1 coalesces with 1A, which may be straight or concave, well before, just before or at the hind margin; costa and hind margin ciliated.

The legs: Coxae are furnished with rows of hairs or bristles; the femora generally bear a pair of apical bristles and the tibiae and tarsi are furnished with numerous bristles and hairs; the first segment of the tarsi is often almost as long as the tibiae.

Genotype. *Taenogera nitidus* Macquart.

Distribution: The typical species together with *latistria* is known from Sydney only; *superbus* from N. S. Wales and Queensland; *gracilis* and *notati-thorax* from Queensland and *nigrapicalis* from South Australia.

In this genus is placed a heterogeneous collection of species which could probably be split into one or two additional genera, but I consider this inadvisable at the present time; *superbus* Schiner, more readily conforms to the characterisation of this genus and has therefore been transposed from *Ectinor-*

rhynchus. *Anabarrhynchus latistria* Walker, is also placed here, bringing the total number of species to six, which number includes the three described as new.

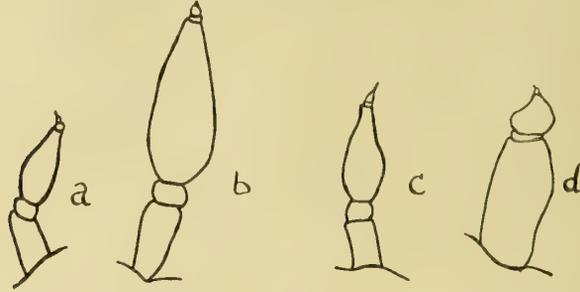


Fig. 3.

- a. Antenna of *Taenogera nitidus* Macquart.—Profile view.
 b. Antenna of *Taenogera superbus* Schiner.—Profile view.
 c. Antenna of *Taenogera nigrapicalis* sp. nov.—Profile view.
 d. Antenna of *Neodialineura striatithorax* sp. nov.—Profile view.

Key to the Species of Taenogera, Krober.

- | | |
|-----------------------------------------------------------------------------------------------------|------------------------------|
| 1. Abdomen entirely black. | 2. |
| Abdomen not entirely black. | 3. |
| 2. Wings banded; with golden yellow apex in female. | <i>superbus</i> Schiner |
| Wings not banded; tinged brown only | <i>nitidus</i> Macquart. |
| 3. Apex of abdomen black. | 4. |
| Abdomen entirely dull orange | <i>gracilis</i> sp. nov. |
| 4. Abdomen attenuated; thorax with golden yellow stripes and spots
or golden spots only. | 5. |
| Abdomen narrowly conical; thorax with greyish stripes. | <i>nigrapicalis</i> sp. nov. |
| 5. Abdomen chestnut and black; thorax with golden yellow stripes and
spots. | <i>latistria</i> Walker. |
| Abdomen orange and black, thorax with golden spots only. | |
| | <i>notatithorax</i> sp. nov. |

TAENOGERA NITIDUS.

Anabarrhynchus nitidus Macquart, Dipt. Exot., suppl. iv., p. 100, 1850; *Taenogera longa* Krober, Ent. Mitt., 1, p. 151, 1912.

Length: 9-12 mm.

Male: Head considerably broader than long; occiput concave, greyish and covered thickly with whitish hairs; ocellar tubercle prominent; eyes separated on the vertex by slightly more than the width of the ocellar tubercle; front shining black, ornamented with a few irregular grooves and carina and bearing some scattered whitish hairs; the antennae are dark brown or blackish brown, separated at the base, the apex of the first segments contiguous and the remaining segments widely divergent; the first segment is three times as long as, and broader than, the second which is more or less globular; both these segments bear numerous black bristles and hairs; the third segment is conical and longer than the first and second together; the style has its first segment somewhat straight sided and slightly longer than the second which is tholiform; the arista is subapical and is

slightly more than half the length of the style; face yellow-grey; cheeks grey and bearing whitish hairs; proboscis black and projecting as far forward as the second antennal segment; the palpi are brownish, bear blackish hairs and are two-thirds the length of the proboscis.

The thorax is shining or dull black with two broad yellowish longitudinal stripes which extend for half the length of the dorsal surface only; and with a further median dorsal yellowish area just in front of the scutellum; pleurae shining black and covered with grey tomentum; scutellum dull black and bearing 6 yellowish marginal bristles; postscutellum dull black.

The abdomen is shining black, somewhat constricted in the middle, the 2-4th segments each have a triangular silvery-white area on the sides and segments 1-4 have their hind margins brown; venter dull black; genitalia red-brown or yellow-brown.

The legs: Coxae black, covered with grey tomentum and bearing rows of whitish hairs; femora black or black-brown; anterior tibiae dark brown or black, remaining tibiae light brown but somewhat darkened at the apices; anterior tarsi dark brown or black, remaining tarsi light brown.

The wings, except for the hyaline base, are tinged brown; R4 decumbent for the whole of its length and joining the margin slightly above the wing tip; Cul coalesces with 1A, which is distinctly concave, slightly before the margin; costa and hind margin ciliated.

The female differs from the male only in having the eyes slightly more widely separated and by the broader and more regular front.

Habitat: Sydney (N.S. Wales) 3 males and 1 pair taken in copula, September and October (G. H. Hardy).

The synonymy recorded above appears to be correct; Krober erected the genus on one specimen (a female) from "Australia" in 1912 and the type was lodged in the Hamburg Museum, but Macquart, in 1850, described the species from 4 males and 5 females and placed it in the genus *Anabarrhynchus*.

The species is separated from all other members of the genus by the uniformly black colour together with the brown tinged wings.

TAENOGERA NIGRAPICALIS sp. nov.

Length: 10 mm.

Female: Head broader than long; occiput concave, greyish-black, and covered with rows of black bristles and hairs; eyes separated on the vertex by slightly more than the width of the ocellar tubercle and from thence gradually diverging; the front is somewhat flattened, black with grey eye margins, covered with black hairs and ornamented with two indistinct transverse furrows; antennal tubercle flattened, black; antennae black, separated at the base, first segments convergent, remainder widely divergent; the first segment is densely covered with black bristles and is four times as long as the second which is globular and similarly covered with black bristles; the third segment is longer than the first and second together and broader than either of them, more or less conical and covered with fine black hair; the style has its first segment broader than long and with the apex deeply concave into which the second segment, which is conical and about twice as long as the first, is received; the arista is short and thick and hardly as long as the first segment of the style; face and cheeks grey, the former covered with short black hairs and the latter with black and whitish hairs; proboscis brown, directed upwards and reaching the apex of the first segment of the antennae; palpi yellow-brown, as long as the proboscis and covered with whitish hairs.

The thorax is black with a patch of greyish on each humeral callus and with two dorsal longitudinal stripes of the same colour which converge as they extend towards the scutellum; there are two rows of 6 dorsocentral, black bristles; pleurae dull black and covered with grey tomentum; scutellum black and bearing 4 black marginal bristles; postscutellum black.

The abdomen is slightly more than twice as long as the thorax and is narrowly conical, covered with black hairs, mainly orange but the first segment is grey, the three apical ones shining black and the posterior margins of segments 2-5 are silver grey; the ventral surface of the first 6 segments is orange and the remainder shining black; genital spines reddish and very weakly developed.

The legs: Coxae black, covered with grey tomentum and bearing black bristles distributed as follows:—A pair on the anterior, 4 pairs on the intermediate and a single one on the posterior; femora light orange, covered with white hairs and the posterior pair are furnished with a pair of black apical bristles; the tibiae and the first tarsal segments, dark orange, covered with black hairs and bristles and the remaining tarsal segments, black.

The wings are tinged dark brown; R4 is decumbent for two-thirds of its length and from thence is curved upwards meeting the border well above the wing tip; M3 and M4 slightly convergent; costa ciliated. The halteres are pale yellow.

The male is unknown.

A somewhat aberrant species differing from the other members of its genus by the narrowly conical abdomen and by possessing the row of dorsocentral bristles. It is easily identified by the orange abdomen in conjunction with the grey longitudinal stripes on the thorax.

The holotype female is unique, was captured at Karoonda, South Australia, by G. E. H. Wright (no date given), and is in the South Australian Museum.

TAENOGERA SUPERBUS.

Ectinorrhynchus superbus Schiner, Reise Novara Dipt., p. 150, 1868; *Ectinorrhynchus viduus* Schiner, *Id.*, 1868; *Ectinorrhynchus superbus* Krober, Ent. Mitt., 1, p. 151, 1912; *Ectinorrhynchus viduus* Krober, *Id.*, 1912; *Anabarhynchus kinbergia* Thomson, Eug. Resa Dipt., p. 478, 1868.

Length: 10 mm.

Male: Head somewhat produced in front; occiput black at the eye margins above and with a row of stiff black hairs, and the remainder, as far as visible, silver-grey; eyes separated on the vertex by the width of the ocellar tubercle and from thence gradually diverging; front considerably flattened, velvety brown-black below the vertex for half the length and from thence to the base of the antennae, somewhat shining black and ornamented with indistinct longitudinal striae and with the eye margins dirty white to below the antennal tubercle which is somewhat shining black; the immediate base of the antennae is dirty white; antennae hardly as long as the head, contiguous at the base, the first segments parallel and the remainder widely divergent; the first segment is brown, parallel sided and bears numerous black bristles; the second is orange, hardly as long as its greatest width and also bearing numerous black bristles and hairs; the third is orange, more than twice as long as the first and second united, three times as long as its greatest width which is about one-third the distance from the base and with the apical two-thirds conical, but when viewed in profile, is broadly conical and much broader than either the first or second segments, bears a few stiff black hairs at the base; the style has its first segment short and convex at

the apex and its second somewhat tholiform; the arista is short and thick, being as long as its greatest width; face black; cheeks very small, black below, silvery grey above and bearing long fine whitish hairs; proboscis brownish black and projecting as far forward as the apex of the second antennal segment; palpi brown and two-thirds the length of the proboscis.

The thorax is hardly twice as long as broad and is almost three times as long as the head, black with greyish pubescence and with a broad velvety black dorsal stripe which extends from immediately behind the head for one-third of the length of the dorsal surface; pleurae black and covered with greyish tomentum; scutellum velvety brown-black with the apex grey and bearing two convergent marginal bristles; postscutellum black.

The abdomen is twice as long as the thorax; black with some greyish pubescence on the hind margins of the first four segments and strongly constricted in the middle; venter dull black; genital forceps of the male conspicuous.

The legs are wholly black except for the anterior tibiae which are yellow-brown and the base of the first posterior and intermediate tarsal segments which are dirty white; the coxae bear rows of stiff hairs; the posterior femora bear a pair of black apical bristles and the tibiae and tarsi numerous black bristles and hairs.

The wings are about four times as long as broad and about the same length as the thorax and abdomen united; faintly tinged with grey and with an irregular, narrow, blackish brown band crossing the base of the median cell and a further broad similarly coloured cross band extending from the apex of the median cell to the wing tip; R4 decumbent for two-thirds its length and from thence curving upward; R4 and R5 slightly convergent; Cul coalesces with 1A, which is straight, well before the margin; costa and hind margin ciliated.

The female differs from the male by having golden pubescence in place of dirty white on the head, the striae of the frons being more distinct, the thorax possessing some brownish pubescence which is absent on the male, the abdomen being more elongate and sharper pointed and possessing bright reddish hairs near the apex, the broader and more regular median cross band, the second black band extending only for one-third of the distance from the base of the median cell towards the apex, the wing being from thence golden yellow and fringed narrowly with black at the apex and by having the second segment of the style more elongate. The genital spines are red.

Habitat: Brisbane, Bunya Mountains, National Park and Mount Tambourine, Queensland; Gravesend, Richmond River, New South Wales; September-January.

Schiner described the male of this species under the name *E. viduus* and the female as *E. superbus*; Krober suggested that *viduus* was possibly the other sex of *superbus* and two pairs taken in copula by G. H. Hardy prove that Krober's suggestion was correct. The species has been transposed from *Ectinorrhynchus* as it seems to naturally conform to *Taenogera*. The general black colouration together with the banded wings readily separate the species from all other members of the genus.

TAENOGERA GRACILIS sp. nov.

Length: 12-13 mm.

Female: Occiput yellow-brown and furnished with rows of similarly coloured bristles and hairs; eyes separated on the vertex by slightly more than the width of the ocellar tubercle which is oval and slightly raised; front brown becoming somewhat yellow-brown towards the antennae and ornamented with a median transverse furrow; antennal tubercle flattened; the antennae are orange, slightly

separated at the base, the first segments convergent and the remainder divergent; the first segment is hardly twice as long as broad and is slightly more than twice as long as the second which is somewhat globular, and both are furnished with numerous dark orange bristles; the third segment is narrower than the second, longer than the first and second united and is narrowly and irregularly conical; the style has its first segment almost as long as the second segment of the antennae and its second segment is conical and twice as long as the first; the arista is one-third the length of the style; face and cheeks yellow-brown; proboscis dark orange; palpi yellowish.

The thorax is dull orange-brown, with a broad blackish longitudinal dorsal stripe and with the humeral calli light orange; the pleurae are dark orange-brown; scutellum orange with a blackish median patch and bearing two dark orange marginal bristles; postscutellum dark orange.

The abdomen is two and a half times as long as the thorax and is uniformly dull orange, covered with yellowish hairs; the venter is dark orange; genital spines yellowish and very weakly developed.

The legs are light orange with the tarsi somewhat blackish; the coxae are furnished with weak orange bristles as follows:—4 on the anterior, 6 with some hairs on the intermediate and 2 on the posterior; the posterior femora bear a pair of orange median bristles.

The wings are tinged brownish; R4 is decumbent for two-thirds of its length and from thence is curved upward, meeting the border well above the wing tip; M3 and M4 convergent; 1A straight; Cul coalesces with 1A just before the hind margin is reached; costa and hind margin ciliated. The halteres are yellowish and somewhat darkened towards their apices.

The male is unknown.

Habitat: Mount Tambourine, Queensland (W. H. Davidson), 2 females—no date given. The holotype and paratype in the Queensland Museum.

This species is evidently closely allied to *latistria* and *notatithorax* but can be readily separated by the uniform dull orange colouration.

TAENOGERA LATISTRIA.

Xylophagus latistria Walker, List. Dipt. Brit. Museum, 1, p. 130, 1848; *Anabarrhynchus longus*. Schiner, Resa Novara Dipt., p. 149, 1868; *Id.*, Kroyer, Ent. Mitt., 1, p. 217, 1912.

Length: 12-14 mm.

Female: Head slightly broader than long; occiput pale golden yellow and beset with dark yellowish hairs and bristles; eyes separated on the vertex by twice the width of the ocellar tubercle, from thence widely diverging; front broad, deep shining black, bearing scattered reddish yellow hairs and ornamented with two distinct depressions, one of which is situated just below the vertex and the other just above the antennae after which there is a transverse, indistinctly bilobed carina which joins the antennal tubercle which is flattened and covered with pale golden yellow pubescence; antennae separated at base, first segments convergent and the remainder widely divergent, shorter than the head, light orange, with some pale golden yellow pubescence on the first and second segments; the first segment is twice as long as the second, short and thick, parallel sided and furnished with numerous black bristles and hairs; the second is almost globular, and likewise bears numerous black bristles and hairs; the third segment is three and a half times as long as the second and longer than the first and second united, when viewed dorsally it is bulbous at the base and practically straight sided from thence to the apex but with a slight inward curve, but when

viewed in profile it is broadly conical and much broader than either the first or second segment; style black with its first segment small, considerably broader than long and hardly as wide as the apex of the third segment of the antennae, while its second segment is twice as long as broad, considerably narrower than the preceding, tapering and rounded at the apex; the arista is elongate and tapering; face and cheeks pale golden yellow; proboscis black-brown, projecting as far forward as the apex of the first antennal segment and bearing black and yellowish hairs; palpi light orange, bearing black and yellowish hairs and projecting slightly beyond the apex of the proboscis.

The thorax is longer than broad, shining black with a pale golden yellow area of pubescence on each side anterior to the wing insertions; situated just inside of the humeral callus on each side there is a somewhat rectangular patch of golden yellow pubescence which is contiguous with two stripes of the same colour extending for two-thirds of the length of the dorsal surface; scutellum dark shining orange and bearing two black marginal bristles; postscutellum shining black.

Abdomen covered with black and whitish hairs, more than twice as long as the thorax; the first segment is shining black, the second and third dark shining chestnut with black reflections laterally and with hind margins broadly silver-white, interrupted in the centre; the fourth is shining black with a lateral area of dark shining orange; the remaining segments shining black with some dark orange reflections towards the apex; venter of the three basal segments dark orange and that of the remainder deep black; genital spines reddish.

Legs: Coxae blackish-brown; femora deep shining orange, the posterior pair being somewhat darker and bearing a pair of apical and similarly coloured bristles; tibiae and tarsi blackish brown.

The wings are more than twice as long as broad and slightly longer than the abdomen; tinged brown, especially on the apical half; R4 curved upwards for half its length, from thence curved inward and meeting the border well above the wing tip; M3 and M4 slightly convergent; Cul coalescing with 1A at the hind margin and the latter vein is slightly concave; costa and hind margin ciliated. The halteres are yellow.

The male is unknown to me.

Habitat: Hornsby (New South Wales), November, 1916 (R. J. Tillyard).

This species was first described by Walker and placed in the genus *Xylophagus* (LEPTIDAE) but it most certainly is not a Leptid. *Anabarrhynchus longus* Schiner is evidently the same as this species. In general structure *latistria* is apparently allied to *gracilis* and *notatithorax*, both of which are herein described as new, but can be easily separated by the chestnut and black abdomen in conjunction with the golden yellow thoracic stripes.

TAENOGERA NOTATITHORAX *sp. nov.*

Male: Occiput shining black with eye margins silvery grey a little below the head vertex and bearing rows of black and dark orange bristles and hairs; eyes separated on the vertex by slightly more than the width of the ocellar tubercle which is oval and prominently raised; front deep shining black with indications of a transverse furrow and adorned with a few scattered dark orange hairs; antennal tubercle flattened; antennae dark orange, hardly as long as the head, separated at the base, first segments convergent, remainder widely divergent; the first segment, when viewed dorsally is broader than the second and third and is considerably longer than the second but slightly shorter than the third and is furnished with numerous black bristles and hairs; the second segment is almost

globular and is also furnished with numerous black hairs and bristles; the third segment is almost as long as the first and second united and viewed dorsally, is narrow and tapering but when viewed in profile it is broadly conical and considerably broader than the first and second segments; the style has its first segment somewhat globular and its second elongate and conical, it being almost as long as the first segment of the antennae; arista black, one-third the length of the style; face pale golden yellow; cheeks greyish and bearing long thin orange hairs; proboscis orange-brown and bearing blackish and orange hairs; palpi bright orange and bearing dark orange hairs.

The thorax is shining black with two, somewhat rectangular, areas of bright golden pubescence on the anterior margin just inside of the humeral calli and immediately behind the head and further similarly coloured areas or spots situated as follows:—Two small median dorsal, one large on each side just prior to the wing insertions and two contiguous with the scutellar suture; pleurae shining black with four areas of pale golden pubescence; the scutellum is orange and bears two elongate orange bristles; postscutellum shining black; thoracic bristles black and dull orange.

The first segment of the abdomen is shining black with the hind margin dark shining orange; second and third segments dark shining orange with a white triangular area of pubescence on each side and contiguous with the hind margins; the remaining segments deep black; venter similarly coloured; genitalia reddish.

The legs: Coxae, femora and tibiae pale orange with the anterior tibiae black towards the apices; the femora bear a pair of orange apical bristles.

Wings tinged yellowish, but somewhat brownish towards the apex; venation similar to *gracilis*; Halteres bright yellowish.

The female is similar to the male except for having the eyes slightly more widely separated, the frontal transverse furrow more distinct and the thoracic spots and abdominal segments paler in colour.

Habitat: The species is known from a single pair taken at Mount Tambourine, Queensland, by W. H. Davidson—no date given.

A slender species which is evidently allied to *latistria* but it is much more slender than that species and can be readily separated therefrom by the abdomen being coloured orange and black in contrast to the chestnut and black and by the absence of the dorsal stripes on the thorax.

Holotype and allotype in the Queensland Museum.

Genus BELONALYS.

Belonalys Krober, Ent. Mitt., 1, p. 124, 1912; *Id.*, Hardy, Proc. Linn. Soc. N.S. Wales, xlv., p. 298-9, 1921.

Genotype. *B. obscura* Krober, New South Wales

The following is the original description given by Krober:—

"Die Gattung ist ausserordentlich charakteristisch durch den Bau der Flügel. Die Diskoidalzelle wird bei allen andern Gattungen der Thereviden an der Basis z. T. von der hintern Basalzelle begrenzt; beide Zellen haben also eine Querader gemeinsam. In dieser Gattung stösst dagegen die Diskoidalzelle als geschlossene, sehr spitz Zelle an die obere Ecke der hintern Basalzelle an, ohne also mit ihr eine Querader gemeinsam zu haben. Infolgedessen erscheint die vierte Hinterrandzelle ausserordentlich lang und breit und die sie hintern begrenzende Längsader läuft gerade von der hintern Basalzelle zum Rand. Der Kopf ist fast kugelig. Die Fühler sind sehr kurz. Sie erinnern an die von *Psilocephala laticornis* Lw. Der Hinterleib ist kurz, walzig.—Da die vierte und fünfte Längsader fast nebeneinander aus derselben oberen Ecke der Diskoidalzelle entspringen, so nähert sich die Gattung dadurch der palaarktischen Gattung *Hermannia* Krob.—Die mir vorliegenden Arten stammen von Neussudwales."

I have failed to recognise this genus and am doubtful if it can be considered valid. White notes that certain of his species of *Psilocephala* have a venation almost the same as this genus and it appears that Krober's primary character for founding same was that the two veins which bound the median cell, on the anterior and on the posterior side, rise from the cell R. in an acute angle.

Two species have been placed in the genus and I append a translation of the original descriptions to aid in their identification; it is possible that they may be the two sexes of the one species as one is described from a male and the other from a female, and, according to the descriptions, they do not differ to any great extent from each other.

BELONALYS OBSCURA.

Belonalys obscura Krober, Ent. Mitt., 1, p. 125, 1912.

Male: Dark brown with scanty white and black pubescence. Frons moderately broad. Antennae very short, the third joint bulb-shaped; back of the head black above, white haired below. The whole body has black pubescence above and white below. Legs dark brown, tibiae and base of metatarsi somewhat brighter. Wings tinged with grey; stigma dark brown. Length: 6 mm., Mount Victoria, New South Wales.

BELONALYS GRACILENTA.

Belonalys gracilentata Krober, Ent. Mitt., 1, p. 148, 1912.

Female: Similar to the foregoing species but is of a very slender form. Head almost globular. Antennae very short, dark brown. Thorax dark brown with traces of two lighter lines. Abdomen dull dark brown with the seventh and eighth segments shining, especially the eighth. Femora dull dark brown, the knee bright yellow brown. Tibiae and tarsi somewhat brighter than the femora. Wings short, small, tinged with dark grey. Length: 5 mm., Springwood, New South Wales.

Genus NEODIALINEURA *gen. nov.*

Small slender species with head distinctly pyriform but broader than long; occiput deeply concave; eyes with a transverse furrow, approximated in the male, widely separated in the female; front bare, broad in female, narrow in male; the antennal tubercle is prominent and divided medianly by a furrow making it distinctly bilobate; the first segment of the antennae is greatly swollen, twice as long as the remainder united and bearing numerous stiff hairs and bristles; the second segment is very short but bears numerous long hairs and bristles; the third segment is broadly conical, one-third the length of the first and furnished with short hairs; style one segmented; arista fine, one-third the length of the style; face and cheeks small, the former pubescent only and the latter furnished densely with fine, long hairs; proboscis projecting as far forwards as the apex of the first antennal segment, spatulate and bearing numerous hairs; palpi very short.

The thorax is strongly convex above and very little longer than broad; scutellum semicircular and bearing two marginal bristles; postscutellum hidden beneath the scutellum.

The abdomen conical, twice as long as the thorax in the female and about one and a half times as long in the male.

The legs of moderate length; the coxae each bearing an apical, the femora with a pair of apical and the tibiae and tarsi bear numerous bristles.

The wings are spotted, as long as the abdomen in the male but shorter in the female, comparatively broad, venation normal except that C_u1 coalesces with

1A well before the wing margin; and sometimes M1 and M2 rise together from the median cell; stigma conspicuous; costa and hind margin ciliated.
Genotype. *Neodialineura striatithorax*.

Distribution: The type species is known from Queensland only. The genus is closely related to the American genera *Tabuda* Walker, and *Dialineura* Rondani, but differs from the former in having the eyes of the male closely approximated and from the latter chiefly by having a one segmented antennal style.

I have a second species before me, represented by one specimen taken in Brisbane which could be placed in this genus, but, as the specimen is somewhat greasy, I refrain from describing it until more are available.

The genus is readily recognised by the bilobate antennal tubercle and the greatly swollen first antennal segment.

NEODIALINEURA STRIATITHORAX *sp. nov.*

Length: 5 mm.

Male: Occiput yellow-brown, somewhat grey-brown medianly and bearing rows of black hairs and bristles; eyes separated on the vertex by the width of the ocellar tubercle, converging slightly below this to the base of the antennal tubercle from whence they diverge widely; front yellow-brown and bearing a few black stiff hairs and ornamented with a black-brown spot which is situated at the base of the antennal tubercle; the antennal tubercle is yellow-brown, divided in the centre by a longitudinal furrow which is black-brown, on either side of this furrow is a large shining black, bare spot; the antennae are brown and all the bristles and hairs are black; the first segment is twice as long as the remainder united, slightly more than one-third as broad as long, straight sided and concave at the apex into which is received the second segment which is very short and cupuliform; the third segment is one-third the length of the first, broadly conical, very slightly longer than its greatest breadth and furnished with short hairs; the style is one-fifth the length of the third segment of the antennae and somewhat rectangular; the arista is one-third the length of the style; face brownish; cheeks greyish and bearing similarly coloured hairs; proboscis and palpi brownish.

The thorax is brown, ornamented with seven dark brown longitudinal dorsal stripes, the centre one of which is regular and the remainder interrupted, forming a chain of rectangular spots; the sides are ornamented with dark brown and irregular short stripes; pleurae greyish brown; scutellum brown with a dark shining brown median spot and bearing two black marginal bristles.

The abdomen is dark brown dorsally and yellow-brown on the sides and covered with black hairs; venter mostly yellow-brown; genitalia pale brown.

Legs mainly brown; coxae greyish; apices of femora, tibiae and tarsi, black.

Wings mottled dark brown; M1 and M2 sometimes arising together from the median cell but generally slightly separated at their origin; 1A straight; C_u1 coalesces with 1A well before the hind margin is reached. The halteres are pale brown.

The female differs from the male by the widely separated eyes, the broad front which is ornamented with two dark brown stripes which are contiguous just below the ocellar tubercle and thence widely diverging (forming a "V.") and also with some dark brown spots, the darker coloured antennae and by the more elongate and sharp pointed abdomen.

The Holotype, National Park, 25/10/23 (H. Hacker) and Allotype, Mount Tambourine (W. H. Davidson) together with 3 female Paratypes in the Queensland Museum; a pair of Paratypes in the author's collection and a further 2 female Paratypes in G. H. Hardy's collection, Brisbane.

Habitat: Brisbane, 2 females, September and October, 1926 (G. H. Hardy) and 1 male, October 6, 1914 (H. Hacker); National Park, 1 male and 3 females, October 3, 1923 (H. Hacker); Mount Tambourine, 2 females (W. H. Davidson), Queensland.

The species is easily recognised by the general brown colouration, mottled wings, small size and greatly swollen first antennal segment.

Genus ANABARRHYNCHUS.

Anabarrhynchus Macquart, Dipt. Exot., suppl. 3, 1848.

Stout, robust species with the head as broad as, or broader than the thorax, generally broader than long but sometimes as long as broad, never longer than broad; the occiput is often bilobate, being divided by a median indentation or sulcus and is furnished with numerous black bristles which are sometimes arranged in more or less regular rows; eyes bare, separated in both sexes, slightly more so in the female than in the male, relatively large, oval, descending well down on to the cheeks, separated on the vertex by the width of the ocellar tubercle or by slightly or considerably more than this, the anterior margin may be straight, convex or concave, fascets uniform; front broad in both sexes, convex, ornamented with two median spots which may be indistinct or confluent, sometimes the front is divided longitudinally by a furrow, covered with numerous stout hairs and pubescence; antennal tubercle flattened; antennae shorter than or as long as the head, separated, approximated or contiguous at the base with the apices of the first segments converging and often touching, the remaining segments are always widely divergent, composed of three primary segments, the third bearing a two segmented style which is furnished with a short thick arista; the first and second segments each bear numerous black bristles and hairs and the former is cylindrical and rather thick and the latter more or less globular and flattened at the extremities; the third segment is more or less conical and when viewed dorsally is seldom broader than the basal segment but when viewed in profile, is invariably broader than same; the style is broadly or narrowly conical, sometimes nearly half the length of the third segment of the antennae, its first segment is much shorter than its second; face bare or tomentose only; cheeks small, receding and densely furnished with long fine silky hair; the proboscis is short and thick, projects forwards and upwards and often lies close against the mouth aperture; the palpi are slightly enlarged at the apices.

The thorax is stout, convex and provided with 3-5 pre-alar, 2-4 supra-alar and 4 pre-scutellar bristles, all of which are black; some of the pleurae bear tufts of hairs in most species; the scutellum is large, semicircular and bears four black marginal bristles (six in *rufipes*); the postscutellum is convex and well hidden beneath the scutellum.

The abdomen is stout and broadly conical, flattened dorsally and hardly more than twice as long as the thorax, hairy, but without bristles.

The legs are stout; the tibiae and tarsi bear numerous rows of bristles and the femora bear a pair or two pairs of apical and, or, a row of intermediate bristles.

The wings are large, broad, sometimes tinged but never banded; R4 sinuous and joins the border well above the wing tip, R5 well below; M1 and M2 widely divergent; M3 and M4 slightly convergent; 1A curved or straight; Cu1 coalesces with 1A well before, near to, or at the margin; costa and hind margin ciliated; pterostigma present and conspicuous; costa slightly inflated (distinctly so in *passus*).

Genotype. *Anabarrhynchus fasciatus* Macquart.

Range: Madagascar, Chile and Australasia.

Distribution: The species are mostly local in their haunts; of the Australasian species, ten are confined to New Zealand, five to New South Wales, three to Queensland and five to Tasmania. Two species extend from Tasmania to southern Queensland, two are known from New South Wales and Queensland, and two occur both in Tasmania and New South Wales and the remaining three, which I have failed to recognise, were originally described from "Australia." *A. montanus* and *calceatus* have been recorded from New Zealand but I am doubtful of the correct determination of these. Krober recorded *fasciatus* from North Queensland, but I have not seen specimens of this species from Queensland.

The genus comprises a number of closely allied species which are difficult to separate, there being but few available structural differences for specific determination. Chaetotaxy is of more value here than in any other genera as the variation appears to be constant for the species, whereas in most of the other genera of the family the variation is individualistic. An important character has been found by comparing the width of the eye separation on the vertex in the various species and often the shape of the anterior margin of the eye affords a good specific character. Apart from these, reliance has to be placed on colour variations.

Thirty-nine species have been referred by various authors to this genus. Of these, ten are confined to New Zealand, five to Chile, one to Madagascar and four have been removed to other genera, leaving nineteen species for Australia and Tasmania. Three new species for the genus are described in the following pages, bringing the total to twenty-two. Macquart and Thomson referred four species to *Thereva* which will in all probability have to be placed in *Anabarrhynchus* when they are recognised.

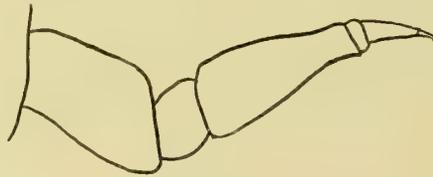


Fig. 4.

Antenna of *Anabarrhynchus* sp.

Key to the Species of Anabarrhynchus.

- | | |
|---------------------------------------------------------------------------|------------------------------|
| 1. Thorax and abdomen shining black | 2. |
| Thorax and abdomen not so coloured | 3. |
| 2. Wings mostly black | <i>argenteus</i> sp. nov. |
| Wings hyaline, veins faintly marked | <i>latifrons</i> Macquart. |
| Wings brown, veins distinctly marked | <i>maritimus</i> Hardy. |
| 3. Costa conspicuously inflated | <i>passus</i> White. |
| Costa slightly inflated only | 4. |
| 4. Sides and venter of abdomen reddish orange; legs unicoloured | |
| | <i>abdominalis</i> Krober. |
| Not so coloured | 5. |
| 5. Sides of abdomen furnished with long pale golden pubescence | |
| | <i>aureovillosus</i> Krober. |
| Abdomen not so furnished | 6. |

6. Thorax yellow with an olive reflection *flavus* sp. nov.
 Thorax not so coloured 7.
7. All femora mainly black 8.
 Anterior femora only, wholly black 10.
 Anterior femora coloured otherwise 11.
8. Anterior margins of eyes converging slightly below ocellar tubercle; tibiae and tarsi brown *fasciatus* Macquart.
 Anterior margins of eyes straight 9.
9. Tibiae and tarsi clear yellow; front wholly brown; wings tinged yellow. *helvenacus* White.
 Tibiae and tarsi yellow-brown; front yellow-brown on the vertical two-thirds, remainder yellow; wings brown *cinereus* Krober
10. Apical half of remaining femora red-brown; lower fourth of front yellow, anterior margins of eyes straight; thorax brown with three stripes. *terrenus* White.
 Remaining femora red-brown except for black side stripes on the intermediate and a black understripe on the hind; lower fourth of front yellow; anterior margins of eyes convex; thorax grey-brown with five stripes. *calceatus* Schiner.
 Remaining femora brown except for the black undersides of the basal half; lower third of front white; anterior margins of eyes straight; thorax grey with three stripes *tristis* Bigot.
11. Thorax with three broad dark brown stripes 12.
 Thorax with five, more or less distinct stripes, which, in comparison, are not nearly so broad and distinct 13.
12. Scutellum with six bristles; upper two-thirds of front yellow-brown, rebristles on the occiput arranged in three rows *rufipes* Macquart.
 Scutellum with four bristles; front wholly yellowish grey; eyes separated by one and a half times the width of the ocellar tubercle; bristles on occiput not arranged in rows *bohemani* Thomson.
13. Abdominal segments margined bright yellow and red-brown with fringes of bright yellow hairs 14.
 Abdominal segments mainly margined grey 15.
14. Tibiae brown; median frontal spots forming a V-shaped area *ornatifrons* Krober.
 Tibiae olive or yellow-brown; median frontal spots widely separated *umbratilis* White.
15. Eyes separated on the vertex by fully twice the width of the ocellar tubercle *validus* sp. nov.
 Eyes separated on the vertex by slightly more than the width of the ocellar tubercle *montanus*, White.

Note.—It has been very difficult to arrange a suitable key to the species of this genus and I have found it necessary to incorporate several characters in some instances where the species are very closely allied. Identifications should be checked by reference to the descriptions. Doubtless there are many forms in collections which will not agree with the descriptions here and these may have to be regarded as new. I have several more new forms in the material under revision before me but I have refrained from describing these because they are represented by one or by damaged specimens. *Anabarrhynchus* being the dominant genus in Australia, it is only to be expected that many new forms will present themselves from time to time.

ANABARRHYNCHUS ARGENTEUS sp. nov.

Length: 12 mm.

Female: Occiput grey with patches of grey near the eye margins, bristles rather stout; eyes separated on the vertex by slightly more than the width of the ocellar tubercle; front dull black on the vertical two-thirds and silver-grey on the lower third, ornamented with a longitudinal median furrow and with some brown reflections; the median spots are large and confluent; antennae black, bristles very elongate on the first segment, separated at the base with the first segments slightly convergent; segment 1 slightly longer than 3 and covered with some grey tomentum; 2 short; 3 broadly conical; the style is one-third the length of the third segment of the antennae and has its first segment very short and the second elongate-conical; the arista is one-third the length of the style; face silvery grey; cheeks silver-white and bearing greyish hairs; proboscis black, projecting as far forward as the apex of the first antennal segment; palpi black, hidden in the oral aperture.

Thorax dull black, yellowish on the sides and hind margin; ornamented with two well-defined, broad, yellowish, dorsal stripes and a grey area just in front of the scutellum; furnished with 4 pre-alar, 3 supra-alar, and 4 pre-scutellar bristles; pleurae yellowish grey, the nota-, mesa- and metapleura furnished with tufts of whitish hairs; scutellum black-brown, broadly margined grey and furnished with four stout bristles; postscutellum black.

Abdomen shining black, covered with black pubescence and with fringes of whitish hairs on the hind margins of the first three segments; segment 1 somewhat brownish; 1-3 with side and hind margins grey; 5 and 6 with the side margins broadly grey; venter of segments 1-3 greyish, the remainder black; genital spines black.

Legs black; tibiae, except for the apices and basal third of the first posterior tarsal segments brown; anterior and posterior femora furnished with two pairs and one pair of apical bristles, respectively.

Wings with the apical two-thirds tinged deep black, the basal third being somewhat lighter; pterostigma black; venation much as in *abdominalis*. The halteres are black.

The male is unknown.

Habitat: Wynnum, Queensland. The unique female Holotype (B. A. Smith) is in the Queensland Museum collection, No. 3278.

This species can readily be separated from all other species of *Anabarrhynchus* by the colour of the wings in conjunction with the general black colour and by the silvery-grey face.

ANABARRHYNCHUS LATIFRONS.

Anabarrhynchus latifrons Macquart, Dipt. Exot., suppl. 4, 1850; *Id.*, White, Proc. Roy. Soc. Tasm., 1915.

Length: 8.9 mm.

Male: Head considerably broader than long; occiput blue-grey, bristles arranged in two rows; eyes separated on the vertex by half as much again as the width of the ocellar tubercle, the anterior margins straight; front black on the upper two-thirds and the lower third grey, frontal spots brown, suffused, and contiguous with the eye margins, bristles and hairs sparse; antennae noticeably shorter than the head, the first two segments grey and the third and style brown, separated at the base with the apices of the first segments touching; segment 1 slightly shorter than 3; 2 short and globular; 3 conical, almost as long as 1 and 2 united; the style is half the length of the first segment of the antennae and

has its first segment one-third the length of its second; the arista is one-fourth the length of the style; face and cheeks very pale grey, the latter bearing greyish hairs; proboscis black-brown, well hidden in the mouth aperture; palpi brown and as long as the proboscis.

Thorax shining black with margins grey and with faint indications of brownish, parallel stripes; furnished with 4 pre-alar, 3 supra-alar and 4 pre-scutellar bristles; pleurae blue-grey; scutellum black-brown in the centre and the remaining portion grey, furnished with four bristles; postscutellum black.

Abdomen very little longer than thorax, shining black with apical and side margins of segments 2 and 3 grey; side margins of 5 broadly grey; 7 wholly grey and 8 wholly brown; venter grey; genitalia brown.

Legs black; tibiae black-brown with apices black; the posterior femora bear a pair of black apical bristles.

Wings hyaline; veins brown; R4 slightly curved upward at the extremity only; Cu1 coalesces with 1A well before the margin; M3 and M4 convergent. The halteres are black with the stems brown.

The female differs from the male in the usual sexual characters only. The genital spines are black.

Variations: M3 and M4 vary in the degree of convergence; the color of the front varies from shining black to dull-black on the upper two-thirds and from grey to yellow-white on the lower third; the first abdominal segment may have the apex margined white.

In the material before me I have one male taken at the Queensland National Park by G. H. Hardy (March, 1921) which varies considerably from the typical *latifrons* and which may represent another species.

The eyes are separated on the vertex by twice the width of the ocellar tubercle; the front is brown, becoming somewhat lighter towards the antennae, the frontal spots are confluent and form an irregular transverse band.

Thorax ornamented with two distinct, grey, parallel stripes.

Abdomen black-brown, segments 2 and 3 with the apical and side margins grey; 5 and 6 largely grey; 7 brown and 8 grey.

Legs brown; coxae black; femora dark-brown and covered with grey tomentum.

Habitat: Tasmania, Wynyard (1 ♂, 2 ♀, January-February); Hobart (1 ♀, March, 1917); Sheffield (1 ♂, January, 1917); Tunbridge (1 ♀, February, 1924); Triabunna (3 ♀, December, 1915); Launceston (1 pair taken in copula, February, 1916); New South Wales, Blackheath (2 pairs taken in copula, November, 1919); Queensland, Sunnybank (1 ♀, August, 1927). All of these were taken by G. H. Hardy.

ANABARRHYNCHUS MARITIMUS.

Anabarrhynchus maritimus Hardy, Proc. Roy. Soc. Tasm., 1916.

Length: 8-10 mm.

Male: Head considerably broader than long; occiput dark grey with black reflections, bristles rather weak; eyes separated on the vertex by slightly more than twice the width of the ocellar tubercle and with the anterior margins straight; front shining black, slightly grey near the antennae, median spots black, confluent; antennae slightly shorter than the head, black, separated at the base with the apices of the first segments contiguous; segment 1 almost as long as the others combined; 2 short and globular; 3 more or less conical; the style is one-fourth the length of the third antennal segment, with its first segment short and somewhat globular and its second broadly conical and three times as long as the

first; the arista is about one-fifth of the length of the style; face and cheeks dirty white, the latter bearing whitish hairs; the proboscis is black and projects as far forward as the apex of the first segment of the antennae; palpi black and two-thirds the length of the proboscis.

Thorax shining black with two yellow-brown parallel stripes which gradually fade until they disappear on the posterior third; sides greyish; furnished with 4 pre-alar, 2 or 3 supra-alar and 2 weak and 2 strong pre-scutellar bristles; pleurae grey, meso-pleura black; scutellum shining black with grey hind margin, bearing 4 erect and stout bristles; post-scutellum deep black.

Abdomen shining black with the apical margins of segments 1-3 faintly grey; venter of first two segments grey, remainder black; genitalia black-brown.

Legs black; tibiae and first tarsal segments, except for the apices, brown; the anterior femora bear two pairs of black apical bristles and the posterior one, a pair of apical.

Wings tinged brown, veins black-brown and well marked; R4 decumbent for two-thirds of its length and then curving upward; Cul coalesces with 1A, which is straight, slightly before the margin.

The female differs from the male by having paler thoracic stripes, and the scutellum sometimes uniformly blue-grey.

Variations: The thorax is sometimes chocolate brown, the stripes vary in colour from yellow-brown to yellow or they may even be somewhat grey; the front may have more or less black and the grey at the base of the antennae may be replaced by yellow; 1A may be curved and Cul may coalesce with same just before or at the hind margin or they may be very slightly separated when they reach it.

Habitat: Tasmania, Dunalley (3 ♂, 2 pairs taken in copula, December, Maria Island (2 ♀, February), all taken by G. H. Hardy; New South Wales, Sydney (2 ♀, G. H. Hardy, September, 1921), Woy Woy (3 pairs, I. M. Mackerras, October, 1924); Queensland, Coolangatta (1 ♀, December, 1925, H. Hacker).

A. maritimus comes close to *latifrons* and *argenteus*, but can be readily separated from both by the colour of the wings and the thoracic stripes. It differs from *argenteus* also by the colour of the face, width of the front on the vertex and by the colour of the margins of the abdominal segments and from *latifrons* by the longer first antennal segment in comparison with the third and by the larger size. The species can be separated from *rufipes*, to which it bears some resemblance, by the colour of the abdomen.

ANABARRHYNCHUS PASSUS.

Anabarrhynchus passus. White, Proc. Roy. Soc. Tasm., 1915.

Length: 8.5-9.5 mm.

Male: Occiput grey, bristles sparse and not arranged in rows; eyes separated by very slightly more than the width of the ocellar tubercle on the vertex; vertical two-thirds of front brown, remainder yellowish, frontal spots dark-brown, confluent and forming a rather broad transverse band, median furrow present but rather short and deep; antennae yellowish grey, rather widely separated at the base; segment 1 is noticeably broader than the others and is about the same length as 3; 3 is somewhat contracted at the apex but otherwise is of the usual conical shape; the style is slightly less than one-third the length of the first segment of the antennae and has its first segment very short; the arista is about half the length of the style; face and cheeks very small, brownish, the latter becoming somewhat silver-grey as they descend under the eyes and bearing white hairs;

proboscis brown, well hidden in oral aperture; palpi light brown and covered with white hairs.

Thorax dark brown, scantily covered with short black hair and pubescence; furnished with 4 pre-alar, and 3 supra-alar bristles; pleurae grey; scutellum dark brown, with a lighter margin, a pre-apical transverse depression and bearing four rather weak bristles; post-scutellum dark grey.

Abdomen rather stout, hardly twice as long as its greatest width, mainly greyish; segment 1 somewhat brownish; 2-4 with a large posteriorly rounded brown area on the anterior margin, this area occupies more than half of segment 2, but slightly less than half of 3 and 4; 8 is deep shining brown; venter and genitalia greyish.

Legs: Coxae dark grey and furnished with tufts of white hairs; femora black-brown, hairy but devoid of bristles; tibiae yellow-brown or pale brown with the apex blackish; tarsi dark brown with blackish reflections.

Wings yellowish along the fore margin; stigma yellow; the basal half of the costa is conspicuously inflated; R4 decumbent for half its length and then curving upward; 1A straight and Cul coalesces with this vein well before the border. Halteres brown with yellow apices.

The female differs from the male by having a paler coloured front, the eyes being separated on the vertex by twice the width of the ocellar tubercle, paler coloured thorax which exhibits faint indications of five parallel stripes, black femora and by having the wings tinged yellow-brown. The genital spines are black.

Variations: A pair of pre-scutellar bristles are sometimes present and the thoracic stripes are often quite distinct.

Habitat: Tasmania, Hobart (2 ♂, 4 ♀, G. H. Hardy, October-December).

This species is quite distinct from all other members of the genus by having the basal half of the costa conspicuously inflated. Most species of *Anabarrhynchus* have a slight inflation of this vein, but the character is well developed in *passus*.

ANABARRHYNCHUS ABDOMINALIS.

Anabarrhynchus abdominalis Kroeber, Ent. Mitt., 1, 1912.

Length: 11-12.5 mm.

Male: Occiput grey, brown at the eye margins, bristles not arranged in definite rows; eyes separated on the vertex by slightly more than the width of the ocellar tubercle; front brown, hairs and bristles rather dense, the frontal spots are brown and contiguous with the eye margins, an indistinct longitudinal furrow extending from the ocellar tubercle to the base of the antennae is present; antennae shorter than the head, rather widely separated at the base; segment 1 grey, about the same length as 3; 2 and 3 black; the first segment of the style is somewhat globular and the second elongate, the whole being slightly more than half the length of the third antennal segment; arista about one-sixth the length of the style; face yellowish; cheeks silvery grey and bearing whitish hairs; proboscis brown, covered with grey tomentum and projecting as far forward as the apex of the first antennal segment; palpi light brown, two-thirds the length of the proboscis, covered with whitish hairs.

Thorax yellow-brown dorsally and becoming brown towards the sides; ornamented with five distinct and rather broad dark brown parallel stripes; furnished with 4 pre-alar, 4 supra-alar, one of which is very weak, and 4 pre-scutellar bristles; pleurae greyish; scutellum brown and bearing four bristles; post-scutellum brownish.

Abdomen shining black and covered with whitish and black hairs; the sides, venter and genitalia mainly reddish-orange.

Legs orange, coxae black, tarsi darkened with black hairs; the anterior femora bear a row of four very weak, the intermediate a row of four to six rather stronger and the posterior ones, a pair of strong apical bristles; the bristles on the tibiae are elongated.

Wings tinged yellow-brown, fore margin yellow; R4 as in *passus*.

The female differs from the male in the usual sexual characters only. The genital spines are black.

Variations: The colour of the thorax may vary in intensity.

Habitat: New South Wales, Sydney (3 ♂, 2 ♀, 3 pairs taken in copula, G. H. Hardy, August-September, 1919, August, 1920).

The species is distinguished from all other *Anabarrhynchus* by the reddish orange sides and venter of the abdomen, in conjunction with the unicoloured legs.

ANABARRHYNCHUS AUREOVILLOSUS.

Anabarrhynchus aureovillosus Krober, Mitt. Ent., 1, 1912.

Length: 9-12 mm.

Male: Head distinctly broader than long; occiput bright brown on the vertical half and from thence greyish; eyes separated on the vertex by slightly more than the width of the ocellar tubercle and from thence gradually diverging; front bright yellow-brown with some dark brown reflections, hairs and bristles rather dense, ornamented with a rather deep median furrow, frontal spots contiguous with the eye margins; antennae black, narrowly separated at the base; segment 1 about the same length as 3; 2 short, globular and flattened at the extremities; 3 is broad and evenly conical; the style is comparatively long, its first segment short and its second elongate-conical; the arista is one-third the length of the style; face yellow, cheeks light grey and bearing whitish hairs; proboscis brown, often projecting as far forward as the middle of the third segment of the antennae; palpi light brown, one-fourth the length of the proboscis.

The thorax is bright yellow-brown, covered with black and pale golden pubescence, ornamented with five indistinct dark brown parallel stripes and furnished with 4 pre-alar, 3 supra-alar and 2 weak and 2 strong pre-scutellar bristles all of which are black; pleurae grey, the nota-, mesa- and metapleurae each bear a tuft of whitish hairs; scutellum bright yellow-brown, covered with black and pale golden pubescence and bearing 4 bristles; post-scutellum yellowish.

Abdomen mainly bright yellow-brown or pale golden, covered with black and pale golden pubescence on the dorsum and bearing dense golden pubescence and hairs on the sides; segments 2-6 ornamented with a large, posteriorly rounded black-brown area on the anterior margin, these areas occupy most of the dorsal surface of 2-4, but only half of that of 5 and 6; venter greyish with yellow tomentum; genitalia brown.

Legs orange, coxae grey and the apices of the tarsi black; the fore femora bear two, the middle five median and the hind, a pair of apical bristles.

Wings tinged brown but with the basal veins and fore margin yellow; venation much as in *abdominalis*.

The female differs from the male in the ordinary sexual characters only.

Variations: The length of the proboscis varies; the colour of the front and thorax varies in intensity; a male in the material before me, from Caloundra, Queensland (H. Hacker, October, 1913) appears to represent a distinct sub-species; it differs from the typical form by having the eye margins parallel for some distance below the vertex before diverging, by the narrower front, yellowish

antennae, uniformly dull black-brown abdomen which has segments 2 and 3 broadly and 4 and 6 narrowly margined posteriorly with pale golden, segments 7 and 8 brown and by the absence of the pale golden pubescence and hairs on the sides of the abdomen. A further male from Sydney (G. H. Hardy, October, 1919) is somewhat distinct in having the eye margins parallel for some distance below the vertex, but to a lesser degree than the Caloundra specimen, but it differs again from that and from the typical specimens by having the abdomen mainly grey, covered with pale yellow pubescence and hairs on the dorsum and on the sides.

The Caloundra specimen resembles *ornatifrons* to a certain extent, but can readily be separated from that species by the shape and ornamentation of the front and by the abdominal colouration.

Habitat: Queensland, Stradbroke Island (2 ♂, 2 ♀, H. Hacker, September, 1915); Dunwich (1 ♂, 1 ♀, I. M. Mackerras, September, 1926); Brisbane (1 ♂, 1 ♀, 1 pair taken in copula, G. H. Hardy, October); New South Wales, Sydney (1 ♂, 1 ♀, 1 pair taken in copula, G. H. Hardy, September-October, 1919).

The species is distinguished from all other members of the genus by the general colouration and by the presence of the pale golden hair and pubescence along the sides of the abdomen.

ANABARRHYNCHUS FLAVUS sp. nov.

Length: 6-9 mm.

Male: Occiput bright yellow, with a deep median indentation and with bristles arranged in three indistinct rows; eyes separated on the vertex by the width of the ocellar tubercle, anterior margins convex; front golden yellow, median spots brown; antennae separated at the base, apices of first segments converging but not touching; segment 1 grey, about the same length as 3; 2 grey, less than one-third the length of 1; 3 brown, conical; the style is slightly more than one-third the length of the first segment of the antennae and has its first segment one-fourth the length of its second; arista one-third the length of the style; face yellow-brown; cheeks grey and bearing similarly coloured hairs; proboscis black and lying close against the mouth aperture; palpi pale brown and half the length of the proboscis.

Thorax yellow with an olive reflection, appearing olive green in some lights; ornamented with two broad yellow but very indistinct parallel stripes; furnished with 4 stout pre-alar, 3 supra-alar and 4 pre-scutellar bristles; pleurae grey; scutellum yellow and bearing four bristles; post-scutellum black.

Abdomen brown-black; segment 1 grey; 2 and 3 with the apical and side margins broadly grey; 8 brown; venter of segments 1-3 grey, 4-7 black-brown and 8 brown; genitalia brown.

Legs: Coxae, anterior femora and apices of all tarsi black; remaining femora orange; all tibiae and the basal half of the first tarsal segments brown; the fore femora bear a row and the hind ones a pair of apical bristles.

Wings hyaline; veins yellow at the base and along the fore margin, the remainder brown, but faintly marked; R4 decumbent for half its length and then curving upward; Cul coalesces with 1A slightly before the margin. The halteres are grey with the apices brown.

The female is unknown.

Holotype male in the Queensland Museum, No. 3279, taken by H. Hacker at Caloundra, Queensland, October, 1913.

Paratype male (Bribie Island, Queensland, H. Hacker, August, 1920) also in the Queensland Museum collection, No. 3280.

This species is readily separated from the other members of the genus by the colour of the thorax and legs.

ANABARRHYNCHUS HELVENACUS.

Anabarrhynchus helvenacus White, Proc. Roy. Soc. Tasm., 1915.

Length: 7-9 mm.

Male: Head considerably broader than long; occiput grey, brown at the eye margins, furnished with numerous black bristles which are not arranged in rows; eyes separated on the vertex by half the width of the ocellar tubercle again, anterior margin straight; front brown, median spots indistinct; antennae black, considerably shorter than the head, separated at the base with the apices of the first segments almost touching; segment 1 about the same length as 3; 2 about one-third the length of 1; 3 conical but slightly bulged at the apex; the style is one-third the length of the third antennal segment and has its first segment very short; the arista is slightly more than one-third the length of the style; face and cheeks silvery-grey, the latter bearing whitish hairs; proboscis black, lying close against the oral aperture; palpi pale-brown almost as long as proboscis.

Thorax dark-brown covered with black pubescence; ornamented with five indistinct dark-brown parallel longitudinal stripes and furnished with 3 pre-alar, 3 supra-alar and 4 pre-scutellar bristles all of which are black; pleurae grey; scutellum brown and furnished with four black bristles; post-scutellum black-brown.

Abdomen densely covered with long, fine, whitish and brownish hairs and black pubescence; brown-black; segments 2 and 3 with the apical and side margins grey; 4 to 6 with the side margins broadly grey; 8 brown; venter grey; genitalia brown.

Legs: Coxae and femora black; tibiae and tarsi and the extreme apices of femora clear yellow.

Wings faintly tinged yellow; costa yellow, remaining veins brown, but all faintly marked; R4 decumbent for half its length and then curving upward; Cul coalesces with 1A slightly before the margin. The halteres are brown with yellow apices.

Female: The female differs from the male by the broader front, paler-brown thorax and by the abdomen having more black.

Habitat: Tasmania, Hobart (1 ♂, 3 ♀, G. H. Hardy, March, 1917, January, 1916); Triabunna (1 ♂, G. H. Hardy, December, 1915).

This species is closely allied to *fasciatus* but can be distinguished by the shape of the anterior margins of the eyes and by the colour of the wings and legs.

ANABARRHYNCHUS FASCIATUS.

Anabarrhynchus fasciatus Macquart, Dipt. Exot., suppl. 3, 1848; *Id.*, Macquart, Dipt. Exot., suppl. 4, 1850; *Id.*, Schiner, Novara Reise Dipt., 1868; *Id.*, Krober, Mitt. Naturh. Mus. Hamburg., xxxi., 1914.

Length: 8-10 mm.

Male: Head broader than long; occiput grey, yellowish at the eye margins and furnished with but few black bristles; eyes separated on the vertex by the width of the ocellar tubercle, converging very slightly below this for a short distance and from thence curving outwards; front yellow with faint brown reflections, the median spots are very indistinct, hairs short and sparse; antennae brown, shorter than the head, separated at the base with apices of first segments contiguous; segment 1 hardly as long as 3; 2 is one-third the length of 1; 3 is almost as long as 1 and 2 united; the style is one-third the length of the third

antennal segment and has its first segment one-fifth the length of its second; the arista is half the length of the style; face yellow-grey; cheeks silvery-grey and bearing white hairs; proboscis black, lying close against the face and reaching upwards to the base of the antennae; palpi yellow and half the length of the proboscis.

The thorax is yellow-brown, ornamented with five brown, parallel, longitudinal stripes, the median one only of which is distinct, the others being very indistinct; furnished with 5 pre-alar, 3 supra-alar and 4 pre-scutellar bristles; pleurae grey; scutellum yellow-brown with a dark brown median spot and bearing four black bristles; post-scutellum black.

The abdomen is dark or blackish brown, with segment 1, greyish brown; 2-4 with the side and posterior margins white, the former being rather extensive and somewhat triangular; 5-7 have the side margins largely white; 8 brown; venter grey; genitalia black.

Legs: Coxae and femora black; tibiae and tarsi brown with black apices. The anterior femora bear a pair of apical, the intermediate, a pair of median and the posterior, two pairs of apical bristles, all of which are black.

The wings are yellowish along the fore margin; otherwise tinged very faintly, brown; venation as in *helvenacus*. The halteres are brown.

The female differs from the male by having a brighter coloured front, the colour of the thorax being more brown and by having the abdomen margined grey. The genital spines are black.

Habitat: New South Wales, Sydney (2 ♂, 3 ♀, 1 pair taken in copula, September-November, G. H. Hardy); (2 ♂, 3 ♀, February-March, I. M. Mackerras); (1 ♂, 1 ♀, April, 1922, J. Mann).

Variations: The ground colour of the thorax varies from grey to brown or yellow-brown.

This species closely resembles *helvenacus* but can readily be separated by the colour of the wings and legs, shape of the anterior margins of the eyes and by the number of thoracic bristles.

ANABARRHYNCHUS CINEREUS.

Anabarrhynchus cinereus Krober, Ent. Mitt., 1, p. 215, 1912.

Length: 13 mm.

Female: Occiput grey, yellow at the eye margins and with a rather deep median indentation; eyes separated on the vertex by slightly more than the width of the ocellar tubercle and with the anterior margin straight; front yellow-brown on the upper two-thirds, the lower third yellow, median spots brown and confluent, forming an irregular transverse band; antennae black, separated at the base; segment 1 almost as long as 3; 2 is one-fourth the length of 1; 3 conical longer than 1 but not as long as 1 and 2 united; the style is one-fourth the length of the third antennal segment and has its second segment six times as long as its first; the arista short, one-fourth the length of the style; face pale yellow; cheeks silver-grey and bearing whitish hairs; proboscis black-brown projecting as far forward as the apex of the first antennal segment; palpi yellow-brown and two-thirds the length of the proboscis.

Thorax pale yellow-brown, ornamented with three narrow brown parallel longitudinal stripes, the outer ones of which are somewhat indistinct; furnished with 3 pre-alar, 3 supra-alar and 4 pre-scutellar bristles; pleurae grey; scutellum brown margined grey and furnished with four black bristles; post-scutellum black.

Abdomen shining black; segment 1 grey-black; 2 with the posterior margin

broadly white and the side margins grey; 3 with the side and posterior margins grey; 4-7 with the side margins broadly grey; venter grey; genital spines black.

Legs black; apices of femora red-brown; tibiae and tarsi yellow-brown with apices black. The anterior femora bear a row and two pair of apical bristles and the posterior femora bear a pair of apical.

Wings tinged brown; R4 decumbent for slightly more than half its length, then curving upward; Cu1 coalesces with 1A well before the border. The halteres are yellowish.

The male is unknown.

Habitat: Broken Bay, New South Wales (1 ♀, December, 1923, I. M. Mackerras).

This species resembles *fasciatus* but can be readily separated by the larger size and colour of the front and abdomen.

ANABARRHYNCHUS TRISTIS.

Anabarrhynchus tristis Bigot, Ann. Ent. Soc. France, Vol. 9, 1889.

Length: 13 mm.

Female: Head considerably broader than long; occiput grey, yellow at the eye margins, median indentation very shallow; eyes separated on the vertex by slightly more than the width of the ocellar tubercle, widely diverging below this but with the anterior margin straight; the upper two-thirds of the front brown, remainder white, median frontal spots large, brown, bristles and hairs fairly dense; antennae black, shorter than the head, approximated at the base with the apical half of the first segments touching; segment 1 shorter than 3; 2 about one-third the length of 1; 3 almost as long as 1 and 2 united; the style is slightly less than one-third the length of the third segment of the antennae and has its second segment about six times as long as its first; the arista is one-third the length of the style; face and cheeks white, the latter bearing greyish hairs; proboscis black with a few red hairs on the underside, projecting as far forward as the apex of the first segment of the antennae; palpi pale brown, half the length of the proboscis.

Thorax grey, ornamented with three broad but very indistinct dark grey parallel stripes; furnished with 3 pre-alar, 1 inter-alar, 3 supra-alar and 4 pre-scutellar bristles, all of which are very stout; pleurae grey; scutellum grey and bearing four bristles; post-scutellum black.

Abdomen black; segments 1 and 2 with the side margins grey and the posterior margins white and 1 bears a fringe of long white hairs on the hind margin; 3 and 4 with the side margins white and the hind margins narrowly grey; 5-7 with the hind margins broadly dark grey; venter black with the hind margins of the segments grey; genital spines black.

Legs brown; coxae, anterior femora and underside of basal half of the intermediate and posterior femora, black; the fore and middle femora each bear a row of black bristles and the hind ones a pair of apical.

Wings faintly smoky, veins brown; R4 decumbent for slightly more than half its length and then curving abruptly upwards; Cu1 coalesces with 1A well before the border. The halteres are brown.

The male is unknown.

Habitat: New South Wales, National Park (1 ♀, I. M. Mackerras, January, 1926).

The type locality for this species was given by Bigot as "Australia" and his specimen was not perfect. My identification of the species is based mainly, on

the colour of the wings, abdomen and front, which readily separates it from all other members of the genus.

ANABARRHYNCHUS TERRENUS.

Anabarrhynchus terrenus White, Proc. Roy. Soc. Tasm., 1915; *Id.*, Hardy, Proc. Linn. Soc. New South Wales, xlv., 1921.

Length: 10-12 mm.

Male: Head very little broader than long; occiput dark grey, brown at the eye margins, with a deep median indentation and furnished with black bristles and hairs which are not arranged in rows; eyes separated on the vertex by slightly more than the width of the ocellar tubercle, anterior margins straight; upper three-fourths of front brown, lower fourth, yellow, median spots suffused and forming an irregular transverse band, bristles and hairs black; antennae black, slightly shorter than the head, separated at the base with the apices of the first segments contiguous; segment 1 considerably shorter than 3; 2 more or less globular; 3 conical, as long as 1 and 2 united; the style is two-thirds the length of the first segment of the antennae and has its first segment very short; the arista is one-fourth the length of the style; face white; cheeks silvery and bearing whitish hairs; proboscis black; palpi brown and half the length of the proboscis.

Thorax brown; ornamented with three distinct dark brown parallel longitudinal stripes and furnished with bristles as in *calceatus*; pleurae grey; scutellum brown and bearing four bristles; post-scutellum black.

Abdomen dull black; segments 1-3 with apical and side margins grey; 4-6 with side margins broadly grey; 8 wholly brown; venter grey; genitalia brown.

Legs black, all tibiae and the apical half of the intermediate and posterior femora red-brown; the anterior and intermediate femora bear rows of bristles and the posterior ones bear a pair of intermediate and two pairs of apical.

Wings tinged brown with the veins dark brown and distinctly marked; venation similar to that of *montanus* except that R4 is decumbent for half its length and then curves upwards.

The female differs from the male by the more slender form and by having considerably more grey on the abdomen.

Variations: The thorax may be tinged greyish and the thoracic stripes may be indistinct and all the femora may be black, or may have the apices only, red-brown.

Habitat: Tasmania, Mount Wellington (2 ♂, 2 ♀, G. H. Hardy, January, 1918); Hobart (2 pairs taken in copula, G. H. Hardy, December, 1915 and 1916); Ballina, New South Wales (1 ♀, A. N. Burns, October, 1922).

ANABARRHYNCHUS CALCEATUS.

Anabarrhynchus calceatus Schiner, Novara Reise Dipt., p. 149, 1868; *Id.*, Krieger, Ent. Mitt., 1, p. 188, 1912.

Length: 12-13 mm.

Male: Occiput grey, with a deep median indentation, bristles numerous but not arranged in rows; eyes separated on the vertex by slightly more than the width of the ocellar tubercle, the anterior margins are curved (convex); front yellow-brown, yellow on the lower fourth, frontal spots suffused and placed on either side of a faint brown longitudinal stripe; antennae almost as long as the head, black, separated at the base, first segments touching at the apices; segment 1 considerably shorter than 3; 2 short; 3 as long as 1 and 2 combined, narrowly conical and somewhat bulged at the extreme apex; the style is narrowly conical and half the length of the first antennal segment, its first segment is very short

and the second more than three times as long as same; the arista is half the length of the style; face and cheeks yellow-white, the latter bearing white hairs; proboscis stout, black-brown and projects as far forward as the apex of the first antennal segment; palpi yellowish and half the length of the proboscis.

Thorax grey-brown, ornamented with five very indistinct dark brown parallel, longitudinal stripes; covered sparsely with black hairs and pubescence and furnished with 4 pre-alar, 3 supra-alar, and 4 pre-scutellar bristles; pleurae grey; scutellum dull brown and armed with 4 bristles; post-scutellum black.

Abdomen black with the apical and side margins of segments 1-3, grey; the side margins only, of 4-6, grey; 8 brown; venter grey; genitalia brown.

Legs: Anterior femora black, intermediate and posterior femora red-brown, the former with a black stripe on each side and the latter with a similarly coloured stripe above; tibiae and first tarsal segment yellow-brown with the apices black, remaining tarsi, black; the anterior and intermediate femora each bear rows of black bristles and the posterior ones a pair of apical.

Wings faintly smoky with brown veins and venation similar to *montanus*. The halteres are brown with yellow apices.

The female differs from the male by having a lighter coloured front and by having the thorax with sides and hind margin grey. Genital spines, black.

Habitat: New South Wales, Como (1 ♂, 1 ♀, G. H. Hardy, October, 1921); Sydney (1 ♂, 1 ♀, G. H. Hardy, October-November, 1919); National Park (Gundamain), (1 ♂, I. M. Mackerras, January, 1926); Blackheath (1 pair taken in copula, G. H. Hardy, November, 1919); Woodford (1 ♀, I. M. Mackerras); Queensland, Caloundra (1 ♀); Brisbane (1 ♂, 3 ♀, G. H. Hardy, 1 ♀, F. H. Roberts, and 1 pair taken in copula, J. Mann, August).

Variations: The fore margin of the wing may be yellow; the dorsum of the three apical segments of the abdomen may be grey and the grey on the side margins may be extensive or diminished. The anterior femora may be black on the basal half only.

This species was described from one female by Schiner, the type locality being Sydney. No mention was made of the width of the eye separation on the vertex. Krober described the species from one male and one female taken in New South Wales and New Zealand and he, too, did not mention the aforementioned characters. In 1915 White described the species from Tasmania and made special mention of the eyes being widely separated on the vertex. In the material before me I have specimens authentically identified as White's *calceatus* and which check up with his description of the species but do not agree with the original description given by Schiner, nor do they agree with that given by Krober. Specimens from Sydney and Brisbane, however, do check up with the original description and with that given by Krober and these do not agree with White's description; from this it is fairly evident that White erroneously identified this species and the one he described as *calceatus* would therefore represent a new species and the Sydney specimens are the true *calceatus*. White's *calceatus* is described in this paper as *validus*.

A. calceatus is evidently closely allied to *montanus* from which it is readily separated by the color of the wings and the abdomen.

ANABARRHYNCHUS RUFIPES.

Anabarrhynchus rufipes Macquart, Dipt., Exot., suppl. 4, 1850; *Id.*, White, Proc. Roy. Soc. Tasm., 1915; *Id.*, Hardy, P. & P., Roy. Soc. Tasm., 1916.
Length: 9-11 mm.

Male: Head considerably broader than long; occiput yellow-brown, somewhat greyish medianly, with a median longitudinal brown groove, the black bristles are arranged in three distinct rows; eyes separated, on the vertex by twice the width of the ocellar tubercle, with the anterior margins straight; front with the upper two-thirds yellow-brown and the lower third yellowish, median frontal spots, brown; antennae almost as long as the head, separated at the base with the apices of the first segments approximated; segment 1 greyish and about the same length as 3; 2 brown; 3 brownish on the basal fourth and the remainder blackish, furnished with a few black bristles at the base; the style has its first segment short and broad and its second about twice as long as the first and rounded at the apex; the arista is two-thirds the length of the style and is slightly sub-apical; face and cheeks whitish, the latter bearing white hairs; proboscis brown, hardly projecting and bearing brownish hairs; palpi yellowish, projecting slightly beyond the proboscis and covered with whitish hairs.

Thorax grey with three broad, parallel dark brown stripes which are considerably darker in the centre; the central stripe is almost black down the centre; furnished with 5 pre-alar, 3 supra-alar and 4 pre-scutellar bristles; pleurae grey, dusted with yellowish tomentum, scutellum grey with a central broad dark brown longitudinal stripe which is darker down the centre, furnished with 6 bristles; post-scutellum grey.

Abdomen covered with black and whitish hairs; black-brown, with the side and apical margins grey on segments 1-5; apical segments yellowish; venter of segments 1-5 grey with the apical margins broadly bright yellow; 6-8 bright yellow; genitalia brownish.

Legs brown with apices of tibiae and tarsal segments black; coxae grey; bristles black; hairs whitish and black; the anterior femora bear 4, the intermediate 2 and the posterior 2 black bristles.

Wings tinged brown with veins deeply marked and almost black; R4 decumbent for two-thirds its length and then curving upwards; M3 and M4 slightly convergent; Cul coalesces with 1A, which is straight, just before the margin. The halteres are yellow.

The female differs from the male by having a whitish occiput and front, and yellowish legs.

Variations: The colouration of the front varies from yellow-brown to brown in the male and from yellow-brown to whitish in the female.

Habitat: Tasmania, Dunalley (1 ♂, G. H. Hardy, December, 1917); Hobart (5 ♂ and 3 pairs taken in copula, G. H. Hardy, January, 1918, March, 1917); Rheban (1 ♀, G. H. Hardy, February, 1918); Maria Island (1 ♀, January, 1916).

The colour of the thorax in conjunction with the colour of the wings and wing veins and the widely separated eyes in both sexes will distinguish this species from all other *Anabarrhynchus* with the exception of *bohemani* and *maritimus*; from the former of these it can be separated by the number of scutellar bristles, colour of the front and the widely separated eyes and from the latter species by the colour of the abdomen.

ANABARRHYNCHUS BOHEMANI.

Anabarrhynchus bohemani Thomson, Eug. Resa. Dipt., p. 429, 1868.

Length: 9-10 mm.

Male: Occiput silver-grey, yellow-brown along the eye margins, bristles not arranged in rows; eyes separated on the vertex by one and a half times the width of the ocellar tubercle and with the anterior margins straight; front yellowish

grey, median spots, black-brown, densely haired; antennae hardly as long as the head, approximated at the base but otherwise as in *rufipes*; face and cheeks yellowish white, the latter bearing white hairs; proboscis brown, projecting as far forward as the apex of the first antennal segment; palpi pale yellow, half the length of the proboscis and covered with white hairs.

Thorax as in *rufipes* except that the scutellum has four bristles only.

Abdomen with segments 1-4 brown with apical and side margins grey; 5-7 black-brown with the apical margins yellow and 8, yellow brown; venter of segments 1-5 grey and 6-8 yellow; genitalia yellow-brown.

Legs as in *rufipes*.

Wings faintly tinged brown; veins black-brown and deeply marked. The halteres are yellow.

The female differs from the male by having lighter coloured legs, and the abdomen coloured, segments 1-4 brown with the apical and side margins broadly blue-grey; 5-8 with the anterior margin brown and the remainder with a dull brick coloured reflection. Genital spines black.

Habitat: New South Wales, Sydney (1 ♂, G. H. Hardy, August, 1920), Woy Woy (1 ♀, 2 ♂, I. M. Mackerras, October, 1924).

This species was described originally from a male taken in Sydney and is closely allied to *rufipes*, but can be separated from that species by the absence of the rows of bristles on the occiput and by the colour of the abdomen.

ANABARRHYNCHUS ORNATIFRONS.

Anabarrhynchus ornatifrons Krober, Mitt. Naturh., Mus. Hamburg., 1914.

Length: 10 mm.

Male: Occiput yellow-brown, golden at the eye margins, bristles arranged in three irregular but distinct rows, median indentation distinct; eyes separated on the vertex by slightly more than the width of the ocellar tubercle and with the anterior margin straight; front golden brown, slightly darker on the vertex and lighter towards the eye margins, the median spots are elongated and confluent at the vertical end, forming a V-shaped, dark brown area, hairs and bristles sparse; antennae separated at the base, with the apices of the first segments touching; segment 1 three times as long as 2 and somewhat yellowish at the base but otherwise brownish; 2 one-fourth the length of 3, brown; 3 as long as 1 and 2 united and is also brown; the style is slightly more than half the length of the first segment of the antennae and has its second segment four times as long as its first; the arista is slightly more than two-thirds the length of the style; face and cheeks bright yellow, the latter bearing yellowish hairs; proboscis brown, covered with yellowish tomentum and projecting as far forward as the apex of the second segment of the antennae; palpi yellow, one-third the length of the proboscis.

Thorax brown, yellow-grey anteriorly, dark brown on the sides and with some yellowish tomentum on the dorsum; covered densely with black pubescence; ornamented with five broad distinct parallel stripes, the central and outer ones of which are darker and more distinct than the other two; furnished with 3 pre-alar, 1 inter-alar, 3 supra-alar and 4 pre-scutellar bristles; pleurae grey, covered with yellowish tomentum, scutellum yellow-brown, with a dark brown median spot and bearing 4 bristles; post-scutellum grey.

Abdomen black; segment 1 yellow-grey with the posterior margin narrowly bright yellow, preceded by a red-brown reflection and bearing a fringe of bright yellow hairs; 2 with side and posterior margins broadly bright yellow and bearing a fringe of similarly coloured hairs; 3 with side margins broadly, and posterior margin narrowly, bright yellow preceded by a red-brown reflection; 4 and

5 with the side margins broadly bright yellow and the posterior margin broadly red-brown and bearing a fringe of yellow hairs; 6 and 7 with the side and posterior margins broadly red-brown; 8 red-brown; venter blackish with posterior margins of segments red-brown; genitalia shining brown.

Legs: Coxae black; femora bright yellow-brown; tibiae and tarsi brown but with the apices black; the anterior femora bear a row of 5 bristles, the intermediate a row of 6 and a pair of apical and the posterior ones a pair of apical.

Wings tinged brown, costa somewhat yellowish; R4 straight for half its length and then decumbent for one-fourth and from thence curving upwards; M2 slightly sinuous; Cu1 coalesces with 1A just before the border. In comparison with the other species of the genus the wings are shorter and broader and much more rounded at the apex. The halteres are yellow.

The female is unknown.

Habitat: North Queensland, Kuranda (1 ♂, A. P. Dodd), Dunk Island (2 ♂, F. Perkins, 27/8/1927).

This species was originally described from one male taken at Kuranda and is easily recognised by the V-shaped area on the front, colour of the abdomen and by the shape of the wings.

ANABARRHYNCHUS UMBRATILIS.

Anabarrhynchus umbratilis White, Proc. Roy. Soc. Tasm., 1915.

Length: 9-10 mm.

Male: Head about as broad as long; occiput grey with a deep median indentation, the bristles not arranged in rows; eyes separated on the vertex by twice the width of the ocellar tubercle, with the anterior margins slightly convex; vertical half of front brown, remainder white, median furrow present and deep, bristles and hairs very numerous, frontal spots widely separated, almost touching the eye margins, but indistinct because of being confluent with the brown of the upper half of the front; antennae black, separated at the base with the apices of the first segments touching; segment 1 covered with grey tomentum, slightly shorter than 3; 2 short and globular; 3 hardly as long as 1 and 2 united; style about as long as the second segment of the antennae, its first segment very short; the arista is one-third the length of the style; face white; cheeks greyish and bearing similarly coloured hairs; proboscis brown, projecting as far forwards as the apex of the first antennal segment; palpi pale brown, two-thirds the length of the proboscis.

Thorax dark brown; ornamented with five parallel stripes; furnished with 3 pre-alar, 1 inter-alar, 3 supra-alar and 4 pre-scutellar bristles; pleurae grey; scutellum brown, bearing four bristles; post-scutellum black.

Abdomen black with side and posterior margins, the latter narrowly, white; venter grey; genitalia brown.

Legs olive or yellow-brown; the apices of the first tarsal segments and all remaining tarsi black. The posterior femora bear two pair of apical bristles.

Wings faintly tinged brown, veins red-brown; R4 decumbent for half its length and then curving upward; Cu1 joins 1A well before the border. The halteres are yellow with the apices brown.

The female differs from the male by having a less hairy front, stronger bristles on the occiput, the last three segments of the abdomen with the side margins broadly grey. The genital spines are brown.

Note.—The two species referred to by White are the female holotype and the male allotype. Evidently White regarded them as being but one sex, describ-

ing from the female form, both according to his sex determination and to the label on his type specimen.

Holotype and Allotype, Wedge Bay (G. H. Hardy, January, 1914); both are in G. H. Hardy's collection, Brisbane.

The species is distinct by the colour of the legs and general light colour throughout.

ANABARRHYNCHUS VALIDUS sp. nov.

Length: 11-12 mm.

Male: Head much broader than long; occiput broadly brown at the eye margins, below this grey, bristles not arranged in rows; eyes separated on the vertex by fully twice the width of the ocellar tubercle and with the anterior margins convex; front drab grey-brown on the upper half, the remainder yellowish, median frontal spots brown and contiguous with the eye margins; antennae black, separated at the base, the apices of the first segments touching; segment 1 longer than 3 but not as long as 2 and 3 combined; 2 slightly less than one-third the length of 1; 3 conical and hairy along the sides; style conical, one-third the length of the third antennal segment and with its first segment about half the length of its second; the arista is one-third the length of the style; face yellowish; cheeks silver-grey and bearing white hairs; proboscis brown-black and projecting as far forwards as half the length of the first antennal segment; palpi brown, half the length of the proboscis.

Thorax brown, somewhat greyish on the anterior margins; ornamented with five narrow parallel dark brown stripes and furnished with 4 pre-alar, 3 supra-alar, and 4 pre-scutellar bristles; pleurae grey; scutellum brown with yellowish margins and bearing 4 strong bristles; post-scutellum black.

Abdomen black with posterior margins narrowly and side margins broadly grey; segment 7 wholly grey and 8 wholly red-brown; venter grey; genitalia red-brown.

Legs red-brown, the tarsi becoming brown towards their apices, coxae and basal half of anterior femora, black; the anterior femora bear a row, and the posterior femora a pair, of apical bristles.

Wings slightly yellowish, basal veins and fore-margin yellow, remainder brown; venation similar to *calceatus*. The halteres are brown.

The female differs from the male by having more grey on the abdomen. The genital spines are black.

Holotype: (Hobart, Tasmania, October, 1914, G. H. Hardy); Allotype: (ditto). Both in G. H. Hardy's collection, Brisbane.

Paratypes: One female and one pair taken in copula all from Hobart, Tasmania (November, 1916, G. H. Hardy).

This species was identified by White (Proc. Roy. Soc. Tasm., 1915) as *calceatus* Schiner, but can be distinguished from that species, as it can from *montanus*, with which it is evidently closely allied, by the width the eyes are separated on the vertex.

ANABARRHYNCHUS MONTANUS.

Anabarrhynchus montanus White, Proc. Roy. Soc. Tasm., 1915.

Length: 10-14 mm.

Male: Head considerably broader than long; occiput greyish, the bristles are arranged in four irregular rows; eyes separated on the vertex by slightly more than the width of the ocellar tubercle, the anterior margins are more or less straight; front yellowish brown on the upper half and yellow from thence to the base of the antennae, hairs and bristles rather dense; frontal spots are

brown and contiguous with the eye margins; antennae considerably shorter than the head, separated at the base with the apices of the first segments touching; segment 1 grey-black, three times as long as 2, straight sided, slightly tapering towards the apex; 2 more or less globular; 3 conical, constricted apically, broader than 2 and slightly longer than 1 and 2 combined, furnished with a few black bristles; scutellum brown with yellowish tomentum on the posterior margin and antennal segment and has its first segment very small and short and its second conical and more than twice as long as broad; the arista is broadly conical; face yellowish; cheeks silver-grey and bearing yellowish hairs; proboscis brown-black and projecting as far forwards as half the length of the first segment of the antennae; palpi brown, two-thirds the length of the proboscis.

Thorax brown with some yellowish tomentum, somewhat darker laterally and ornamented with 5 narrow parallel dark brown stripes, the outer ones of which are not so distinct; furnished with 5 pre-alar, 3 supra-alar and 4 pre-scutellar bristles at the base only; the style is received into the apical hollow of the third bearing 4 bristles; post-scutellum greyish black.

Abdomen short and broad, twice as long as its greatest width; black with fine blackish pubescence, greyish laterally with fine whitish pubescence; venter grey; genitalia brown.

Legs orange, coxae and basal half of anterior femora greyish black and the extremity of the tarsi, black; the anterior femora bear a row of 4 black bristles and the posterior and intermediate ones are each provided with two pairs of black apical bristles.

Wings three times as long as broad, tinged brown with basal veins and costa yellowish and the remainder brown; R₄ decumbent for half its length and then curving down and then up; Cul coalesces with 1A well before the border. The halteres are brown.

The female differs from the male by having the front uniformly light yellow-brown. The genital spines are black.

Variations: The tinging of the wings grades between yellow and brown in both sexes; the stripes on the thorax may be quite indistinct.

In the material before me I have one male taken by G. H. Hardy at Mount Wellington, Tasmania, which varies considerably and may possibly represent another species, but I would not care to describe it as such until further specimens are available. It is more hairy than the typical *montanus* and the thorax is densely covered with black hairs, especially on the posterior third; there are four stout and one weak pre-alar bristles and the scutellum bears six marginals.

Another variable specimen, a male, taken at Barrington Tops, New South Wales, by the Sydney University Zoological Expedition (February, 1925), may also represent a distinct species. In this specimen the thorax is grey and sparsely covered with short black hairs and is ornamented with three brown stripes only, the centre one of which reaches to the scutellar suture and the others extend for two-thirds of the length of the dorsal surface only.

Habitat: Mount Wellington (2 ♂, 8 ♀, and 2 pairs taken in copula, G. H. Hardy, January 1918 and 1924); Maria Island (1 ♂, G. H. Hardy, December, 1915), Tasmania.

A large thick set species closely resembling *calceatus* from which it can be separated by the width of the eye separation on the vertex.

ANABARRHYNCHUS FULVIPES.

Anabarrhynchus fulvipes Macquart, Dipt. Exot., suppl. 4, 1850.

"Niger, Pedibus flavis. Alis basi flavidis."

"Long. 4 l. fem. Corps entierement noir. Hanches noires; un peu de noir a l'extremite des jambes posterieures; les trois derniers articles des tarses noirs Ailes grisatres, a bord exterieur jaunatre."

"De la N-Hollande. Coll. de M. Bigot."

I have not recognised this species; the description does not contain any outstanding specific characters to make identification easy.

ANABARRHYNCHUS RUFICORNIS.

Anabarrhynchus ruficornis Macquart, Dipt. Exot., suppl. 4, 1850.

"Thorace nigro; scutellum rufo-marginato. Abdomine mas fusco, incisuris anoque testaceis; fem. testaceo, vitta dorsali nigro. Antennis pedibusque rufis."

"Long. 2 3/4 mas., 5 l fem. Tromp peu saillante. Face et front noirs; ce dernier etroit mas. assez large fem.; antennes d'un beau fauve. Thorax a cotes testaces fem.; ecusson a petite bordure fauve. Abdomen mas, d'un brun noiratre; armure coputatrice et ventre testaces; fem. testace, a bande dorsale noire, interrompue aux incisions; ventre testace, a bande longitudinale brune sur les cotes. Pieds fauves avec les deux derniers articles des tarses bruns. Ailes un peu jaunatres."

"De la N-Hollande; cote orientale. Museum."

The black face and front together with the fawn antennae should readily distinguish this species. It is not represented in the material before me.

ANABARRHYNCHUS RUFIVENTRIS.

Anabarrhynchus rufiventris Macquart, Dipt. Exot., suppl. 4, 1850.

"Thorace nigro. Abdomine rufo. Antennis pedibusque rufis."

"Long. 3 l. fem. Face brune. Front noir. Antennes fauves, a style noir. Thorax noir en-dessus, fauve sur les cotes et en-dessous; ecusson noir, borde de fauve. Abdomen fauve, a premier segment brunatre, et bord posterieur fauve; deuxieme et troisieme a petite tache dorsale noire, oblongue, n'atteignant ni la base ni l'extremite. Pieds fauves; tarses: les trois premiers articles a extremite noire; les deux autres noirs. Ailes un peu jaunatres."

"De la N-Hollande; cote orientale. Museum."

Species of Uncertain Generic Position.

The following species, described under the genus *Thereva*, have not been recognised but they probably all belong to *Anabarrhynchus*.

Thereva varipes Macquart, Dipt. Exot., suppl. 2, 1847. Tasmania.

Thereva dimidiata Macquart, Dipt. Exot., suppl. 2, 1847. Australia.

Thereva aperta Macquart, Dipt. Exot. suppl. 1, 1846. Sydney.

Thereva ochropa Thomson, Emg. Resa. Dipt., 1868. Sydney.

Genus PSILOCEPHALA.

Psilocephala Zetterstedt, Ins. Lappon, Dipt., p. 525, 1830.

Genotype. *Bibio imberbis* (Sweden), by Coquillett's designation, 1920.

Krober records 13 species of *Psilocephala* as belonging to the Indo-Australian region and states that only two of these occur in Australia (Ent. Mitt., 1912).

White described four species in 1915 from Tasmania and Krober recorded one from the same island in 1912 and described one from Sydney in 1913, bringing the total number of species to eight.

I have failed to recognise any species of the genus and consequently am not in a position to draw any definite conclusions.

White characterises the genus as follows:—

"Head as broad as, or a little broader than, the thorax; front bare.

Proboscis usually lying close against the face. Antennae short, the 1st joint about 3 times the length of the 2nd, but shorter than the 3rd. Eyes joined in the male, but widely separated in the female. Thorax bare, but with the thoracic bristles well developed, the dorso-central being either complete or consisting of from one to three pairs of pre-scutellar bristles. Abdomen narrow, conical in the male, but greatly lengthened in the female; genitalia of the male extended and conspicuous. Legs slender, of medium length, the tibiae bearing short bristles. Wings either without markings or spotted and banded; the 4th posterior cell in Australian species always open. This genus is distinguished from *Anabarhynchus* in both sexes by the much more slender shape and the bare front and in the male by the joined eyes and extended genitalia."

This species is evidently allied to *ruficornis* and the fawn antennae readily separates it from other species of the genus and the colour of the thorax and abdomen would distinguish it from *ruficornis*.

The species are listed below and the original descriptions are given when the works are difficult to locate.

PSILOCEPHALA NUDIFEMORATA.

Thereva nudifemorata Macquart, Dipt. Exot., suppl. 1, 1846.

Psilocephala nudifemorata White, Proc. Roy. Soc. Tasm., 1915.

This species was originally described as a *Thereva* and White gives the following note:—"This species described under the name *T. nudifemorata* is unknown to me; von Krober states that it belongs to the genus *Psilocephala* and I place it here on his authority; the genus *Thereva* does not occur in Australasia."

PSILOCEPHALA LUTEA.

Psilocephala lutea White, Proc. Roy. Soc. Tasm., 1915.

Type locality: Bagdad Valley, Tasmania.

The male is unknown.

PSILOCEPHALA NITENS.

Psilocephala nitens White, Proc. Roy. Soc. Tasm., 1915.

Type locality: Hobart, Tasmania.

The female is unknown.

PSILOCEPHALA VENUSTA.

Thereva venusta Erichson, Arch. V., Nat. VIII., 1842.

Psilocephala venusta Krober, Ent. Mitt., 1912; *Id.*, White, Proc. Roy. Soc. Tasm., 1915.

"Nigra, nitida, ano rufo, pedibus testaceis, alis dimidiato-nigris, fascia alba. Long 4 lin."

"Nigra, Antennae obscure testaceae, articulo primo nigro-hirsutulo; haustellum obscure testaceum. Frons tenuiter albo-pubescentis, medio leviter impressa. Caput infra albo-pilosum. Thorax tenuissime canopruinosus, obsolete striatus. Scutellum ferrugineum, basi nigrum. Abdomen nigrum, nitidum, segmentis ultimis duobus rufis. Pedes flavotestacei, coxis posterioribus basi nigricantibus, tarsis apice fuscis. Halteres fuscis, stripite flavo. Alae basi ad medium usque hyalinae, nervis costaque flavescens, dein nigrae, fascia transversa albo-hyalina."

Described from Tasmania. The male is unknown.

PSILOCEPHALA OCCULATA.

Psilocephala oculata White, Proc. Roy. Soc. Tasm., 1915.

Type locality: Bagdad, Tasmania. The male is unknown.

PSILOCEPHALA RUFA.

Psilocephala rufa Krober, Ent. Mitt., p. 253, 1912.

Type locality: Sydney. The male is unknown.

PSILOCEPHALA SAXATILIS.

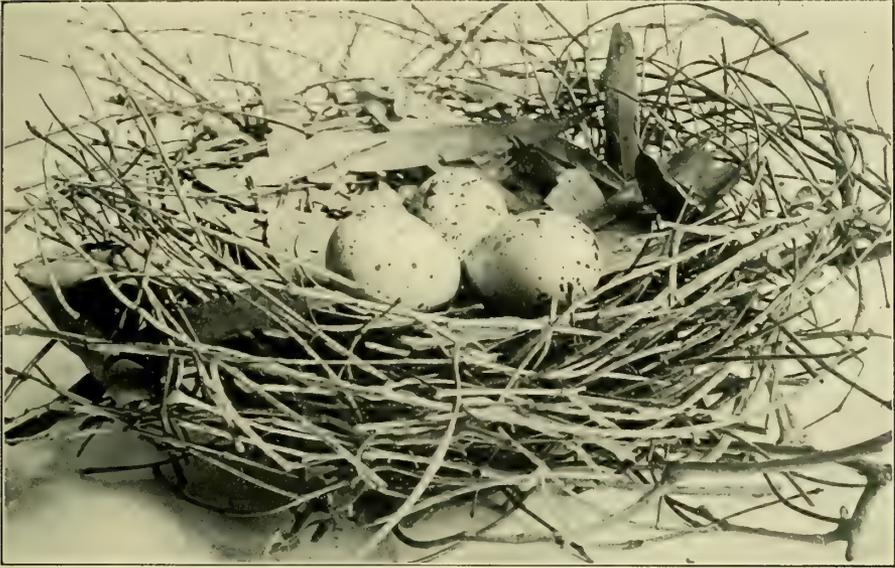
Psilocephala saxatilis White, Proc. Roy. Soc. Tasm., 1915.

Type locality: Bagdad Valley, Tasmania

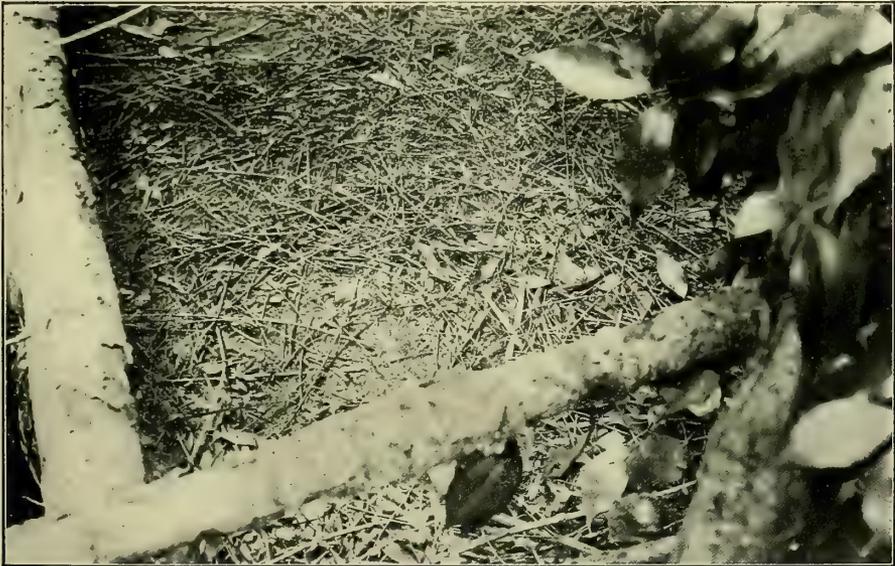
Both sexes are known.



*Yours sincerely
Launceston Harrison.*



Nest and Eggs of Satin Bowerbird.



Platform used for display by Female Satin Bowerbird.

PUBLICATIONS (Continued).

AUSTRALIAN ZOOLOGICAL HANDBOOKS.

Check-List of the Fishes and Fish-like Animals of New South Wales, by Allan R. McCulloch, Zoologist, Australian Museum, with additions by Gilbert P. Whitley. 108 pp., 43 plates. Price, 2/-. Postage, 4d.

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"THE AUSTRALIAN ZOOLOGIST."

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THE ANNUAL MEETING.

The 1927-28 Annual General Meeting of the Society was held at Taronga Park, Mosman, on Saturday, 21st July, 1928, at 3 p.m., 32 members being present.

The President, Mr. J. R. Kinghorn, C.M.Z.S., read the annual report, as follows:—

THE ANNUAL REPORT.

On 30th June, 1928, there were 436 members on the Register, divided into the various categories, as follows:—Associate benefactor 1, life members 28, ordinary members 258, life associate members 21, associate members 118, honorary members 6, and honorary associate members 4. Six members died during the year, six resigned, the names of twelve members were removed from the Register, and fifty-two new members were elected, giving a net increase of twenty-seven members for the year. The complement of 300 ordinary members will probably be complete by the time this report is published. The loss by death of no less than three of our most distinguished scientific members—Dr. E. W. Ferguson, Professor Launcelot Harrison, and Dr. W. E. J. Paradise—has been the saddest feature of the past year. Obituary notices and portraits of these members were published in *The Australian Zoologist*. Other losses by death included Mr. P. Burrows and Mr. A. E. Jaques, ordinary members, and Mr. John Hopson, life associate member, a keen lover of nature.

The Council.

Vacancies in the Council occurring through death of Professor Harrison and Dr. Paradise were filled by the election of Messrs. T. C. Roughley (December 8, 1927), and Clifford Coles (May 10, 1928). Ten meetings of Council were held during the year, at which the attendances were:—Messrs. Hull and Troughton 9, Kinghorn, Cayley, Dixon, Musgrave, Shipway and Stead 8, Drs. D'Ombrian

and Waterhouse 7, Mr. Nicholson 6, Messrs. Chisholm and Halloran 5, Messrs. Bryce, Pollock and Roughley 4, Mr. Froggatt and Dr. Paradise 3, Mr. Coles 2. The average attendance was 11.6. Messrs. Bryce, Froggatt and Pollock were absent on leave for part of the year.

Sections.

There has been a marked increase in the activity of the Sections, and attendances have on many occasions taxed the accommodation of our meeting room to its utmost capacity. It is most gratifying to find so much enthusiasm amongst our specialists, and that many "lay" members take advantage of the interesting lectures and displays provided.

The Australian Zoologist.

Two parts of this journal were issued during the year. Although the number was equal to the previous year's issue, the size of each part was very much greater.

Finances.

For the first time our total funds are less than at the end of the previous year. Although the decrease is only £11, to this must be added the normal annual increase, which would make the aggregate difference exceed £100. However, a glance at the balance sheet will show that the printing bill was more than double that of the previous year. Not only was the journal greater than usual, but nearly £100 was expended from the Handbook Publication Fund, an expenditure which is already well on the way to be recouped by the sale of publications.

Aquarium at Taronga Park.

Although during the first year after its opening the Trustees of Taronga Park were unable to make members' passes available for the Aquarium owing to the cost of construction, they have now granted this concession. The success attending this addition to the attractions of the Park has been phenomenal, and a second or tropical section has been added, and will shortly be open to the inspection of visitors.

The Society's Jubilee.

On 24th March, 1879, the foundations of this Society were laid by the formation of a Society to encourage the acclimatisation of birds and animals. Thus the year now entered upon will be the Jubilee Year of this Society, and steps will be taken to fittingly mark the occasion upon the completion of the fiftieth year of its activities. There are many ways in which the event can be appropriately celebrated, and suggestions are invited from those members who have the interests of the Society at heart.

Election of Councillors.

The six retiring members of Council,—Messrs. C. Coles, J. R. Kinghorn, A. J. Nicholson, T. C. Roughley, P. Shipway, and Dr. G. A. Waterhouse, were re-elected.

The Honorary Treasurer then presented the balance sheet, and moved the adoption of the report and balance sheet. The motion was seconded by Dr. Anderson, and carried.

The President then delivered an address, entitled "Faunal Problems." On the motion of Dr. T. Storie Dixson, seconded by Dr. G. A. Waterhouse, and supported by Mr. Clifford Coles, a vote of thanks was accorded to Mr. Kinghorn.

Election of Officers for 1928-29.

At a meeting of Council, held at the close of the Annual General Meeting, the following officers were elected for the year 1928-29:—

President (and Honorary Editor): Mr. A. F. Basset Hull.

Vice-Presidents: Mr. J. R. Kinghorn, Messrs. W. W. Froggatt, Aubrey Halloran, and A. J. Nicholson.

Honorary Secretary: Dr. G. A. Waterhouse.

Honorary Treasurer: Mr. Phillip Shipway.

Honorary Librarian: Mr. A. S. Le Souef, C.M.Z.S.

New Members.

The following new members have been elected since the publication of the last list (May 14, 1928):—

Ordinary:—E. Bloch, W. H. Cornford, A. C. Chandler, A. J. Carruthers, W. J. Dellow, F. B. Fleming, G. Pizzey.

Associate:—C. Le Souef, Miss D. A. Selby.

REPORTS OF THE SECTIONS.

BIOLOGICAL SURVEY SECTION.

During the past twelve months valuable additions have been made to the National Park collections, and a number of new species, principally of Diptera, has been placed on record in various publications. Studies of life-histories and distribution have been published, and further work in this direction is in progress. Perhaps the most important recent Australian contribution to biology was the study of mimicry in insects, presented by Mr. A. J. Nicholson, in his Presidential Address to this Society, and it is a source of satisfaction to the Section that a number of the field observations recorded therein were made in the National Park.

The difficulty of systematising and co-ordinating the work of the Section has received considerable attention, and an endeavour is at present being made to prepare a definite programme of work, in which each member will find scope for his particular field of investigation.

The following office-bearers were elected for the year 1928-29:—

Chairman: Mr. A. J. Nicholson; Vice-Chairman: Dr. G. A. Waterhouse; Hon. Secretary: Dr. I. M. Mackerras; Committee: Professor W. R. Browne, Mr. E. Cheel, and Mr. P. A. Gilbert.

I. M. MACKERRAS, Hon. Secretary.

ENTOMOLOGICAL SECTION.

During the year eleven meetings were held, with an average attendance of eight, exclusive of visitors. During the year the Section lost by death two of its most valued members, who had always taken a very keen interest in the work of the Section until hindered by ill-health. Dr. E. W. Ferguson had been the Vice-Chairman of the Section since its inception, and Professor L. Harrison was a regular attendant at its meetings. On the initiation of the Section, the Council of the Society admitted to honorary associate membership, Dr. T. L. Bancroft, and Mr. J. R. Malloch, on account of their distinguished services to Australian entomology. The exhibits at the meetings during the year were of great interest to all those present.

During the year, Mr. Compere gave an account of the control of Mealy Bugs, in California, and Messrs. W. W. Froggatt, Musgrave, Nicholson and Dr. Waterhouse gave accounts of trips they had taken outside New South Wales.

G. A. WATERHOUSE, Chairman.

G. M. GOLDFINCH, Hon. Secretary.

At the Annual Meeting, held on August 8, 1928, the following officers were elected for the ensuing year:—Chairman, Dr. G. A. Waterhouse; Vice-Chairman, Mr. H. J. Carter; Hon. Secretary, Mr. T. G. Campbell.

MARINE ZOOLOGICAL SECTION.

The Marine Zoological Section has now completed the second year of its existence. A most successful and entertaining programme has been maintained throughout. During the early part of the term a sad happening marred our

activities; this was the death of our late lamented Vice-Chairman, Dr. W. E. J. Paradice, on November 3, 1927. An obituary notice giving the facts of his unfortunate demise is published in the *Australian Zoologist*, v, 1, 1927.

At all meetings of the Section excellent lectures were contributed by members, and these were illustrated by great numbers of lantern slides. In addition, numbers of exhibits were shown and their features discussed at length.

Lectures delivered during the year were as follows:—

"Among the Birds and Turtles of the Capricorn Group, Queensland," E. F. Pollock; "Sea Snakes and Turtles," J. R. Kinghorn; "Observations on the Great Barrier Reef and Deductions Therefrom," Dr. W. E. J. Paradice; "With Sir Douglas Mawson in Antarctica," W. H. Hannam; "Catching Sharks for Profit," T. C. Roughley; "Marine Camouflage," W. Boardman; "A Talk on Sponges," W. Boardman; "The Activities of the Australasian Association for the Advancement of Science, Hobart (Tas.), meeting (1928)," A. Musgrave, supported by T. C. Roughley; "A Naturalist's Impressions of Central America," M. Ward; "The Possibilities of a Zoological Survey of Port Jackson and Vicinity," G. P. Whitley; "Early History of Zoological Exploration in Australia," T. Iredale; "The Marine Ecology of the Islands of the Capricorn Group, Queensland," M. Ward.

The Chairman, T. C. Roughley, attended the Commonwealth Government's Fisheries Conference, in Melbourne, towards the end of 1927, as New South Wales' delegate. He strongly advocated the establishment of Marine Biological Stations in each of the States, and it is expected that one of the first to materialise will be situated in Port Jackson. If this eventuates, there will be a great opportunity presented for this Section to become a most influential and greatly enlarged body. In this regard all members are keenly watching for what the future will reveal.

The December, 1927, meeting was specially designed as a Christmas gathering. Several visitors were invited to join in the proceedings of the evening, and the cheerful spirit appropriate to the season was manifested throughout. The Chairman addressed the members, and stated that the idea was an innovation in the Royal Zoological Society of New South Wales. He hoped other Sections of the Society would imitate the Marine Zoological Section in fostering the social aspect of their activities.

A special meeting of the Section was called for Thursday, July 5, in order to welcome the members of the English Great Barrier Reef Investigation Expedition, headed by Dr. C. M. Yonge, who were passing through Sydney on their way to Queensland. The purpose of the meeting was to enlighten the visitors on the various aspects of the Great Barrier Reef and its fauna, and to afford them an opportunity of meeting the local marine zoologists, together with members of the Australian Great Barrier Reef Committee. Several who had visited the Reef delivered lectures, illustrated with selected lantern slides. A general discussion followed, during which much light was thrown on the conditions of living north of the tropic of Capricorn. This was much appreciated by the visitors, and Dr. Yonge and others replied in an appropriate manner, giving an outline of the aims and objects of the expedition. All who spoke highly complimented the lecturers on the excellence of their lantern slides, many of which had been carefully coloured from life.

T. C. ROUGHLEY, Chairman.

F. A. McNEILL, Hon. Secretary.

At the Annual Meeting, held on August 16, 1928, the Chairman and Hon. Secretary were re-elected for the ensuing year, with Mr. W. H. Hannam as Vice-Chairman.

ORNITHOLOGICAL SECTION.

The most pleasing feature to report of the Section's activities during the last twelve months is the increased attendance of members at the regular monthly meetings. Twelve meetings were held and the lectures delivered were thoroughly enjoyed; the many beautiful photographs used as illustrations, added numerous new subjects and proved most instructive.

Two trips to the Capricorn Group, organised by Mr. E. F. Pollock, were both well attended by members of the Section, and, besides the excellent collections of bird photographs, much material of zoological interest was secured. Mr. Pollock is to be congratulated upon the promotion and success of these excursions, and our best wishes and thanks are extended to him.

Members greatly appreciated the opportunity of viewing Mr. R. T. Littlejohn's "Lyrebird at Home" film, which was screened on two occasions at the Australian Museum, in the Lecture Theatre. Mr. Littlejohn's film is unique, and he has set a standard which is the admiration of all nature photographers; to him we extend our thanks and hearty congratulations.

The institution of regular monthly week-end excursions to localities of ornithological interest should prove an added incentive to members, and during the coming spring months many enjoyable outings are looked forward to.

Another proposal, of which it is hoped members will avail themselves, is a "Camp-out," to be held during November, the locality suggested is Port Stephens.

The Bird Cabin in National Park has been occupied at most week-ends, and to members, as well as visitors from other States and abroad, it has been a boon.

In May we had the honour of a visit to our Cabin by His Excellency the Governor-General, Lord Stonehaven and party, under the leadership of Messrs. A. S. Le Souef and N. W. Cayley. Subsequently His Excellency desired to be shown some of the results obtained by our Nature photographers. Opportunity was taken at the rooms of the Society to screen, in the presence of the Vice-Regal party and members of the committee, a selection of outstanding bird pictures; these elicited enthusiastic comments by our visitors.

A summary of the lectures given during the year is as follows:—

July 15th.—Mr. J. R. Kinghorn, a lecture entitled, "Enemies of Birds," illustrated with lantern slides taken by himself and others.

August 15th.—Mr. M. S. R. Sharland, a most interesting lecture on "Tasmania's Birds," illustrated with excellent lantern slides made from his own photographs.

September 16th.—Mr. Tom Iredale, an instructive lecture on Albatrosses, illustrated by lantern slides from photographs taken by Mr. E. F. Pollock and others.

October 21st.—Discussion on the trafficking in Australian Finches and the issuing of permits to bird-trappers. Meeting then adjourned and attended the Gould League of Bird Lover's annual celebration of Bird Day, held in the King's Hall, Hunter Street, Sydney.

November 18th.—Mr. P. A. Gilbert lectured on "Nesting Habits," illustrated with types of nests of certain insects and birds, and lantern slides.

December 17th.—Mr. Tom Iredale gave an account of a visit he and Mr. A. H. Chisholm made to two of a group of islands known as Five Islands, South Coast, and exhibited photographs, as lantern slides, taken by Mr. Chisholm, of rookeries of Silver Gulls and Crested Terns, the Little Penguin, and the nesting burrows of the Wedge-tailed Shearwater.

January 20th.—Mr. P. E. B. Barnett exhibited a fine collection of his Nature

photographs as lantern slides. The subjects included many beautiful nests of birds, and a splendid series of different insects.

February 15th.—Mr. E. J. Bryce delivered a lecturette, profusely illustrated by lantern slides, dealing with his trip from the Cape to Cairo.

March 16th.—Mr. Clifford Coles gave an interesting account of the salvage operations at the wreck of the "S.S. Riverina," illustrated with a complete pictorial record of the whole operations and the birds noted during the period.

April 20th.—Mr. E. F. Pollock exhibited as lantern slides a very fine collection of bird photographs taken on his trips to the Capricorn Group.

May 18th.—Mr. N. W. Cayley gave an address on "Birds of Prey," illustrated with water-colour drawings of the different species, both diurnal and nocturnal, as well as their eggs.

June 15th.—Mr. P. A. Gilbert gave an address on the habitats and distribution of certain species of birds, and exhibited splendid photographs, as lantern slides, of different classes of country and of typical species usually found therein.

CLIFFORD COLES, Chairman.
NEVILLE W. CAYLEY, Hon. Secretary.

At the Annual Meeting, held on July 20, 1928, the Chairman, Mr. Clifford Coles, suggested that one way to attract people to the study of Natural History, in general, and birds in particular, would be to open the Australian Museum at night.

Official figures, he pointed out, showed that approximately 200,000 people attended picture shows in Sydney and suburbs each night. Other amusements drew further thousands. The Museum was open only during the day, when most people were at work, and it was fair to assume that great good would accrue if it opened at night.

Other speakers supported Mr. Coles, and it was agreed to make representations to the Government on the matter.

Mr. Coles was re-elected Chairman of the Society, with Mr. A. S. Le Souef as Vice-Chairman, Mr. Neville W. Cayley, Hon. Secretary, Messrs. A. H. Chisholm, A. F. Basset Hull, J. R. Kinghorn, and P. A. Gilbert, members of Committee, and Mr. J. K. Hindwood, Hon. Secretary of the Field Club.

PRESIDENTIAL ADDRESS.

FAUNAL PROBLEMS.

By J. R. KINGHORN, C.M.Z.S.

My address to-day deals with a subject which has attracted many scientific workers throughout the world, it is that concerning Faunal Problems, and particularly those relating to Australia. It is such a vast subject that volumes could be written on any one section of it, and so, in touching on a number of different points, I am able to give only what is a mere summary of my thoughts.

Our faunal problems concern the introduction and acclimatisation or prohibition of importation of foreign species into Australia; the economic and scientific utilisation of such of our faunal resources as might be available; the better protection and development of our native fauna; the better education of the public regarding the aesthetic and economic value of our fauna; and the great necessity for the establishment of a Government Bureau of Economic Zoology if we wish to keep pace and step with the great Powers of the world.

While fauna conservation and preservation would embrace, in its broadest sense, all forms of animal life, a subject far too big for me to discuss here, I wish to restrict my remarks to mammals, birds and reptiles.

The fauna of a country which is in its virgin state takes its correct place in that great machinery which we term "the balance of Nature." All may appear calm and peaceful, but there is a great struggle going on the whole time. For twenty-four hours of the day, year in year out, one species is pitted against another, and one individual seeks life at the expense of another. The weak succumb and the strong prevail; and, except for occasional plagues or irruptions of one species or another (usually the indirect outcome of an upheaval of the elements), the comparative numbers remain practically unaltered.

After a few years man arrives, that is civilised man, bringing with him his most advanced developments for slaughter in the form of guns, and an increased mobility through the use of the motor car. Under these conditions, the balance of nature is completely upset, the fauna is seriously interfered with, and man's troubles begin.

In many instances where this has occurred, it has been found necessary to restock by introducing from other countries new animals, to take the place of those which have been annihilated; but, unless a complete biological examination has been carried out regarding the food and general habits of the animals to be introduced, the practice would be dangerous. We have examples of this in the introduction of the Sparrow, Starling, Rabbit and Fox, of which I will say more later on.

It is natural that, in opening up and developing new countries, man will disturb nature and perhaps unconsciously almost exterminate members of species which may be weak, either physically or numerically. So long as this disturbance is the direct result of land cultivation, or the domestication of such wild animals as are necessary for his existence, he is justified in his actions. Such disturbance rarely brings about the extinction of a species; it is unchecked commercialisation which dooms our fauna to this end.

The native races of Africa, India, America and Australia and other parts have been killing the game of their respective countries for centuries past, yet the fauna has not suffered, but, since the advent of civilised man, and his commercialisation of the fauna—Elephants for the ivory, Bison for hides and sport, Kangaroos for their hides, and also for sport—the numbers of these and other species have become so reduced, some being on the verge of extinction, that legislation has to be resorted to, to bring man to his senses, and enable the animals concerned to re-establish themselves. Such problems are immediately associated with the study of economic zoology.

We all know very well that every living creature has its place in Nature, and yet man sits in judgment and says:—This species is destructive, it must be killed; that one is beneficial, it must be preserved, and, as I can't find any special use for this other one, I will declare it "game" and shoot it "for sport." I ask the question—has man the right to do this? My answer is, yes; but only when in his "struggle for existence" he finds they are retarding his advance or the advancement of his country, for a creature which might be destructive in one direction might be highly beneficial in another. There is a certain cycle in Nature with which it will always be difficult to keep pace, and it will never be completely overtaken; if it were, the wheels would cease to turn, and life on the globe would perish.

Let us take an example:—The fauna and flora are entirely dependent on each other for their existence. Birds live on fruit, insects and seeds; plants depend largely on birds and insects for their pollination, and therefore their existence. Destroy one and the other also perishes. All life depends on air and water; and so, when man irrigates what was once a desert area, and practically devoid of plant or animal life, his cultivation of the land produces plants, which in turn attract insects and birds. Some of these he will regard as pests, and others as friends, depending entirely on his individual outlook. One man may be a grazier, another an orchardist, still another a farmer. The sheep man may not worry at all about starlings, or sparrows, knowing that they will help, in some small way, to keep a check on the Blowfly, his greatest pest, but the other two will have much to worry them, as the birds mentioned eat both fruit and grain. On the other hand, the orchardist or farmer would not worry about eagles, crows or foxes, they do him no damage, but the sheep man knows them to be destructive, and regards them as pests.

I have reference to an instance where an orchard was infested with a destructive insect pest. The orchardist encouraged insectivorous birds, which undoubtedly helped him considerably, but, even though they were in great numbers, they could not cope with the insects. It was estimated that the birds had re-established the output of the orchard about 40 per cent. As the insects were causing alarm by their spread to neighbouring areas, an economic entomologist recommended another insect which would parasitise, and so eradicate the fruit pest. But, as the birds could not distinguish between man's insect friends and enemies, they waged war on all. The affected orchardists then turned round and declared the birds pests, while neighbouring orchardists were still acclaiming them as allies. This instance would tend to illustrate that in the present state of affairs, it is man the individual, not the race, who declares for or against a species, according to its attitude towards his products.

Such a condition of affairs, if allowed to develop, or if left entirely to the individual to determine, would create a condition of chaos, and, to say the least, would not be in the best interests of the country. Here is where an economic zoologist should be consulted, a complete zoological survey made, and the fate of

the bird decided only after consideration of a full report. There are many persons who firmly believe that all that is necessary to determine the value of a bird is to watch it feeding. This, of course, may be of some value, but the scientific method is to collect some hundreds or thousands of specimens, of the species under consideration, from the forest, the open country, the field garden and orchard, systematically throughout every month of the year. An examination of the stomach contents is then carried out, during which the various items of food are sorted, weighed and counted. By this method only can a correct estimate of the value of the species be determined.

Five years ago a certain body of sportsmen, shooters, and others, seeking a variation in the open season for Stubble Quail (*Coturnix pectoralis*), made the statement that they were destructive and that they destroyed much grain. About the same time, quite without knowledge regarding the move being taken by any other bodies, the Farmers and Settlers' Association declared the Stubble Quail a most valuable bird to them, and asked the authorities controlling the Birds and Animals' Protection Act to place it on the absolutely protected list for a period of five years. These two opposite statements caused quite a war, and the department concerned called on the Australian Museum for an opinion. Later, I was instructed to carry out an investigation as far as time and money would allow. The farmer had stated that the numbers of quail were considerably diminished throughout the State, while the opposition said they were in great abundance.

The Police Department kindly co-operated and selected shooters in their respective country districts, but only thirty quail were collected. These were collected in grass land, lucerne, and stubble fields; one quail only contained wheat (and that from the base of an old stack, where it was shot); of the remainder, the majority had been feeding on weed seed, thistle seed and some insects, while a number which had been collected in stubble lands contained the remains of large numbers of grasshoppers. The result was a proclamation notifying two years' total protection for Quail throughout New South Wales.

During the past year I was able to carry out an investigation in regard to the alleged damage to rice fields in the Murrumbidgee Irrigation Area by wild ducks. The species mainly concerned were:—The Black Duck *Anas superciliosa*, Wood Duck or Maned Goose *Chenonetta jubata*, and Grey Teal *Querquedula gibberifrons*.

As my report on those investigations is in the hands of the Water Conservation and Irrigation Commission, I am not yet in a position to divulge its contents. The investigations were on a rather small scale, but, had more time and money been available, a more thorough and satisfactory examination could have been carried out.

The problem is a rather complicated one, for it is an instance where irrigation has attracted thousands of birds which otherwise never would have visited those parts, and ducks congregated there, especially in drought time, in tens of thousands.

When rice-growing was in its infancy on the Area, and only a few hundred acres were under cultivation, such masses of ducks undoubtedly could have done considerable damage; but, now that some 15,000 acres are under rice, the ducks spread themselves and the damage is infinitesimal, and, in the words of some of the growers, not worth worrying about. In support of this, I might say that the harvest this year was a record one, both for the Area and for the individual.

The United States Department of Agriculture uses the aeroplane extensively for fumigating, spraying insect plagues and other purposes, and it is appropriate to mention here that it has been used against the duck. The Pacific fliers,

Squadron Commander C. Kingsford Smith and Flight Lieut. C. T. P. Ulm, were at one period engaged on this economic zoological work, the Department employing the former to fly over the rice fields to frighten away the ducks.

With the successful entry of the Moth 'plane into the fields of commercial aviation, we might look forward to the time when it will be used for economic zoological work in this country.

This work on my part is but an apology for what economic work should be, for the best work can only be carried out by a fully equipped department, such as we would hope to have, if a Bureau of Economic Zoology should be formed in this State.

Apart from the economic value of Ducks as a reserve food supply, certain species are of value as destroyers of the aquatic larvae of certain noxious insects. Throughout those parts of the world where rice is grown, ducks are known to destroy large quantities of weed, weed seed, and caddis larvae which are harmful to rice plants, and they also are a contributing factor in keeping down mosquitoes. Dr. Samuel Dixon, Commissioner for Public Health, Pennsylvania, U.S.A., proved the value of wood ducks and mallard in this direction. Two ponds each 1,400 square feet were prepared; in one he placed goldfish, in the other ducks. Within a short time the fish pond was swarming with mosquito larvae, while none appeared in the duck pond. Then, to prove his statement that the ducks were superior to the fish, ten mallards were introduced to the fish pond, and, within 48 hours, all the mosquito larvae had been eaten by the ducks.

Perhaps the best lessons regarding the proper protection of food crops from insect enemies were learnt during the World War, and many valuable pamphlets have been issued in the United States of America setting out the economic value of many species which previously had met with mixed receptions from the "man on the land." As an instance I might mention the Hawk family; because a few renegade species take to poultry stealing, the whole family has been persistently persecuted. The United States Department of Agriculture carried out very extensive investigations, the stomachs of over 50,000 hawks, of 75 species, from all parts of the United States, were examined, and only six species were found to be wholly detrimental to the interests of agriculture, their main diet being insectivorous birds (one of those hawks is very closely allied to our Goshawk *Astur approximans*) but the Kites and Kestrels were found to be highly beneficial. A pamphlet was drawn up and issued to farmers, in which they were told that, on an average, each bird destroyed two noxious rodents (field mice) per day, and that, if one mouse inflicted only 1 cent's worth of damage to a field in a day, every mouse-eating bird would consume at least seven dollars worth of mice in a year. If the average life of such hawks was ten years, then each single bird would be worth 70 dollars to the United States of America.

The same work was done in regard to the Starling (*Sturnus vulgaris*) in the United States, and after an examination of 8,000 stomachs, extending over a period of a year, and recorded as "one year's food of the Starling," it was declared to be 75 per cent. beneficial and 25 per cent. destructive, the latter being for its attacks on cherries.

There are certain introduced birds in Australia which should be eradicated now before they spread and become pests, such as Sparrows and Starlings. I say Starling, despite the fact that it probably is 50 per cent. beneficial, but the 50 per cent. damage that it does is what we must save.

The Red-whiskered Bul-Bul *Otocompsa emeria* is a pest, as was shown by me in the pages of the Australian Museum Magazine, but now that its name has been added to the first schedule of the Birds and Animals' Protection Act, those

persons who were crying out against it are quite satisfied, and imagine that, because it is so placed, it will die out. We will have to kill it out, it is not enough for us merely to place it in the "rogues' gallery," and then sit back hoping that it will die.

Much work has been done in other countries regarding the economic value of birds, but the United States takes pride of place for extensive investigations and the distribution to the farmer of leaflets and pamphlets setting forth the results.

Such work should be started in Australia before it is too late. Pamphlets should be issued containing the details of investigations, and the results of such examinations, and should not only be issued to farmers, but distributed to schools and broadcasted throughout the State.

Through the enterprise of Broadcasting Station 2 F.C., I had the honour of delivering several short talks during educational sessions, and I did not miss the opportunity of making good use of those occasions, broadcasting knowledge concerning the economic value of our fauna, its conservation and development.

One could go on and on giving similar instances of the value of birds in other countries, which are allied to our species, but in very few instances can we show that investigations have been carried out in Australia. This is a very necessary work, a tremendously important one, and if a special department is not formed to deal with economic zoological problems, money should be made available so that zoologists attached to our museums, and similar institutions, might be able to give the necessary attention to the matter.

Reptiles are of more economic value than we are inclined to admit. Carpet Snakes and Diamond Snakes (*Python spilotes*), harmless species which grow to 12 and 9 feet respectively, are destroyers of rabbits, rats and mice, and occasionally birds. The large Queensland Python (*P. amethystinus*) which grows to twenty feet in length, besides being a destroyer of our fauna, somewhat compensates the damage it does by possessing a very valuable skin. Snake skin makes a very excellent and lasting leather from which is manufactured bags, belts, shoes, and even overcoats for ladies. Hundreds of hunters are finding a ready market in Australia for snake skins, and the demand appears to be growing every month. Anything seems possible these days, and I would not be at all surprised to hear of Python farming for commercial purposes.

The skin of the Goanna (*Varanus varius*) is of even greater value than that of Snakes, it is tougher, and is in great demand by bootmakers and fair wearers of fancy shoes. The goanna skin shoe is an ornamental, as well as a lasting shoe, especially when the skin has been "chrome dressed," this producing a white and grey finished article. Though we have thousands of available Goannas, that is to say thousands which are large enough to be marketable, we unfortunately have few firms that can treat the skin to the best advantage, tanning being the most popular method of treatment, and so the majority of the chrome dressed skins are imported. Most of the white dressed, Australian skins are "alum dressed," and, though they look very much the same as the "chrome dressed" article, they are not so soft, or lasting in quality.

Blue Tongue Lizards (*Tiliqua* spp.) and most of the Skinks (*Lygosoma* spp.) are insectivorous, and when the former is kept in the garden, the snails, slugs and slaters soon disappear. Several species of Australian lizards have been recommended for introduction to the cane fields of Fiji, where they will do good work under the fallen leaves, destroying cane borers and other pests.

The value of crocodile and alligator hide is so well known that comment is hardly necessary, suffice it to say that, not only are hundreds of thousands of wild saurians killed each year, but crocodile farms have come into existence, the

demand for hides is so great. The Australian species *Crocodilus johnstoni* is rather small in size, but the Estuarine Crocodile (*C. porosus*) which is known from India, through the Malay Archipelago to Australia, grows to over twenty feet, and is now keenly hunted for the value of its hide, many thousands from North Australia being marketed annually.

The gradual disappearance of many species of our birds and mammals is due to several causes; the advance of settlement, their unscientific commercialisation (if one might be pardoned for using such a term); the introduction of the fox, the rabbit, the rat; and the ravages of the domestic cat gone wild. The Cat (*Felis domestica*) is becoming a tremendous problem, and our worst enemy, and now is the time to turn our attention towards methods of exterminating it before it is too late. Mr. A. S. Le Souef dealt at length with some of those problems (*Aust. Zool.*, III., 3, June, 1923, pp. 108-111). Mr. W. E. Sanders, of the U.S.A., made some caustic remarks regarding "wild" cats, in an address before a Commission of Conservation in that country. He wanted to be appointed a "Cat Ranger," but said he could prove that cats were of some use:—Buried under apple trees he had eaten them as apples, and buried under rose bushes he has picked them as roses!

The Common Rat (*Mus norvegicus*) is a problem which intrudes itself wherever man lives. It is unfortunately a most prolific breeder and a destroyer of man's works, and this, together with its cunning make it a pest and scourge to man. The rat is a carrier of plague, which, in some countries, takes heavy toll of the population. It is only a few years since the rat gained access to Lord Howe Island. There, in new surroundings, it thrived rather too well; there was an abundance of food in the form of birds, and, in a comparatively little while, rats overran the island. Insectivorous birds and their eggs were devoured wholesale, and the balance of Nature so completely upset that, insects, particularly palm weevils having no natural bird enemy, increased beyond comprehension. They and the rats attacked the palm seed so persistently and effectively that the industry was almost abandoned. It was only three years ago that the Chief Secretary's Department, after consulting Mr. E. le G. Troughton and other zoologists, recommended the introduction of Owls, and a few of these birds, "Barn Owls" (*Tyto alba*) were liberated on the island. To-day, reports state that owls working together with man are gradually gaining the upper hand again, rats appear to be diminishing, insectivorous birds gradually increasing and weevils suffering accordingly.

I recommended the introduction of Diamond Snakes (*Python spilotes*) as they could get into every crevice among the rocks on the island, and would drive the rats out of inaccessible places, but Snakes do not appeal to man, and so the suggestion was cast aside. The Barn Owl, however, is certainly one of our best natural rat traps, as Mr. A. M. Lea showed in his "One Year's Food of the Owl." He estimated that an owl casts up two pellets each day, and he therefore collected 730 pellets from under one roosting place, this being the estimated remains of one year's food. The pellets contained the remains of: 1,407 mice, 143 rats, 375 sparrows, 23 starlings, besides reptiles, frogs, and many insects.

The recent "open season" for that beloved Australian, the Native Bear (*Phascolarctus cinereus*), declared in Queensland, brought forth such a storm of protest, that the season was very quickly closed again. The exploitation of the skins of Bears has been going on for many years, and in the year 1906 there were 193,000 skins sold on the London market under the name of "Wombat" (*Phascolomys* sp.). It may be difficult to believe this, but only three years ago a Canadian, from the far north of that country, called at the Museum to see what

a Wombat was like, as he had been buying their skins for over 30 years, to make furs for the people of the north. He thought I was having a joke with him on being shown a Wombat, as it had coarse hair and not the fur he knew so well. He walked on past the Opossums and stopped in front of the Native Bear, and at once acclaimed it as the bearer of the fur he knew so well as "Wombat."

The only method of stopping the illegal trade in skins is by having a strict examination (by a zoologist, or someone else who knows a Bear from a Wombat, or an Opossum) of all skins submitted to the Australian markets. Over 2,000,000 skins of Native Bears were exported in 1924, and if we are to save it from extermination we must see that it is totally protected throughout the Commonwealth.

In regard to the exploitation of Australian marsupials, I need mention only a few, to further illustrate my remarks in regard to their rapid extermination.

In the year 1906, 7,000 Kangaroos, 60,000 Wallabies and 4,161,685 Opossums skins, were marketed overseas in London and New York alone. In 1910, 20,000 Kangaroos, 320,000 Wallabies, and 1,300,000 Opossums were so disposed of. In 1913, Kangaroo export had increased to 25,000, Wallabies to 880,000, while 467,000 Opossums were sold in New York alone, the London figures not being available to me.

In regard to fur bearing animals, and the possibility of developing an industry or industries in this country, let me take species which are not Australian, for there is no need to destroy our native fauna for such purposes. We have the fox and the rabbit, both of which, though unmitigated pests, are turning over vast sums of money to those who are exploiting them.

The introduction and acclimatisation of the rabbit and fox have caused us much to regret, and had the first Acclimatisation Society, which was founded in 1861, known as much then as we do to-day, this mistake would not have been made. The objects of the Society were "The introduction, acclimatisation and domestication of all innocuous animals, birds, fishes, insects and vegetables, whether useful or ornamental; the perfection, propagation, hybridisation of races newly introduced or already domesticated, the spread of indigenous animals, etc., from parts of the colony where they are not known," etc.

In regard to the Rabbit, Surgeon P. Cunningham, in his book, "Two Years in N.S.W.," published in 1827, says:—

"Rabbits are bred about the houses, but as yet we have no wild ones, though there is a good scope of sandy country on the sea coast between Port Jackson and Botany Bay fit for little else than goat pastures and rabbit warrens." This is not the earliest record, for Governor Phillip in his despatch—9th July, 1788—mentions five rabbits among the live stock of the colony.

It was not, however, until about 1791 that rabbits were introduced by Governor King, from Capetown, and liberated. They immediately established themselves, the climate and general environment being so much to their liking that they rapidly increased and spread throughout the country, until to-day they are in countless billions, and it has been rightly stated that, if the rabbit were eradicated, New South Wales alone could carry another 10,000,000 sheep.

The problem of their possible eradication has engaged the attention of scientists and many others for years past, but still the rabbit is on the increase, and as long as the rabbit is plentiful there will be many persons seeking to make money from its pelt and carcase. While the money so gained is to be placed on the credit side of the ledger, it by no means compensates for the vast amount of damage done by the pest—but surely there is nothing to be said against making a pest pay in cash, as well as with its life, for some of the damage it does. Having been born and brought up in the country, I can relate the following from close personal knowledge.

The poisoning of rabbits is far from a good method, as many of our most valuable birds suffer comparatively as many casualties as rabbits. Gassing has been tried, but so far with little success; digging out is the surest method, but it is costly and slow, though this method has to be resorted to on many small holdings along river frontages. Trapping eradicates more rabbits than all other methods, but trappers will only work during the months when the pelts are at their best. Systematic trapping in "pit traps" on the part of the farmer was the means of catching most, if not all, of the rabbits which invaded his farm from outside lands, and this method was effective as long as the traps were kept in order, and regular "drives" made at night through the affected paddocks, but the traps were allowed to fall into a state of disrepair and so the method was condemned as practically useless.

The export of rabbits from Australia, in the form of carcases and pelts, has been going on for many years, and, though millions are killed every year, the pest appears to be on the increase. The extraordinary thing is that, while the pest is increasing the prices paid for pelts are on the increase also. In the year 1910 only 30,000 rabbits were exported, while to-day those figures have greatly increased. The rabbit is always spoken of as a pest, and of no value to us, yet there is another side to the question which shows that it does return to us a certain dividend to set against the damage it does to agriculture.

Fourteen years ago carcases could be purchased retail for 4d. or 6d. per pair, and skins varied in price from 8d. to 27d. per lb. To-day carcases retail at 1/- each and skins (in prime) bring from 1/7 to 2/- each, or as much as 10/- per lb. During June, 1927, over 30,000,000 skins of rabbits were marketed, and, if they averaged only 1/6 each, over £2,250,000 must have changed hands for pelts alone, while if we add the value of the carcases, at an average of only 9d. each, well over £4,000,000 would have been returned by bunny for one month's work. Yet we know that nearly £3,000,000, for skins alone, was the return for that month. In the year 1926, over £4,000,000 worth of rabbit skins were exported, and the carcases brought in another £3,000,000. What can we say to this?

In discussing the rabbit problem we must take a broad view and not forget that thousands of persons depend on that animal to return them a living, and the sudden extermination of rabbits in Australia would throw all those thousands out into the already over-swelled ranks of the unemployed. If we find a way to exterminate it, we must also consider some way of employing the persons affected.

Fur and hat factories in New South Wales alone engage many hundreds of persons, one Sydney firm employing over 200 hands and turning out over 240 dozen rabbit fur hats every week. The fur of the rabbit is used throughout the world, and, after scientific treatment, is sold as muffs, coats, etc., under such trade names as Coney Seal, etc.

A Tasmanian company has lately been established to deal with rabbit fur, and last year treated thousands of skins, turning them out as a Coney Seal, which is considered by experts to be equal to those manufactured in America and the Continent.

I would predict a flourishing future for the rabbit fur trade in Australia if it is developed by scientific methods such as are used in other parts of the world. On the Continent and in England there are numbers of fancy rabbit farms, the varieties kept being Chinchilla and Angora. The former are worth 7/- each after 3 months growth, and 30/- each after a year. One lady keeps 500 Angora Rabbits and they return 30/- each from their combings and clippings each year.

Rabbits such as these, would have no chance of survival if they escaped from captivity, and I see no reason why some enterprising fur breeder should not at-

tempt to farm them in Australia. Such enterprise would be sure to meet with the greatest success. If an export duty of 1d. per skin was imposed over £500,000 would go into the coffers of the Customs Department. It has been argued that such a duty would be the thin end of the wedge, the man on the land eventually having to bear export duty on sheep, hides, wool, etc. This statement is ridiculous in the extreme, and is unworthy of consideration, for the law could be so framed as to apply only to introduced animals.

Another problem in Australia is the Fox, and without delving deeply into historic details I might be permitted to mention that this animal was first introduced into Australia by members of the Victorian Hunt Club, in the year 1868, and later numbers of them were liberated in southern Victoria between Geelong and Colac. From those districts they quickly spread throughout the country into other States, and to-day we count the Fox as a pest which is second only to the Rabbit.

The depredations of the Fox are unfortunately too well known, but quite apart from the damage it does among sheep and poultry, its ravages among our wild birds and mammals is a serious matter. It kills out many of the ground-nesting species of birds, among which are some of our most valuable insectivorous species.

As far as the marketing of its pelt is concerned, I might mention that in 1910, there were 38,000 Australian fox skins sold overseas, and in recent years this number has been greatly increased, but the value of the pelt is small when compared to the pelts of foxes from overseas, and it is no compensation for the damage done by the animal. Fashion plays the biggest part in determining the value of fur, and a bigger demand on the part of the wearers of furs for Australian fox furs would have the immediate effect of running the market up overseas, but this is not likely to occur.

Although we cannot compare the pelt of the introduced fox with that of the English or European fox, yet the species is the same. The climatic conditions and general environment have so affected the fox since its introduction to this country, that the fur has become harder, thinner, and of a different general colour to that of its ancestors. It would appear to me that, in the colder climates of Australia, say Kosciusko, or parts of Tasmania, we should be able to take the fox and by scientific breeding on farms develop a type of fur which would increase in value, ten times, in a very little while, and one which would eventually stabilise a fox farming industry in Australia.

Failing this, there is surely an opportunity for some enterprising persons, with the necessary money and experience, to start fox farming operations in Tasmania, New Zealand, or Kosciusko, with Canadian Silver, Black or Cross Foxes, such as are bred in Canada and some parts of the United States of America. If this were done there is little doubt that a flourishing and profitable business could be established and developed.

The Silver Fox in its original wild state could not be compared, in quality, to the scientifically developed one, and the same might be said regarding other species or varieties.

The Silver Fox is a dark phase of the ordinary Canadian Red; it is dark all over, with silver hairs intermixed (guard hairs) but no red ones, and a white tip to the tail. Foxes are selected and gradually bred to black, eliminating all the red, outbreeding a certain amount of black until silver hairs are grown, but retaining the white tip to the tail. This form is then specially selected from and bred, to ensure a fair percentage of typical offspring. The pure Black Fox, though very valuable, is not popular, because it can be too easily imitated by dyeing processes.

Silvers are selected and bred from Cross Foxes, as well as bred from wild stock—tested breeders are worth from 13,000 to 30,000 dollars a pair to members of the American Association of Breeders, and pelts from the offspring may bring anything between 500 to 25,000 dollars each. Fancy Fox breeding is anything but easy, it requires careful selection and scientific treatment, and presents many other difficulties. I do not wish to be misunderstood, for I am not advocating the protecting of our wild fox, which undoubtedly is an unmitigated pest; but I do advocate experimenting with it, in regard to the possibilities of breeding by special selection, until a marketable fur is obtained.

The breeders in America formed an Association, each breeder, as well as all of his foxes being registered. A standard has now been established and pelts branded and registered; no fox is registered as a Silver Black which shows the slightest signs of any red or rusty hairs; there is a very efficient system of inspection; members of the Association are well protected, and swindlers are very heavily punished.

In regard to fur farming in Australia, I understand that in Blackwood, South Australia, there is an Opossum farm, and that the breeding of them on scientific lines is proving successful, and a profitable business is being established.

In Tasmania there is what is called an Opossum farm, but it is rather a misnomer. The fact is that certain lands which bear a very large number of Tasmanian Black Opossums have been leased to a certain party, thereby giving him the right to trap and thin out the stock practically at will. This type of "farming" should be condemned.*

To me there appears to be no reason why many of our fur bearing animals should not be "farmed" on scientific lines, but, always in captivity, the farmer and his stock being registered, and strictly supervised, much on the lines of similar farms in America.

In the foregoing remarks, I have dealt briefly with the possible ways of developing our fauna and commercialising introduced fauna. Now let us consider briefly ways and means of protecting our native animals and birds.

While the purely sentimental grounds for protection put forward by the bird and animal lover are to be admired, yet our admiration must not lead us to become extremists. We must modify our ideas so as to meet the best methods for the economic treatment of the fauna, on the strict scientific lines of economic zoology.

When economic zoology is mentioned in public, and sometimes in certain natural history bodies, there are numbers of persons who believe that any amateur can work successfully on an economic problem, but, while we have some amateurs who could certainly carry out such work, more especially in economic ornithology, we have many others who, while imagining they could do the work, would make a failure of it. They do not understand the basic principles as understood by the scientifically trained man, for the latter is always in a position to produce the most faithful results.

In "The Australian Zoologist" (iii., 2, March, 1923, p. 44) Mr. A. F. Basset Hull remarked:—"While many of the subjects taught in secondary schools and Universities have a direct bearing on economic zoology, they are more or less disconnected, divided between the professional chairs of Biology, Zoology, Agriculture, and consequently lacking in correlation. It therefore requires a separate

*Nothing has been done on these "leases." The conditions regarding fencing, etc., not having been complied with.—Ed.

and concrete study for schools, and a special chair at the University to provide the necessary course of instruction in economic zoology."

These remarks while applied to New South Wales, should apply to the Commonwealth, and some effort should be made to institute such courses of study.

The Section of Economic Zoology which, as a section of this Society, was formed in November, 1922, has, of late years, ceased to meet because of lack of interest and attendance of members. This is most unfortunate, especially as the main object of the Section was to advocate the establishment of a Chair of Economic Zoology at the University of Sydney. I have endeavoured to interest members of the Society in economic work and have suggested the reforming of this section, and would ask all interested to get into touch with the Secretary, so that the good work started by the late Charles Hedley and others, may be carried on. Closer relationship between Scientific Societies, Natural History bodies and the general public is urgently needed, and this can be best brought about through the teaching of economic zoology or economic natural history in schools.

During the last four years, the Australian Museum, in conjunction with the Department of Education, has been able to spread the knowledge of Natural History to thousands of scholars in the primary and secondary schools of Sydney and suburbs. Lectures dealing with Natural History and Economic Zoology are given every second Tuesday afternoon in the Museum Lecture Hall, and by this method, with an average attendance of 280, over 15,000 scholars have been given an insight into these subjects. Museum extension lectures in country centres are also spreading knowledge, and in my opinion these extension lectures are far more effective than the city lectures, because they instruct and interest those people who come in direct contact with the fauna.

In regard to the school lectures I might add that, while very few of the scholars can be expected to become working naturalists, we can count on about 80 per cent. of them becoming interested in the protection of the fauna, with the object of passing it on to future generations. While the authorities at the Museum teach zoology in general, they do not encourage children to collect mammals, birds, nests, or eggs for private collections or collectors, but they are taught how to observe and make extensive notes on Natural History subjects.

It is unfortunate that so many people advocate the making of private collections of birds or eggs for school children; the egg-collecting habit among school-boys undoubtedly has disastrous results as far as local birds are concerned. It is not the individual that does the harm, except when all desire to be the individual, but it is when a number of boys compete with each other to see who can gather the largest collection of eggs for the season that great damage is done. When I have made these remarks to private collectors, they have rather scoffed at the idea, but my estimate as to damage done is based on the numbers of boys who call at the Museum month after month, each with a large collection of eggs to be named. In the majority of cases the boy has no idea as to the identity of the bird which laid the egg, no information or data of any kind has been kept, the eggs were collected mainly to compete with some other boy. Eventually such collections find their way to the rubbish heap, and thousands of our birds are thus destroyed.

Much has been written and argued in scientific circles regarding private collecting, many private collectors having been roundly condemned. I must add, however, that there are collectors who are ornithologists of note, and they do not collect for monetary considerations, or to become dealers in any way. Most of their specimens eventually find their way to our museums and other public institutions.

One thing is certain, however, the law, as laid down in the Birds and Animals' Protection Act, has failed to check the depredations of the selfish collector, the professional, the dealer. The people with whom the collector deals are the ones we should control, for they are the real culprits. The former is making money, and in these days can hardly be condemned for that, but the latter is often hoarding to his own gratification.

Our Birds and Animals' Protection Act certainly gives a degree of protection to our fauna, but the best protection comes not from the enforcement of the law, but from the willing observance of it by the people. How can we produce the desired result? By teaching the children who are to be the parents of future generations, not only to love the fauna because it is Australian and unique, but to protect it because of its economic value to the nation.

The Game Laws and Protection Acts of the various States of the Commonwealth leave many loopholes of escape for the trapper; an open season here, a closed one there, total protection here and partial protection there, make the guarding of the fauna a very difficult matter within the States.

I think that all migratory birds should be controlled by the Federal authorities, as in the U.S.A., and that the various State Acts should be brought more into line. I advocated and moved this two years ago at the annual Congress of the R.A.O.U., and an inter-State committee is now working towards that end. We want more sanctuaries, and better protection within the sanctuaries; furthermore a great deal of good might be done by re-stocking our sanctuaries with species which have been driven out, and by others which we hope to preserve.

While the advance of settlement is certainly driving many species away, and perhaps even contributing in no mean degree to the extermination of others, there is very little to stop the farmer from encouraging round his homestead such species as may be beneficial.

Not till we have taught the people something of the value of the fauna, can we hope for any appreciable change of attitude towards it, and not till we teach economic Natural History in our schools can we hope to preserve our fauna as it should be preserved and use it as it should be used.

And we cannot teach until we are sure of our facts. These facts cannot be satisfactorily demonstrated until the fauna has been studied from all points, and not until we have established something in the form of a Bureau of Economic Zoology, or at least a Chair of Economic Zoology at our University, can we hope for success and advancement.

A SECOND MONOGRAPH OF THE GENUS *TISIPHONE*, HUBNER.

By G. A. WATERHOUSE, D.Sc., B.E., F.E.S.

Plates xxv., xxvi.

Introduction.

About fifteen years ago, I recognised that the butterfly, known as *Tisiphone abeona* Donovan, was one that was specially worthy of study. I then began an investigation on this species and its geographical races, which has continued almost without interruption ever since. This investigation has already borne important results and it is even now far from completed, but sufficient has been achieved to show that with this species the research undertaken has not been in vain and more important problems are clearly indicated. I have already published several papers dealing with this genus (23-29).

The species and its races are always eagerly sought for by collectors in other parts of the world, and they are always spoken of as some of the most handsome Satyrids of the world.

Historical.

The first mention of this species occurs in the first work devoted to Australian Insects (7), when Donovan in 1805 described and figured the upper and underside of a female of "*Papilio abeona*." He says: "There are few insects more striking than *Papilio abeona*. This appears to be one of the more common species of the Butterfly tribe in many parts of the Australasian regions; we receive it in this country not very infrequently among other insects from vicinity of the English Settlements at Port Jackson."

"It excites some surprise with us that, although a painting of this fine insect existed among the drawings of our worthy friend, William Jones, Esq., of Chelsea, at the time Fabricius was in this country, he should either by accident or design have omitted mentioning it, since he had unreserved access to these drawings and was indebted solely to them for his descriptions of nearly all the new species of the *Papilio* genus included in his 'Species Insectorum' (1781) and 'Entomologia Systematica' (1792-4)."

Even at the present time *abeona* can be found within a few miles of the centre of Sydney, and in the early days of the settlement here, must have been very common, where the busiest part of Sydney now stands. No doubt if Captain Cook had landed on the northern rather than the southern shore of Botany Bay, this species would have been caught by Sir Joseph Banks in 1770.

Hübner (10) under the name *Oreas marmorea zelinde* figured the upper and underside of a male, which is undoubtedly *abeona* and the race found at Sydney, though no locality was given. The generic name *Tisiphone* was first used by Hübner (11) in his catalogue, with *zelinde* (= *abeona*) as the first species. Scudder (20, p. 285) has shown that *abeona* must be taken as the type of *Tisiphone*, since Hübner's later use of *Tisiphone* for *hercyna* (a species from Mexico

to Brazil) in the second volume of his Exotic Butterflies, was much later than his Catalogue. (Scudder, 20, p. 96 and p. 285).

Godart (9) described both sexes and Boisduval (2) gave a short description under the name *Satyrus abeona* from New Holland.

From 1850 until the end of the century, various different genera were used. Westwood (30) placed *abeona* in *Lasiommata* section *Xenica*, the first-mentioned species being *acantha* Donovan, which by subsequent action became the type of *Xenica* (Scudder, 20, p. 289). Butler when describing (3) and figuring (4) his new species *joanna* used the genus *Enodia*, but almost immediately transferred (5, 6) *abeona* and *joanna* to *Xenica*, incorrectly designating *abeona* as the type. Semper (21) later also places *abeona* under *Xenica*.

Kirby (12) was the first to place the species in *Epinephile* and in this he was followed by Miskin (15, 16), Mathew (14), Staundinger (22), Olliff (17, 18), and Anderson and Spry (1). Miskin used this genus when describing the dark northern race *rawnsleyi* (15).

When I first began to collect butterflies, in 1893, *Epinephile* was in general use in Australia for these species, but when I published my Catalogue (23), 1903, I decided that Scudder's opinion (20) should be followed. I was unaware that Kirby (13) about the same time was taking similar action, as he proposed a new name *Manataria* for the American species included in *Tisiphone* and insisted that this name should be kept for *abeona* and its allies. This action has been followed ever since, except in the case of Seitz Macrolepidoptera, where in the American section Weymer still uses *Tisiphone* for *hercyna*. Fruhstorfer (8), however, in the Indo-Australian section points out that this usage is incorrect and insists that *Tisiphone* should be reserved for *abeona* and its allies.

The only other genus in which *abeona* has been placed is *Heteronympha* (type *merope*) in a paper by Wallengren which I have not been able to consult.

That *zelinde* is the same species as *abeona* is given by all the authors quoted who mention *zelinde*.

In 1903, in my Catalogue (23), I considered *abeona* and *joanna* as distinct species with *rawnsleyi* as a variety (what I considered *joanna* at that time was the race I subsequently described as *morrissi* (25)). This probably misled Fruhstorfer in his treatment of the genus in Seitz Macrolepidoptera (8) in which he gives *rawnsleyi* as a colour aberration and *joanna* as a race of *abeona*. In 1904 I separated the Victorian race, *albifascia* (24), in 1914 I described the white banded race *morrissi* (25), and in 1915 I separated another orange banded race *aurelia* (26), and in this paper I describe still another white banded race *regalis*.

The Systematic Position of the Species.

On account of the rudimentary nature of the front legs in both sexes, the swollen bases to three of the four principal veins in the fore-wing (Text-figure 1) and the closed cells in both wings in the imago, the almost smooth larva, the smooth pupa suspended by the tail, *Tisiphone abeona* is a typical Satyrid. It and *T. helena* the other species of the genus have no great affinity to the other Australian Satyrids, but rather stand alone.

Tisiphone helena from North Queensland bears a strong superficial resemblance to some species of the Amathusid genus *Morphopsis* from New Guinea. These species are about twice its size and when analysed marking by marking show a very close approximation to *T. helena*, but they lack the subternal ocellus and the swollen veins of the forewing. I have little doubt that when the mountain fauna of that large island north of Australia is thoroughly investigated, a Satyrid allied to *Tisiphone* will be discovered.

Life History and Habits.

I have had all the stages of the seven races of *abeona* at one time and another, and cannot find any material differences in the early stages in any of them, so I treat them all together. Mr. F. P. Dodd tells me that he has bred *T. helena* at Kuranda, North Queensland, and from his remarks the larvae and pupae differ but slightly, if at all, from the corresponding stages of *T. abeona*.

a. *The Foodplant.*

All the races feed on species of *Gahnia*, a sedge-like plant commonly known as sword grass or cutty grass on account of the serrated edge to the leaves, and the hands invariably are cut when searching the plant for larvae or pupae. The plant on germinating from the seed sends up a single main shoot and later on from the base of this shoot many lateral shoots arise, and the plant increases in size to a large clump, often several feet round. It is found usually growing in moist situations, as in and around the coastal swamps where it sometimes almost completely covers an area of several acres. When the country is hilly it usually occurs in or close to the creek beds. This is usually its method of occurrence on mountains, though both in the Blue Mountains and the range west of Mackay I have found it growing quite away from water. It prefers sandy soil and grows to perfection in this soil when well drained, but if it gets a foothold in unfavourable situations it does not die out, for I have even found it growing on the Wianamatta Shale. In the early spring it sends up from the centre of the older shoots a long flowering spike and many young lateral shoots from the base. After many attempts at various times of the year, I have found that the spring is the best time to remove it into the experimental cages and ensure it growing.

Gahnia belongs to the *Cyperaceae*, a natural order of monocotyledonous plants. It is also the foodplant of many species of *Hesperiidae*. All the known larvae of Australian *Satyridae* feed on monocotyledonous plants and also all known larvae of the true Australian *Hesperiidae*, the exceptions in the latter family being the *Ismeniinae* and *Hesperiinae*.

Gahnia psittacorum Labill. is the species that has the widest range, extending from Queensland through New South Wales and Victoria to Tasmania, and it is upon this species that the larvae of *Tisiphone* are most often found. It occupies large areas along the coast of eastern Australia, preferring the swamps, but also extends to an elevation of 4,000 ft. *G. aspera* Spreng., which does not favour such moist situations and is found usually at an altitude, is another species eaten by the larvae, and I have found them on a few occasions on *G. microstachya* Benth., a species occurring only above 2,000 ft. Probably all the species of *Gahnia* found within the range of *Tisiphone* are eaten by the larvae, but some of the species are rare. The correct determination of the species of *Gahnia* is admitted by botanists to be difficult.

Cladium jamaicense Crantz (*C. mariscus* R. Brown) has been recorded by Mathew (14) as the foodplant. This is not a common plant and, though *Tisiphone* probably does feed upon it, *Cladium* is not likely to occur in the locality given by Mathew.

I have never been able to get the larvae of *Tisiphone* to feed on any plant other than *Gahnia*, though the other Australian *Satyrids* will eat any soft grass and I have even found them feeding on *Gahnia*.

b. *The Egg.* (Plate xxv.).

The egg is nearly spherical, slightly flattened at the point of attachment, smooth to the eye, but when examined under a lens, is seen to be slightly roughened: it is without any fine vertical ribs as is usual in the eggs of many Satyrids. In colour it is yellow green, emerald green and rarely with a bluish tint. In size it is very large, exceeding in size the egg of *Papilio aegaeus*, a butterfly over twice its wing expanse. The diameter of the egg is about twice that of the egg of *Heteronympha merope*, a species but little its inferior in size. The eggs are usually laid singly on the very young leaves of the foodplant that rise vertically from near the centre of a shoot; at times I have seen them laid either on the upper or under surface of the older leaves that had drooped over. On one occasion I saw an egg laid by a wild female on a dead twig near the foodplant. In the experimental cages they are sometimes laid on the sides of the cage, and once I found an egg attached to the leg of the parent.

When about to lay an egg the female alights on a leaf to which she clings with her four feet, she then places the end of her abdomen round the edge of the leaf so that it is touching the opposite side of the leaf to that on which she is resting. She then moves her abdomen slightly to seek a favourable spot to deposit the egg, and then places the end of the abdomen firmly against the leaf. The egg is then slightly obtruded, a short pause then occurs to allow the egg to adhere to the leaf and the abdomen is then slowly drawn away. In some cases another egg is laid near the first, but this is not always so, though usually two eggs are laid with a short interval between, the female then flying away and waiting some considerable time before laying further eggs. The number of eggs laid by one female has varied from 16 to 58, though more than 40 is very unusual. In four cases only were all the eggs contained in the abdomen deposited. In my experimental work it has been my custom to dissect the remaining eggs from the abdomen whenever I consider it necessary to kill the female. From 39 records kept the average number of eggs laid was 25; and from 26 completed records the average number of eggs was 24 laid and 9 dissected. These varied between 58 eggs laid with 2 dissected, and 24 laid with 25 dissected. In only very few cases was more than one of the dissected eggs fertile.

The length of time before the young larvae emerge from the eggs is dependent upon the time of the year and on the state of the weather. Those laid in the early spring are a few days longer in the egg than those laid in the late summer and early autumn. My records show that eggs laid in October emerged in 13 or 16 days, in November 11 or 12 days, in December 9 or 10 days, in February 12 or 14 days, and in March in 10 to 13 days. Two days before the young larva emerges, the egg becomes paler in colour and the black head of the larva is clearly seen through the egg shell. The young larva makes a break in the egg shell and gradually eats its way out and in most cases completely devours the empty egg shell.

c. *The Larva.* (Plate xxv.).

Mathew (14). Rainbow (19).

The young larva on emergence, no matter on what position of the foodplant the egg is laid, crawls to the young leaves at the centre of a shoot, and remains there for one or two days before feeding. In the first instar it usually feeds very early in the morning and remains hidden towards the base of a leaf during the rest of the day and night. When feeding it usually eats a subtriangular piece out of the young leaf. From the second instar onward the larvae usually feed in the early evening and hide head downwards in the shoots during the day,

though on a cold morning in May, 1923, I observed three young larvae feeding before 7 a.m. They cut a similar but larger subtriangular piece from the leaf when eating, rarely crawling towards the end of a leaf and eating right across. The larva in its first instar has a very large head for its size, being about twice the width of the widest part of the body, shining black with a very few long hairs; under a powerful lens it is seen to be minutely punctured; body pale green with paler longitudinal lines and about six long brown hairs to each segment; tail bifid, each division ending in a long whitish bristle. This instar lasts about 10 to 12 days.

The larvae in their remaining instars have an elongate rough pale green head with very short white hairs, longer towards the mouth which is black surmounted by white, eyes minute, black. The thorax and abdomen are usually pale yellow green, sometimes emerald green with several indistinct paler longitudinal lines, covered with minute white dots and very short white hairs.

The three thoracic segments are narrower than those of the abdomen, each segment has a number of transverse furrows, which are conspicuous when the larva is resting, but almost disappear when it is crawling. Tail bifid, with somewhat longer hairs and often tipped with pinkish. Spiracles minute, black. Ventral surface paler than dorsal. Legs pale cream. I have often found larvae of all the races with a broad reddish brown median dorsal band. Shortly before pupation the larva turns a pale bluish green. The duration of the larval period even for eggs that hatch at the same time is very variable and for eggs laid in the spring is from 3 to 5 months. For eggs laid in the autumn the larval duration is from 5 to 8 months. The figures show a full grown larva and one beginning to pupate (slightly enlarged).

d. *The Pupa.* (Plate xxv.).

Rainbow (19).

The pupa is bright yellow green or emerald green, and only rarely pale bluish green with the termina of wing cases outlined in bright yellow. It is short, stout, smooth with a slight projection on either side of the head. If the clumps of sword grass are thick it pupates, suspended by the tail from the underside of the larger drooping leaves, usually close to the ground, at other times it wanders away from the foodplant to pupate on neighbouring plants and in my cages it sometimes pupates on the sides of the cages. The pupal duration is dependent upon the time of the year that pupation takes place, as the following times show: August 41-45 days, September 29-39 days, October 24 days, November 19-26 days, December 18 days, January 18 days, February 17 days, April 28-34 days. The figures show a lateral and a dorsal view of the pupa (slightly enlarged).

When the pupa begins to show any colouration, the first parts noticed to darken are the ocelli of the forewing, then any of the paler markings and finally the ground colour. The following details apply to a pupa recently observed. On the evening of the 8th December, the ocelli could first be seen through the wing case; at 8 a.m. next morning the ocelli were very distinct and the pale markings could be seen and a median dark dorsal line appeared on the abdomen; by noon the whole of the wing had darkened, the ocelli being much darker; by 5 p.m. the thorax had darkened but not the whole of the abdomen; by 10 p.m. the whole abdomen was dark and drawn away from the pupal skin and the weight of the butterfly had caused an extension of the pupal skin between the fourth and fifth abdominal segments; at 6.30 a.m. the following morning a female emerged.

I had thought that the scales of the ocelli would show some marked differences from those of the other parts of the wing, but a microscopical examination has shown that this is not so. The scale illustrated (Text-fig. 2, No. 5) is from

a forewing ocellus, and the length and three anterior points are characteristic, both of the ground colour scales, and the orange scales. I found some few scales of the ocelli with four anterior points and a very few of the orange scales with only two anterior points. One butterfly watched emerge from a pupa gave the following details:—From the time of splitting of the pupa until the butterfly had completely crawled out, 40 seconds, and until the wings were fully expanded but still limp, 6 minutes; the hindwings expanded their full size before the forewings and the proboscis on emergence was pale grey, becoming dark brown later on.

e. *The Imago.*

They all have a weak irregular flight and confine themselves chiefly to the shade. The females are never found far from their foodplant, but the males like those of so many other butterflies are sometimes found playing round the hilltops. The females always emerge from their pupae early in the morning, usually about an hour before the males, and in a very few cases I have had males emerge in the afternoon. When the foodplant is growing in profusion, the males may be seen about 10 a.m. fluttering round clump after clump in search of the females, which are not so often seen on the wing. During sunshine the males are almost continuously on the wing, but when the sky becomes overcast they settle on their foodplant or some neighbouring shrub. During showery weather I have often collected large numbers by picking them from their resting places with forceps. If cliff faces or overhanging ledges are near the foodplant, they very often spend the night in these positions.

They first appear on the wing from Sydney north in the month of August and continue until May, but predominate during September and October, and again in March and April. In more southern latitudes they are not on the wing until late in September, and in the higher parts of the Main Divide not until late in October. I have not been able to determine the length of time the butterflies themselves live in nature, but it is probably as long as a month. A male lived for 4 days without feeding and a female for 7 days in the open without feeding, whilst with artificial feeding I have kept specimens as long as 15 days.

Pairing usually takes place during the morning, and in all the cases I have observed has never lasted longer than 23 minutes. This short length of time no doubt accounts for the fact that this species is seen so rarely in copulation in the bush. One male has been known to pair with more than one female, and on at least two occasions the female has been paired with the male twice. I am strongly of opinion that in nature after about half of the eggs are laid a further copulation is necessary before the remaining eggs are laid. I have never observed that any eggs are laid before the female has paired.

The records of the time from the laying of the eggs until the butterfly emerges shows that eggs laid in October produce butterflies in $3\frac{1}{2}$ to $6\frac{1}{2}$ months, in November in $3\frac{1}{2}$ to 6 months, in December in 3 to 4 months, in March in $7\frac{1}{2}$ to 8 months, and in April 7 to 10 months. Taking separate families, I found that eggs laid by the same female from 31st October to 7th November produced butterflies from 25th February to the 13th May, and eggs laid by another female on 18th and 19th April produced butterflies from 13th November until 13th February. In every family with very few exceptions the males were the first to emerge, then males and females, and towards the end of the period only females. In some cases the percentage of butterflies reared from eggs was very high, reaching up to 80 per cent. The percentages from eggs laid in the spring was always much greater than for eggs laid in the autumn owing to the larvae being subjected to more rigorous conditions during the winter.

The antennae are less than half the length of the costa of the forewing, with clubs long, gradual and very slender. Eyes smooth.

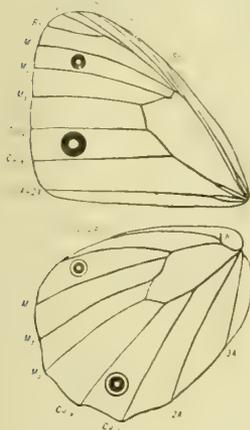


Fig. 1.

The forewing venation shows the basal portion of the Subcostal (Sc), Cubitus (Cu) and Anal (1A. + 2A.) veins swollen: R₂ arising close to the end of the cell; M₁ longer than M₂. In the hindwing the media has three and the cubitus two branches, and the humeral veinlet (h) is short and not well developed.

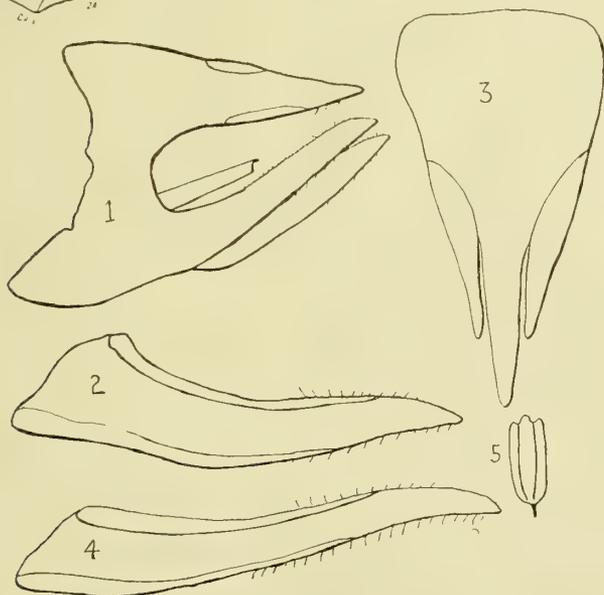


Fig. 2.

The male genitalia do not depart in any marked degree from the ordinary Satyrid type. Text-figure 2 gives a much enlarged profile view of the genitalia of *abeona* (1); a view from below of the uncus still further enlarged (3); whilst much enlarged views from the inside of a valve of *abeona* (2) and *morrissi* (4) are given. An examination of several specimens of both these races shows that there is no appreciable differences in their genitalia.

In the coastal districts of New South Wales the butterflies are extremely common in the spring and again in the autumn, as many as a dozen or more being seen at one time. In some districts many thousands of plants of *Gahnia* are to be found growing in the one swamp. In the mountains they are not so plentiful, but when the foodplant is located near a stream they can readily be found.

TISIPHONE ABEONA ALBIFASCIA Waterhouse.

Proc. Linn. Soc. N.S. Wales, 1904, p. 468. Waterhouse (25), Plate I., figs. 23, 27, 28. Waterhouse and Lyell (29), fig. 816. *Epinephile abeona* Anderson and Spry (1), figured.

This is the Victorian race which extends into the southern coastal districts of New South Wales. Above in the forewing, the postcellular pale bar is much broader than in *abeona* and is cream in the female; the broad central area is slightly paler than in *abeona* and sometimes in the male and usually in the female is cream where it crosses the cell; the ocelli are usually larger than those of *abeona*, and the white pupils are larger than in *abeona* and the blue scales surrounding them more extensive. In the hindwing the ring to the subterminal ocellus is always more conspicuous than that of *abeona*, and there are sometimes, especially in the females, indications of an inner subterminal pale band.

Beneath the white markings are always much more conspicuous than those of *abeona*, especially the discal and two subterminal white bands of the hindwing. Fig. 816 *albifascia* and Fig. 815 *abeona* in the Butterflies of Australia (29) show the distinctions of the undersides very well.

Holotype male Wandin December 10, 1899; Allotype female and Paratype male and female Wandin without date are in my collection.

In addition to the dates already given (29), I have it from Wandin (which includes Fern Tree Gully), in September, and Mr. J. A. Kershaw records its occurrence at Wilson's Promontory from early November to February.

Mr. C. H. Borch gives me the following Victorian localities:—Wilson's Promontory right to the southernmost point in December; Upper Beaconsfield in May and December; Bayswater in January; Belgrave in November and December.

The change to the typical race *abeona* appears to begin about Narooma, six specimens I collected there showing a slight diminution of the size of the white bands on the hindwing beneath. Specimens from Kiola about 60 miles further north are almost typical *abeona*.

I have had numerous larvae sent me in the spring from Macedon and Fern Tree Gully, and the butterflies emerged in Sydney from September 30 to December 31. The pupal duration of those emerging early in December was 19 and 20 days. Larvae from Eden produced butterflies in Sydney from December 15 to February 6. Larvae I found at Narooma in October gave me the following results: Larva pupated November 2, male emerged November 28, larva pupated November 5, female emerged November 29, the butterfly was also caught at this place in October.

This species varies somewhat in size, some females being very large, the markings beneath also vary in size, but are always much more conspicuous than those of *abeona*. One interesting male I have from Fern Tree Gully (emerged Sydney, October 10) has on the hindwing above, an obscure reddish brown discal band, a female also from the same place (emerged February 23) has a similar band, but broader and paler, whilst another male caught at Fern Tree Gully (November 21) is like the first male. The presence of this band on the hindwing above shows that the influence of the northern race *morrisi* is not wholly lost in Victoria.

TISIPHONE ABEONA ABEONA Donovan.

Donovan (7), pl. xxii, fig. 1; Godart (9); Boisduval (2); Standinger (22), pl. 81; Rainbow (19); Fruhstorfer (8); Waterhouse (25), pl. i, figs. 21, 22; Waterhouse (28), pl. ii, fig. 1; Waterhouse and Lyell (29), figs. 75, 76, 815.

Donovan's figure (7) represents the upper and underside of a female, it is somewhat more highly coloured than specimens found near Sydney at the present day. An examination of all Donovan's figures shows that they are all more or less inaccurate and usually too bright. As the specimen is said to come from Port Jackson and considering the early date (1805) it could not have come from anywhere else, and also as the figures agree much better with Sydney specimens than they do from anywhere else, Sydney must be taken as the type locality.

Hübner (10), unaware of Donovan's figure, gave coloured figures of the upper and underside of a male under the name *zelinde*. These figures are good, much better than those in the reissue (13) and undoubtedly represent the Sydney race. Godart (9) describes both male and female, but makes no mention of *zelinde*, but all subsequent authors mention *zelinde* as a synonym of *abeona*. The figures given by Standinger (22) and Fruhstorfer (8) are both males and undoubtedly this race.

This race is distinguished from *albifascia* by the dull red surround to the subterminal ocellus of the hindwing above (in this it also differs from *aurelia*), and by having the white bands beneath very much narrower, often reduced to a white line. Only rarely do the orange bands of the forewing above show any cream towards the costa and beneath these same bands show much less cream.

This race occurs along the coast from Kiola to the southern bank of the Hunter River wherever the foodplant is growing, and is practically continuous over this area, being absent only where advancing civilisation has destroyed its foodplant. It also occurs in any of the gullies between the coast and the Blue Mountains, but is absent from the plains between Parramatta and Penrith. It occurs in suitable places in the Blue Mountains up to 4,000 feet. Dr. E. C. Chisholm records it from Marrangaroo, I have taken it further north near Iford and Dr. N. W. Hansard tells me it occurs near Rylstone. At Sydney, within a mile of the sea, it is found from August to April, but on the mountains, it appears later and ends earlier.

Three very interesting aberrations of this race are in my collection. A female from Woodford, 2,000 feet, in October, which has the subterminal ocellus of the forewing over twice the usual size; a male from Stanwell Park, 1,000 feet, in October, which has no orange postcellular bar on the forewing above and beneath. On the hindwing beneath there is no discal band, the outer subterminal band is absent, but the inner one is present, broader and obscure; the third specimen is a male, Wentworth Falls, 2,800 feet, in January, caught by Mr. G. M. Goldfinch, in this specimen there is a complete absence of orange above, the bands being white, and the surround to the subterminal ocellus is brown and not dull red. On the underside the postcellular bar of forewing is white, the broad band is white in the cell and yellow below the cell, on the hindwing the surround to the ocelli is brown. When Mr. Goldfinch saw this specimen first he mistook it for the female of *Het. mirifica*, until he noticed the difference in flight.

TISIPHONE ABEONA AURELIA Waterhouse (26).

Australian Zoologist, p. 50, 1915; Waterhouse (25), fig. 26 (as *joanna*).

This is another of the orange banded races and can be distinguished from the typical race by its brighter orange markings and the more prominent markings beneath. Its chief difference from *abeona* is that, whilst it has the general appearance of the southern races, it has orange rings to the ocelli of the hindwing.

The type series of this race were caught by me at Nelson's Bay, Port Stephens. I have had about 30 specimens from this locality and they do not show any marked variations, except that in some females there is a trace of the pale discal band on the hindwing above. My two Tuncurry specimens are similar. From Coopernook, Manning River, I have had about 50 specimens, most of which agree with those from Port Stephens, the discal band on the hindwing above is more often present and is orange. In some few males the broad orange band of the forewing is reduced where it crosses the cell. In some females the postcellular bar of the forewing above is cream and not orange. Two interesting specimens have the broad orange band of the forewing above almost divided by a vertical irregular brown band. None of the specimens is cream above.

From near Camden Haven and a few miles further south, I have examined over 100 specimens, which show the same variations as those from Coopernook, some males have the orange band of the forewing above reduced in the cell to an ill-defined patch not connected with the well-defined portion below the cell. The females show an orange discal band on the hindwing above in many cases. From this locality I have a male and two females which have cream bands on the wings above and are very close to figure 795 of *joanna*, Waterhouse and Lyell (29).

Coopernook is about 70 miles distant in a direct line from Nelson's Bay, Port Stephens, whilst the locality near Camden Haven is about 15 miles further north. Port Macquarie is a further 20 miles north.

The above localities to which I restrict the race *aurelia* show at Nelson's Bay typical *aurelia*, at Coopernook the influence of the northern race begins, that is after crossing the Manning River and it is more evident near Camden Haven.

Described from a series of specimens in my collection caught in October, 1914, at Nelson's Bay, Port Stephens, or reared from larvae taken at the same time. Holotype male emerged in Sydney, November 27; Allotype female emerged November 27; Paratype males (9), October 25 to December 7; Paratype females (5), October 25 to November 14. The pupal duration is about 15 days at this time of the year.

Localities: Port Stephens, March, October to December; Tuncurry, April, May; Coopernook, April, October, November; Camden Haven, April, October. Very probably occurs at all these localities from August to May.

TISIPHONE ABEONA JOANNA Butler.

Enodia joanna Butler (3); Butler (4), pl. iv., fig. 8; Waterhouse (25), pl. i., figs. 1-14, 16-18, 29, 30; Waterhouse (28), pl. ii., figs. 2, 4-15; Waterhouse and Lyell (29), figs. 102, 794-814, 816; not *T. joanna* Waterhouse (23).

I have now seen over 400 specimens caught chiefly by myself within eight miles of the post office at Port Macquarie. Amongst this large number of specimens there is no particular form that predominates. We find specimens on the one hand that if they had been caught 50 miles further south would be considered typical *aurelia*, others if caught 50 miles further north would be considered typical *morrisi*. Between these two extremes every intergrade is found, specimens with the colour of *morrisi* and the shape of markings of *aurelia* and vice versa. In some few cases the markings are reduced and approach *rawnsleyi* very closely. I have given many illustrations (some in colours) of these variations as shown in the references above and also in the Butterflies of Australia (29); fig. 102 is taken from an illustration of the type in the British Museum.

I have already suggested that the type reached England early last century, very probably through the instrumentality of Alexander Macleay. Until I had

received the coloured drawing of the type in the British Museum I had considered the race *morrissi* to be *joanna*.

I have specimens of this race from Port Macquarie, from September to May (except December), no doubt it is also caught there in August and December. Dr. E. C. Chisholm has sent me two males from the Comboyne, March and April which belong here.

TISIPHONE ABEONA MORRISI Waterhouse.

Plate xxvi., figs. III., III. A., IV., IV. A.

Waterhouse (25), pl. i., figs. 19, 24, 25; Waterhouse (28), pl. ii., fig. 3; Waterhouse and Lyell (29), figs. 77, 78, 817.

This is the coastal race, extending from the Macleay River to Southport, in Queensland, and I also include here my specimens from Crescent Head, about 20 miles north of Port Macquarie, in September, as nearly all of the 20 specimens agree with *morrissi*; the most notable example is a female, which has a yellow tinge in the broad band on the forewing above; this band also extends somewhat into the cell; two other specimens show a trace of this extension into the cell. These specimens occupy, at the end of the southern range of *morrissi*, a similar place that the specimens from near Camden Haven occupy at the end of the northern range of *aurelia*.

The figures on the plate accompanying this paper show this race very well, and also show how different it is to the race *abeona*. The fact that I have been able to pair *abeona* and *morrissi* is sufficient to show that they are geographical races, even without the further evidence of the intermediate hybrid race *joanna*.

The type series were all caught at Ballina, Richmond River, chiefly in September and October, 1902. They consist of the following in my collection: Holotype male, September 29, 1902 (fig. 24 in 25); Allotype female, February 5, 1898 (fig. 19 in 25); eight Paratype males, January 1, 1898, and the others October, 1902 (one of which is fig. 77 in 29), and seven Paratype females, all October, 1902 (one of which is fig. 817 in 29).

Localities: Richmond River (type locality), September to April; Southport, Queensland, December; Tweed Heads; Clarence Heads to the Macleay River, September, October (numerous specimens collected over the whole coastal area); in addition Urunga, Bellinger Heads, November to March.

In my catalogue (23) I used the name *joanna* for the specimens of this race I had taken prior to that date and distributed many of these specimens under that name.

On the road from Coff's Harbour to Dorrigo I have a fine series of specimens. Those at Coff's Harbour are ordinary *morrissi*, and so are those from Ulong (November), about 20 miles away, and at an elevation of about 1,500 feet. From Dorrigo, I have two series of specimens,—one lot caught by Dr. R. J. Tillyard, in December, 1911, and the other by Mr. W. Heron, in November, 1914. These specimens are from an elevation of over 3,000 feet, and are larger and finer, with more white markings than coastal specimens. I regard these as the next race *regalis*, but not quite typical. Mr. Heron's specimens are labelled E. Dorrigo, within 15 miles of Dorrigo, and Dr. Tillyard's Dorrigo, which is about 20 miles from Ulong.

The upperside male on Plate xxvi. is from Urunga and the underside male from Macksville, both figures slightly larger than natural size. The figures of the females are from paratypes taken at Ballina, in October, 1902.

TISIPHONE ABEONA REGALIS *subsp. nov.*

Plate xxvi., Figs. I., I. A., II., II. A.

Male. Above. Forewing dull black: a postcellular bar and a large subternal patch, white: a small subapical ocellus and a large subternal ocellus, deep black, the former faintly ringed white and both white-centred and sprinkled with blue scales: cilia blackish. Hindwing dull black: a broad irregular discal band, white: a small subapical deep black ocellus, centred white and surrounded with a yellow-brown ring, a similar larger subternal ocellus, centred white, sprinkled with blue scales and surrounded orange-red: usually a small white spot below the subapical ocellus and another above the subternal ocellus. Cilia white, at veins black.

Beneath. Forewing dark brown: markings as above, but more extended, subternal patch extended as a broad white bar across cell and as well nearly joining the subapical bar: ocelli distinctly ringed cream: two subterminal white lines, inner more distinct: usually two white spots between the ocelli: cilia black and white. Hindwing dark brown: markings as above, two subterminal white lines, inner more distinct: both ocelli ringed orange-red. Cilia white, at veins black.

Female. Above as in male: white markings much broader and a faint white spot near end of cell in forewing and traces of an inner white subterminal line on both wings and an outer white subterminal line on hindwing: subapical ocellus of hindwing ringed dull orange-red.

Beneath as in male; white markings broader and more distinct and an additional irregular white surround to the four ocelli.

There is not much variation in the males, which are not in the best condition. In the females the chief variation is in the size of the cell patch in the forewing above; in one specimen this is as distinct as it is beneath.

It differs from the race *morrisi* by the slightly darker colour above, the much broader white markings above and beneath, especially the very extensive subternal patch and the cell bar of forewing beneath.

Holotype male (fig. I.), February, 1925; Paratype male (fig. I.A.), January 26, 1922; Allotype female (fig. II.A.), January 26, 1922; Paratype female (fig. II.), emerged from pupa in Sydney, October 25, 1922. Also 12 paratype males and 12 paratype females December 16 to February 5, all from Barrington Tops, New South Wales.

I found this race sparingly when I visited Barrington Tops in January, 1922, and again in January and February, 1925. On both occasions eggs and larvae were found, and some of these produced butterflies at Sydney in October. The name is given as the type locality is at the end of the Mount Royal Range. The specimens caught by Dr. R. J. Tillyard at the Dorrigo in December, 1911, and by Mr. W. Heron at East Dorrigo in November, 1914, belong to this race, as does a specimen from near Hanging Rock on the Main Divide. Types in my collection.

This is a large and magnificent race, larger than any of the others. It appears to be confined to an altitude of 3,000 feet and over, and will probably be found in many other places on the Main Divide of this altitude. The type locality is due west of Tuncurry, where an orange race occurs and for at least 40 miles further north the same orange race occurs, so we have over a distance of at least 40 miles, a broad banded orange race (*aurelia*) on the coast and over the same latitude on the Main Divide a narrow white banded race (*regalis*).

TISIPHONE ABEONA RAWNSLEYI Miskin.

Epinephile rawnsleyi Miskin (15); Waterhouse (25), pl. i., figs. 15, 20; Waterhouse and Lyell (29), figs. 82, 83.

This race is smaller than those found in the south and is a very sombre insect. Above it is brown black, with the ocelli of the forewing deep black, rarely in the male, usually in the female, ringed with pale yellowish, those of the hindwing deep black, conspicuously ringed with orange red. On the underside the white markings are much reduced in size.

In many specimens, especially in the female, there are traces of a white discal band on the hindwing above; this more often appears basad of the ocelli and in none of my specimens forms a complete band as in *morrisi*. Two females show a white streak basad of the subternal ocellus on the forewing above.

This race is well described as a small form of *morrisi* that has lost or nearly lost all the white markings above.

The type series is in the Queensland Museum from the Maroochy River, Queensland, later Miskin (16) gives the locality as Mooloolah, where the race is very common. I have it from Caloundra, October; Mooloolah, October to December; Palmwoods, October, March, April; Nambour, October; Eumundi, March.

TISIPHONE HELENA Olliff.

Epinephile helena Olliff (17); Olliff (18), figured; Fruhstorfer (8), pl. 94; Waterhouse and Lyell (29), figs. 84, 85.

The type of this species is from Mount Bellenden-Ker (about 3,000 feet) and is in the Australian Museum, Sydney. Otherwise I only know it from near Kuranda (about 1,000 feet) and Mr. A. N. Burns has taken it near Gordon Vale at about 500 feet. The swamps near Cardwell should be searched to see if it occurs there. The species has an appearance quite unlike that of *T. abeona* and reminds one of the much larger *Morphopsis* from New Guinea.

Mr. C. H. Borch has a record of this species at Highleigh (about 1,300 feet) in the Gray Ranges, south of Cairns, in November.

Its Distribution.

In September and October, 1914, I made a rapid survey of the coast line between Coff's Harbour and Ulladulla, collecting at over twelve distinct localities and extended my collecting to the Blue Mountains at about 2,000 feet. Mr. H. W. Simmonds collected *rawnsleyi* from Mooloolah in October of the same year, and in November collected at Bermagui, Tathra and near Eden. Mr. W. Heron, in October, collected at six different localities between Yamba and Coff's Harbour, and in November sent me specimens from Ulong and East Dorrigo. Mr. S. J. Turner sent me a long series collected in October from Kiola, south of Ulladulla. So in this spring of 1914, the only gap in the collecting approaching 50 miles in the stretch of coast from Yamba, Clarence Heads to Eden, was the gap between Kiola and Bermagui, which I have since partially filled by collecting at Narooma. In November and December of the same year, I also received specimens from Macedon, Fern Tree Gully and Wilson's Promontory, in Victoria. This one set of collections amounted in all to nearly 600 specimens. Before 1914, I had made three collections at the Richmond River, and also at many intermediate localities in the range of the race *abeona*, both on the coast and in the mountains. Since 1914, I have collected several times at Urunga, Port Macquarie, Camden Haven, Cooperbrook, and have received many specimens of *rawnsleyi* from South Queensland and *albifascia* from Victoria. Besides this I

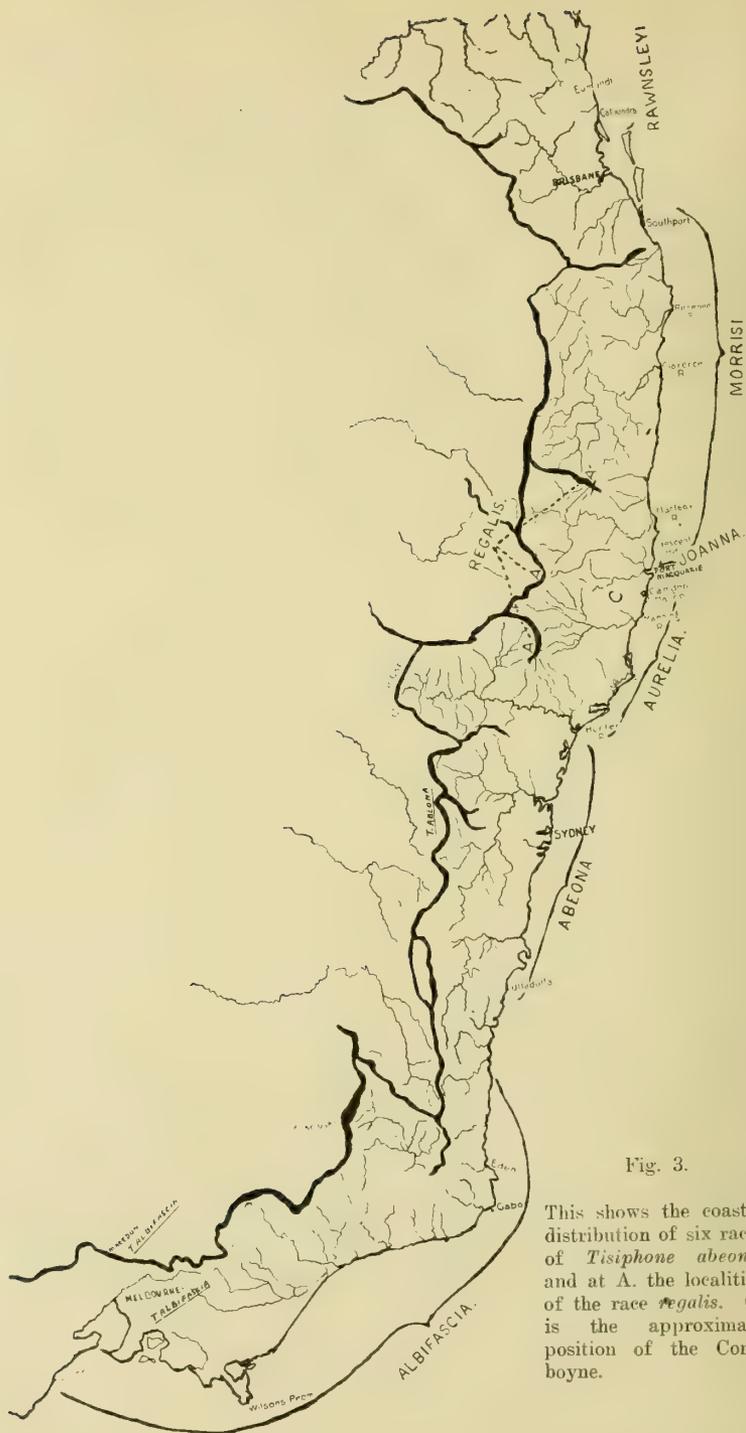


Fig. 3.

This shows the coastal distribution of six races of *Tisiphona abeona*, and at A. the localities of the race *Regalis*. C. is the approximate position of the Comboyne.

have had two trips to the Barrington Tops and collected the new race *regalis* there. In all I must have examined over 2,000 specimens of the various races of *abeona* in my own and other collections.

For *T. helena* I have had to rely on my friends, Messrs. R. E. Turner and F. P. Dodd, as I have been to Kuranda only during June and July, when this species is not on the wing.

Text-figure 3 shows an outline sketch of the coast line of New South Wales, together with portions of South Queensland and South-east Victoria. The sketch is modified from that previously published by me (27). An examination of this map, together with that of the localities, shows that I have an almost continuous range of specimens from Southport to Eden, a gap occurs in the north between Southport and Caloundra, and in the south between Eden and Wilson's Promontory. With regard to the first, I have very little information, but I doubt if the foodplant now exists between Caloundra and the Brisbane River. On the south, the species no doubt occurs in many localities between Eden and Wilson's Promontory.

At an elevation, the collecting has not been so extensive nor continuous. The southern race has been taken at Mount Macedon and in the Dandenongs. It is doubtful if it occurs in the Victorian Alps, where several experienced collectors have collected. At Mount Kosciusko, it must certainly be absent, for this spot has been more intensively collected than any place in eastern Australia, above 3,000 feet. It appears in suitable places in the Blue Mountains and the portions of the Main Divide nearby. I searched for it very carefully on the low portion of the Main Divide, known as the Cassilis Gap and again on the Divide near Murrurundi, but without success. It appears again at Barrington Tops, on a spur from the Main Divide, at Hanging Rock, on the Main Divide, and again, near Dorrigo, on another spur from the Main Divide. Further collecting is necessary to determine how far the various races are distributed along the Main Divide.

The seven races fall naturally into two pairs of three with the intermediate hybrid race at Port Macquarie. The three races from the south have a very broad orange band on the forewing above and no pale band on the hindwing above. These three races differ from one another only in degree. The Victorian race *albifascia* occurs, both at the coast and in the mountains to about 2,500 feet, and on the coast from north of Bermagui passes almost imperceptibly into *abeona* at Kiola, there being no barrier to keep the two races entirely distinct, though the extremes at the type localities are abundantly distinct.

The Sydney race *abeona* is at times very common and is also found both on the coast and in the mountains, the most southerly mountain record being near Bowral and the most northerly near Rylstone. At the present day, there is a definite barrier between *abeona* and the next race *aurelia*. This is the large swampy area of the estuary of the Hunter River and also the extensive settlement surrounding the city of Newcastle. North of the Hunter River, there is also the long stretch of sanddune country behind the Stockton Beach which does not now, if it ever did, have the foodplant growing. There is at the present time no chance of the races *abeona* and *aurelia* ever mixing.

The swampy areas at the Hunter River are of a different type to those in which the foodplant grows so readily at other places on the coast, and they probably never at any time had *Gahnia* growing in them.

The area occupied by the race *aurelia* is not very extensive, from Port Stephens to Camden Haven, and it is only in the southern parts of this range that it is constant; to the north, there is an occasional mingling with the next

race *joanna*. The race *aurelia* does not occur in the mountains to the west, where it is replaced by one of the northern races *regalis*.

The race *joanna* occupies a very limited area around Port Macquarie, where it is very common and very variable. I visited the Comboyne in 1914, but failed to find *Tisiphone*, but Dr. E. C. Chisholm has sent me two males from there. He says it is very local and far from common. A fuller discussion on the race *joanna* appears in a later portion of this paper.

The three northern races also differ from one another in degree and may be described as having narrow white bands on the forewing above, and a white discal band on the hindwing above.

The race *morrisi* occupies a long stretch of coast north of Port Macquarie into southern Queensland. North of the Macleay River, it is very constant, but at Crescent Head, some 20 miles north of Port Macquarie, it shows some influence of the southern races, due to an occasional mingling of a specimen of *joanna*. The water of the creek near Crescent Head flows south to join the Hastings River which enters the sea at Port Macquarie. At Southport the race *morrisi* seems to have disappeared. Mr. R. Illidge caught it there many years ago, and in July, 1919, accompanied me there, but, though I spent many hours searching the foodplant, which was very plentiful, I could find no trace of larvae. Larvae of *rawnsleyi* were obtained by me at Mooloolah, only a few days before our visit to Southport.

The race *regalis* only occurs in the mountains and its range owing to insufficient collecting chiefly, cannot be accurately delimited. The southern range is certainly Barrington Tops, but the northern is doubtful. The race is the finest and most heavily marked of them all.

The race *rawnsleyi* is a small and dark one, with the white markings above almost absent. It is confined to a small area between Brisbane and Gympie. With the exception of Caloundra on the sea coast, all the records are from near stations on the railway line from Landsborough to Eumundi inclusive. Now, as probably in the past, the estuary of the Brisbane River forms the barrier between this race and *morrisi*. I found larvae in quantity at Mooloolah in July, 1919, and since then I have had many specimens from there. This race requires much more investigation. The question should be settled as to whether Caloundra is its southern limit and how far north does the race actually extend.

From this race north to the Cairns district no *Tisiphone* have been found. Extensive collecting has been done near Rockhampton, Mackay and Townsville. In 1923, I visited Eungella in the Ranges, 45 miles west of Mackay and, though *Gahnia* was found, no larvae of *Tisiphone* could be discovered after a very careful search.

In the Cairns district *T. helena* occurs and always at some elevation above sea level.

Although the foodplant is found in Tasmania, especially on Mount Wellington, *Tisiphone* has not been recorded from there. Such a conspicuous species could not possibly have been overlooked.

Position of Tisiphone amongst the other Australian Satyrids.

Of all the groups of butterflies in Australia, the Satyrids exhibit in a marked degree the two distinct elements in the Australian fauna. These consist of a comparatively recent migration from the north, entering Australia by way of a late Pliocene or early Pleistocene connection with New Guinea across the present Torres Straits. These Satyrids are typical of the Torresian Region and have advanced southwards along the east coast of Australia to meet the older Satyrids, which now have their central location in south-eastern Australia. One or two

species have extended westward along the north coast and have reached at least as far as Port Darwin. The migrants from New Guinea all belong to well known genera, and probably entered Australia at two or perhaps three different periods of time. The genus *Hypocysta* was the first to arrive and has extended along the east coast nearly to the Victorian border. This genus has a limited range in the Indo-Australian Region, besides Australia it is only found in New Guinea and some of the neighbouring islands. Of the six Australian species five are endemic, the remaining form has only advanced a short distance down the Cape York Peninsula. The endemic species have a facies considerably different from the New Guinea species. They have been accompanied on their travels by the single species of *Yphthima*. With *Yphthima*, the remaining genera *Melanitis*, *Mycalesis*, and *Orsotrioena* have a very extended range, reaching as far westward as India and Ceylon. It is very noteworthy that the two wideranging species of *Mycalesis* and *Orsotrioena* have not extended so far south as the two purely Papuan species of *Mycalesis*; this is another argument in favour of two separate and distinct migrations from the north into Australia.

All the species of the above genera have two distinct broods in the year; exhibit in many cases strong seasonal dimorphism; with the exception of *Hypocysta adiante* have not developed any marked geographical races in Australia and with the one exception of *Yphthima arctuous*, the heads of the larvae are distinctly horned. These Torresian species found on their arrival the south-eastern portion of Australia (the Bassian Region) in possession of a very distinct endemic group of Satyrids; species belonging to the genera *Heteronympha*, *Argynnina*, *Oreivenica* and *Xenica*, that have only a single brood during the year; that have in most cases developed in one or other of their stages marked specialisation and have amongst the widespread species developed marked geographical races, so marked as to be considered distinct species by some entomologists. The only species that could be questioned as having two broods during the year is *Argynnina cyrila*, normally appearing on the wing in the early spring, and a few specimens of which have been reported to have been taken in the autumn. I have recently proved that the normal pupal duration of this species near Sydney is seven months (February to August) and that the pupal envelope is particularly thick to withstand the winter, but it is quite possible that under special climatic conditions a few specimens might possibly emerge during the autumn. Though I have often searched its haunts during the autumn, I have never been able to see one on the wing myself. These Bassian species have in some cases their early stages specialised. *Heteronympha merope*, *H. philerope*, *H. paradelpha*, *Oreivenica orichora* and *O. latialis* have their larvae without prominent horns to their heads, their pupae are smooth and lie unattached on the ground. The larvae of *H. mirifica*, *H. banksi*, *H. solandri*, *Argynnina hobartia*, and *Xenica acantha* have prominent horns on their heads, and the pupae hang suspended by the tail, as do the pupae of *O. lathoniella*, *O. correae* and *X. klugi*. (I do not know the life-history of *Heteronympha cordace*). All the species of these four genera have one brood in the year. Fruhstorfer's suggestion that *ella* (8, p. 304) and *suffusa* (8, 305) are dry-season forms of *X. kershawi* and *H. merope* is therefore not tenable. The first is a northern race of *O. kershawi* and the second a melanic aberration of *H. merope*. Seasonal dimorphism is found only rarely in Australia, and is quite absent in the south. Geographical variation and sexual dimorphism on the other hand are frequently met with.

As an illustration of the life-history of a Satyrid of south-eastern Australia, I have figured (pl. xxv.) that of *Oreivenica latialis*. This species as far as is known is confined to Mount Kosciusko above 5,000 feet. It was described and figured (29, p. 43, figs. 823, 824) as an alpine subspecies of *O. lathoniella*. Sub-

sequent to the publication of the description in 1914, I found the early stages of both and they differed, so in 1923 (28, p. xviii.), I raised *O. latialis* to specific rank. Though the larvae are very similar in both these species, the pupae are very distinct. The pupa of *O. lathoniella herceus* is attached by the tail and hangs suspended head downwards: its dorsal surface has a number of transverse ridges. The pupae of *O. correae* and *O. kershawi* are somewhat similar. On the other hand the pupa of *O. latialis* is smooth, and it lies unattached on the ground or amongst tufts of snow grass on which the larvae feed. I found at Mount Kosciusko that along Digger's Creek the ranges of *O. latialis* and *O. lathoniella herceus* overlapped for a distance of about two miles in length and about 400 feet in elevation, the former being caught from above the waterfall up to Pretty Point, whilst the latter from the hotel to the junction of Digger's Creek with the Snowy River. In February I only caught one specimen, but it was very common in March of the same year.

Larvae found at Kosciusko in December and brought to Sydney where they pupated emerged at the end of February with a pupal duration of 16 days. Eggs laid at Kosciusko in March and brought to Sydney gave me butterflies the following summer from December 26 to January 21, with a pupal duration of 21 to 22 days. Pupae left lying on a smooth, flat surface produced perfect butterflies.

The genus *Tisiphone* does not fall completely into either of the above groups. Its range is greater than and inclusive of the range of such Bassian species as *Heteronympha mirifica*, *H. banksi*, *H. paradelpha*, *Oreixenica kershawi*, and *O. correae*, though it has not reached as high an altitude as *O. correae*. These, however, belong to a later development in the Bassian fauna, as they also have not reached Tasmania. *Tisiphone* also occurs much further north than any Bassian Satyrid. It shows no seasonal variation, but has developed in a marked degree geographical races. It is single brooded at a high elevation, where the period of warm weather is not sufficiently long to complete two broods in twelve months. Though in many cases on the coast two broods are produced in one year, the duration of the larval stage from the same batch of eggs is so variable, that only a proportion of the eggs laid in the autumn produce in the following spring butterflies that in turn give rise to butterflies the next autumn. The year 1923 showed in a marked degree the effect of weather conditions on this species. Many eggs that were laid in the autumn gave butterflies up to December, whilst some larvae from the same family were only half grown in January, 1924, and did not produce butterflies until the autumn. For the season September, 1923, to March, 1924, the species must then have been both single and double brooded in the same family.

In its relation to the Torresian fauna *Tisiphone* has extended much further south than any of the Torresian Satyrids. I am of opinion that *Tisiphone* belongs to a very early migration from New Guinea, a migration small in number of species (including *Papilio macleayanus*) and that eventually in the mountains of New Guinea a near ally of *Tisiphone* will be found as has already been done in the case of *Papilio macleayanus* and still more recently a form of the wide ranging but discontinuously distributed *Argynnis hyperbius* has been discovered at over 4,000 feet in New Guinea.

Since *Tisiphone* has developed well marked geographical races and has a range extending beyond any Torresian Satyrid, its appearance in Australia must have been earlier than these. Since it has not reached Tasmania, where its food plant is found, its appearance must have been after the Bassian Satyrids that occur there.

The Problem of the Race joanna.

One problem of importance has been clearly indicated in what has been written above and that is the explanation of the great variation shown amongst the numerous specimens of *Tisiphone* caught in the Port Macquarie district. This variation is so great that, if say, a dozen specimens were selected and submitted to many a competent entomologist unacquainted with their history, they would without hesitation all be considered distinct species. The problem then was to account for this variation as from the field observations they could only be a single variable race. I then proposed that *morrissi* and *rawnsleyi* were not distinct species as had been thought, but only geographical races of *abeona* and that *joanna* was a race made up by the crossing of the broad orange banded southern form with the narrow white banded northern form.

The Proof that the Race joanna is a Hybrid Race.

This proof has been established in two different ways, but the apparatus used and method adopted require explanation. It is essential to have the growing foodplant under continual observation. I therefore brought home many plants of sword grass and placed them in wire gauze cages about 3 feet high and 2 to 3 feet wide and deep. These cages were so constructed that larvae could not escape and that parasites, unless extremely minute, could not enter. They were all marked with a letter or number for reference. In order to obtain the maximum efficiency from the cages, which were limited in number owing to their cost, pairings were not made in the cages themselves. A number of sword grass plants were grown in kerosene tins and several special wire cylinders made three feet high and two feet in diameter. One of these cylinders was placed over the foodplant growing in a tin and the top of the cylinder covered with mosquito net. The butterflies readily paired in these cages and, according as few or many eggs had been laid, the tin of sword grass was removed to the numbered cages containing the best amount of growing sword grass to feed the larvae. As soon as it was ascertained that pairing had taken place the male was killed and set and the female kept alive by feeding as long as possible. The method of feeding was to use about four tablespoonfuls of sugar dissolved in an ordinary cup of water. The butterfly was held in a clip made by slitting down a small piece of bamboo which gave sufficient spring to hold the butterfly. In most cases as soon as the butterfly was placed over the sweetened water, it uncoiled its proboscis and extended it to the liquid. If the butterfly did not attempt to feed, the proboscis was uncoiled by using a pin, and always when the butterfly was placed over the sweetened water the second time, it uncoiled its proboscis itself. The cages proved very satisfactory, and the only enemies that could not be entirely eliminated were spiders, which when very young could enter through the wire mesh, but a daily search reduced this pest almost to a negligible quantity. The cages were of a size easy to search, and when the larvae pupated they were removed from the cages and labelled, and so were under more direct observation until the butterflies emerged. Two distinct methods of proof of the hybrid nature of the race *joanna* are described below (a) by rearing to butterflies from females caught at Port Macquarie, (b) by pairing specimens of the races *abeona* and *morrissi*.

a. *By Breeding from Females of the Race joanna.*

On April 17, 1922, I caught two females of this race at Port Macquarie and brought them alive to Sydney. I caged them separately with growing plants of sword grass. Specimen E. laid altogether 14 eggs and was killed on April 19. Specimen D. laid 9 eggs and during my absence escaped and could not be found. Specimen E. produced 12 butterflies, six males and six females. These, with their

mother, have already been described and figured (see Waterhouse (28), pl. ii.). They show that of the twelve specimens nine had orange and three had white markings, and that the markings were not identical. This family showed the sexes in equal numbers, but four males emerged before the first female, followed by two more males and then four females; though the eggs were all laid within two days of one another and hatched within two days of one another, the difference in time of appearance of the first and last specimens was three months, whilst the difference in time between the first and last male was a little over one month: the difference in time between the first and last female was about two months and a half.

The mother of this family was marked above somewhat like *morrisi* with the colour more like *aurelia*, but the shape of markings of the offspring was much more like *aurelia* than *morrisi*, and the colour of nine of the twelve specimens was that of *aurelia*.

The other family consisting of two males and three females was the offspring of a pale coloured female, and the specimens obtained showed a greater likeness to *morrisi* than *aurelia*, one female was almost a typical *morrisi* and the males close to it. The other females were close to *aurelia*, but both showed traces of a pale band on the hindwing above.

The great differences shown in both colour and shape of markings of the seventeen specimens of these families prove that *joanna* is by no means a pure race, but made up from the broad orange banded southern form mating with the narrow white banded northern form.

b. *By Pairing the Races abeona and morrisi.*

In the late winter and spring of 1920, the initial steps were taken to begin this experiment. A large number of larvae of *abeona* were collected near Sydney, about 400 in all being obtained. These when they had pupated were kept carefully under observation. Early in October a trip was made to Urunga at the mouth of the Bellinger River, where about 100 larvae of *morrisi* were obtained; these were brought to Sydney and allowed to pupate. Urunga was chosen as a suitable spot as the foodplant was plentiful, and it was sufficiently far north to be beyond any possible influence of the orange banded races south of Port Macquarie. When suitable butterflies emerged and the weather conditions were satisfactory, I made my pairings and secured ten sets of fertile eggs, having five pairings with male *abeona* and female *morrisi* and five reciprocal pairings; these gave me in the autumn of 1921 one hundred butterflies of the first generation. From these first generation specimens I secured ten further pairings, in no case mating brother and sister. The weather during the winter of 1921 was not at all conducive to success, and the larvae of the first generation had made such great inroads into the foodplant that I was only able in the spring of 1921 to secure thirty butterflies of the second generation. I made two successful pairings from these, which gave me twelve butterflies of the third generation in the autumn of 1922.

Fifteen of these butterflies have already been figured (28, pl. i.). They were chosen from the three generations, and also to parallel as far as possible the specimens of *joanna*, already figured in the Butterflies of Australia (29). It would be possible from amongst the specimens caught at Port Macquarie and the hybrids to secure even greater approximation.

Owing to the importance of this series of experiments a further set was begun in the spring of 1922, using, as before, butterflies of *abeona* from larvae and pupae obtained near Sydney, and of *morrisi* from larvae and pupae obtained at

Urunga. The experience obtained in the first set of experiments and the increase in the number of cages enabled me to secure, in the autumn of 1923, 126 butterflies of the first generation from 13 separate pairings. From pairings made amongst these first generation hybrids, I secured sixty-nine butterflies of the second generation. Having then over three hundred butterflies known to have resulted from the pairings of *abeona* and *morrissi*, I can say with confidence on comparing them with the specimens of the race *joanna* caught at Port Macquarie, that this race *joanna* is the result of such a crossing in nature. The experiments will be of added value when they are carried to a greater number of generations, for the equivalent of a first generation between *aurelia* and *morrissi* never occurs at Port Macquarie at the present day.

Previous to this, in 1919, I had made a pairing between a male *rawnsleyi* (emerged in Sydney, September 9) and obtained three males and two females as the result. Both these females were paired with brothers, and I secured seven specimens of the second generation. In October, 1919, I received freshly caught specimens of *rawnsleyi* from Mr. R. Illidge, one of which had laid an egg in its paper envelope; this emerged in 14 days and on March 3, 1920, produced a female. I at once secured a wild male and paired it, and in the spring of 1920 bred three males and a female.

In all I secured from these experiments 203 males and 177 females, including a large bulk experiment of several families placed in one cage, the male parents being *abeona* and the females *morrissi*.

The thorough examination of all these hybrids will necessarily be a long process, and for some of the points that require investigation, sufficient material has not yet been obtained to give accurate statistical results. Some points have been studied and are worthy of note.

The first series of experiments showed first generation families of 1 to 17 in the *abeona-morrissi* cross and families of 5 to 22 in the *morrissi-abeona* cross. In the second series the results were 2 to 12 for the *abeona-morrissi* cross and 5 to 23 for the *morrissi-abeona* cross. The average number of individuals per family for both series was eight for the *abeona-morrissi* cross and twelve for the *morrissi-abeona* cross. Thus when the mother was a specimen that emerged in its own locality, I secured an average of four more specimens than when the mother was reared from a larva brought to Sydney from a locality over 200 miles north.

When the whole of the male specimens of the two series of experiments were examined, I noticed that the males, whatever way the cross had been made, were all more or less similar and intermediate between *abeona* and *morrissi*. The band of the forewing above did not extend through the cell, but was always larger than that of *morrissi*; in colour it was never as deep as *abeona*, but more often was the colour of *morrissi*. The females, however, showed an interesting result. Whenever the male parent was the orange *abeona*, the resulting females always had orange markings, and if the male parent was *morrissi* the resulting females were white. This colouration of the wings following the male parent, also applied to those specimens which had a discal band on the hindwing above, as several of them had. This result was true for the 23 families, and also for the bulk experiment without exception.

The same applied to the two families in which *rawnsleyi* was used as one of the parents. With the *abeona-rawnsleyi* cross the female was orange, and with the *rawnsleyi-abeona* the two females were white. This goes a long way to prove that *rawnsleyi* is a race derived from *morrissi*, which has lost the white markings above.

The Explanation of the Origin of the Race joanna.

The explanation of the origin of this complex race *joanna* is dependent on the physiographical history of eastern Australia. At a period roughly dated as Pliocene (when Australia undoubtedly had a butterfly fauna) the shore stood farther eastwards than at present, trespassing upon what are now the Tasman and Coral Seas, the watershed was lower than at present and lay further westward, whilst the land continued south to Tasmania and beyond and north to New Guinea.

Then followed what Andrews has called the "Kosciusko Cycle," the coast retreated westwards, the coastal mountain range rose higher, Torres and Bass Strait opened. Movement of the coast range re-organised the river system and exposed different rocks to the surface. Specific differentiation in both fauna and flora then proceeded rapidly.

The palaeontological record shows so far no fossil butterflies earlier than the Tertiary, but in the Oligocene of both Europe and North America we find fossils of even the more developed groups and, included amongst these, several fossil Satyrids. Present-day Satyrids are of world-wide distribution, and there is every possibility that as early as the Miocene they had a similar distribution and that the ancestral forms of our present Bassian Satyrids were then in Australia.

It is reasonable to suppose that, before the great uplifting movement at the end of the Pliocene, the ancestor of *Tisiphone* was present in eastern Australia. I consider that first of all the genus became restricted to the higher elevations where moisture was more abundant. At the low-lying portion of the Main Divide known as the Cassilis Gap, the conditions became unsuited for its existence and it disappeared. This barrier then produced a discontinuous distribution and allowed the ancestral *Tisiphone* to develop independently to the north and to the south, gradually producing what we now know as broad orange banded forms in the south and narrow white banded forms in the north. The southern form now occurs almost up to the southern end of the Cassilis Gap and, though no form has been taken near the northern end of the Gap, a white banded form occurs at the southern end of the Mt. Royal Range almost in the same latitude. As time progressed the two forms were able to reach the coast, the southern probably first, and, finding suitable conditions, moved northward and southward, meeting in the small area of Port Macquarie and thus were able, in fairly recent times, to reunite and form the very complex race *joanna* there. Tasmania, though possessing the foodplant, does not possess any *Tisiphone*, which may possibly have died out or was not in a position to pass along the land connection at what is now Bass Straits. This would point to *Tisiphone* belonging rather to the earlier of the newer Papuan invasions from the north than to the older Satyrid fauna occurring in south-eastern Australia and now represented by such genera as *Heteronympha* and *Xenica*.

Summary and Conclusion.

The study of *Tisiphone abeona* illustrates an event that has not often been observed—the formation of no less than seven subspecies in a continental area. Subspecies more often arise as insular races, limited by definite barriers not liable to be broken, except at long intervals of time. Probably similar conditions exist nowhere else than in Australia. I know of no case nearly so marked amongst the *Rhopalocera*, the nearest approach being the four races of *Papilio primumus* occurring in tropical and subtropical parts of eastern Australia, but here the subspecific differences, though recognisable, are not very great. These butterflies belong to the rain forest, and the barriers that have caused their subspecific differ-

entiation have been the intervening dryer forest country. Where subspecific differences have been found in other Australian butterflies, the cause is not hard to discover. Many races of eastern species occur at Port Darwin, and some Tasmanian species differ slightly from the forms on the mainland. A few occur on the east coast, but none have their barrier anywhere near the latitude of the Cassilis Gap.

The ancestor of *abeona* entered Australia probably in early Pliocene times and advanced southwards to the present haunts of the species. Recent mountain building of the Kosciusko period changed both the local climate and the local physiography; *Tisiphone*, but not *Heteronympha*, responded to this change by branching off into a series of subspecies.

If we examine the range of some of the other Australian Satyrids in comparison with that of *T. abeona*, we find that *Heteronympha mirifica* is confined wholly within the range of the former, but I cannot find any tendency to sub-specific differentiation, though six of the races of *abeona* occur in its range. Six races of *abeona* also occur in the range of *Heteronympha banksi*, but the latter species does not vary. *Heteronympha merope* occurs over the whole range of *abeona*, but, though two subspecies occur beyond its range, *H. merope* is particularly constant within the range of *abeona*. This points to *Tisiphone* being a much newer species than the constant species of *Heteronympha*.

It has been shown above that the four forms of *Tisiphone*, namely, *abeona*, *joanna*, *rawnsleyi*, and *morristi*, which had for many years been considered distinct species, were not so, but only geographical races. They illustrate the process of evolution that had proceeded up to a certain point, when changes in the physiography of eastern Australia broke down the previous barrier at the Cassilis Gap and allowed the two distinct forms to mingle. Differentiation had not gone so far as to prevent these two from mating and having perfectly fertile offspring.

Had this barrier not been broken, an almost perfect example of species formation by isolation would have been presented to us.

Tisiphone shows an inclination to depart from two broods in a year to one brood. This change may be correlated with progress from a warmer to a cooler climate.

The explanation given of the origin of the hybrid race *joanna* hardly admits of any other view and suggests a very probable explanation of how new species may have arisen in some cases in the past.

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EXPLANATION OF PLATES.

Plate xxv.

Upper figure. Early stages of *Tisiphone abeona*. Egg much magnified, larva, larva pupating, lateral and dorsal views of pupa, all slightly magnified.

Lower figure. Early stages of *Oreixenica latialis*. 1. Egg much magnified. 2. Young larva magnified about 6 times. 3. Full grown larva magnified about 5 times. 4. Head of young larva much magnified. 5. Head of full grown larva much magnified. 6, 7, 8. Lateral, dorsal and ventral views of pupa magnified about 5 times.

Plate xxvi.

- I. *T. abeona regalis* n.subsp. Holotype male, Barrington Tops, February, 1925.
- I.A. *T. abeona regalis* n.subsp. Paratype male, Barrington Tops, January 26, 1922.
- II. *T. abeona regalis* n.subsp. Paratype female, Barrington Tops, emerged Sydney October 25, 1922.
- II.A. *T. abeona regalis* n.subsp. Allotype female, Barrington Tops, January 26, 1922.
- III. *T. abeona morrissi* Waterhouse, male, Urunga, emerged Sydney February 25, 1913.
- III.A. *T. abeona morrissi* Waterhouse, male, Macksville, October 11, 1920.
- IV. *T. abeona morrissi* Waterhouse, Paratype female, Ballina, October 11, 1902.
- IV.A. *T. abeona morrissi* Waterhouse. Paratype female, Ballina, October 12, 1902.

(Figures I. and III. about 8% over natural size, figures II. and IV. slightly under natural size).

THE CRUSTACEA OF THE CAPRICORN AND BUNKER GROUPS,
QUEENSLAND.

By MELBOURNE WARD.

Plates xxvii.-xxix.

Introduction.

Our knowledge of the Crustacean fauna of the Capricorn Group has been confined hitherto to collections made upon Masthead Islet and N.W. Islet, which respectively have formed the subjects of papers by McCulloch, Grant and McNeill. No general survey of the Crustacea of the Capricorn Group has been attempted, and the Bunker Group so far as the Crustacea are concerned has been *terra incognita*.

While on a recent visit to the Bunker and Capricorn Groups as a member of a party organised by Mr. E. F. Pollock, some insight into the distribution of the Crustacea of this group of pseudo-atolls was possible.

Despite the fact that the general ecology of the reefs of Masthead and N.W. Islet has been dealt with by the late Chas. Hedley and Mr. A. Musgrave, respectively, it would be appropriate to preface my notes on the distribution of the Crustacea with a few remarks on the general formation of the Islets and their surroundings, particularly since many have not previously been visited by scientists. This has been deemed advisable so that some idea may be formed of the types of localities inhabited by the various species.

Three kinds of small islands are associated with coral reefs; all are formed of sand. In the Capricorn Group there is a certain amount of conglomerate rock very hard and coarse in formation which helps to build the conformation of the Isle. The most lowly type of island is a small bank of sand raised only a few feet above the sea level by the action of storms; this is termed a cay. A pseudo-atoll differs from a true atoll in being a wooded cay placed on the edge of a more or less circular coral reef. The true atoll has a lagoon in the centre with usually one or more channels leading in from the sea.

The Capricorns are essentially pseudo-atolls, and, apart from the points of conglomerate breaking up the encircling steep beach, they offer no great individual differences, though sometimes we find that the sand is replaced by slabs of dead coral forming steep shingly beaches.

Five ecological zones are associated with these Isles: (1) Beach above sea level; (2) beach exposed during low tide; (3) mud beach covered at low water (in some cases this is replaced by beds of dead bivalve shells); (4) living coral on sand; (5) reef crest upon which are the nigger heads (pieces of dead coral wrenched from the edge of the living reef and cast upon the crest).

If we cut an imaginary section through the zones we find the beach sloping steeply down to the mud flat covered by about eighteen inches of water at low tide. The same level is held through the next zone, but at the crest one finds only an inch or two covering the solid coral floor, which slopes gradually to the extreme edge of the reef where the coral drops away abruptly to the sea.

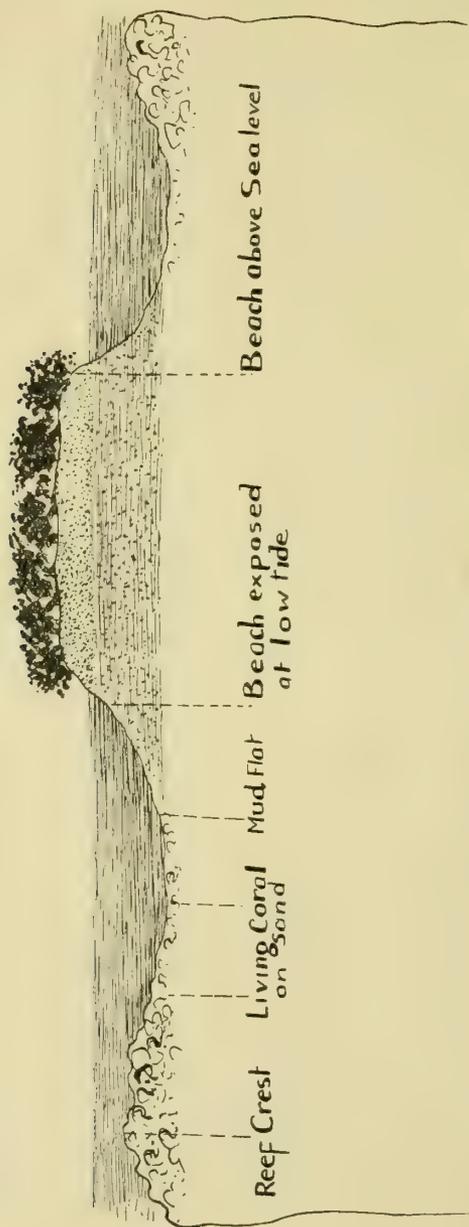


Fig. 1. Diagram showing ecological zones of a pseudo-atoll.

The conglomerate rock is found only along the sides of the island, and supports a fauna of its own which at low tide is exposed to the merciless rays of the tropic sun. Under one stone are to be found a colony of *Clibanarius virescens*, a number of *Petrolisthes lamarckii*, a large *Eriphia sebana* or a *Grapsus strigosus*, and a couple of gobies whose bodies are as moist as the average frog in spite of the intense heat. When disturbed these fish hastily flop their way to the protection of another stone.

To assist the above list of zones a map is added, with each clearly marked. Further details are given under separate headings for each zone.

Sand Flats.

(a). Above high tide. Here the sand is crossed and re-crossed by turtles driven ashore by Nature's strongest urge, the perpetuation of their species; gulls patrol up and down pecking at the bodies of dead marine animals cast up amongst the tidal wrack. The common crab is *Ocypoda ceratophthalma* whose burrows are numerous, well away from the edge of the tide.

(b). Exposed during low water. A No-Man's Land between the amphibious and marine faunas. At high tide the Shovel Nosed sharks lazily hunt upon it, the Box Crabs *Calappa hepatica* lie hidden in the wash of the waves, and Nomadic Crustaceans wander over its ridges in search of prey.

During the time it is exposed the only signs of life are the small colonies of *Mycteris longicarpus*: these were on N.W. Islet, at the western end of the beach. If the low tide occurs in the evening the Ghost Crabs come down in large numbers and are to be seen feeding.

(c). Mud beach. As this is always under water the fauna is not affected by the change of tide, so we find the characteristic crab, *Macrophthalmus graeffei*, making burrows in the soft surface silt.

In the less silted portions of the beach a goby has its lair. One was observed resting with its tail partly blocking the entrance of the burrow from which a Crangonid shrimp appeared at intervals pushing before it with the major chela, small quantities of sand and fragments of shells it had excavated; both animals ignored each other, the one a paragon of industry, the other keeping a wary eye on the manoeuvres of nearby fish. The shrimp invariably came out chelae first, and, although travelling for some inches from shelter, it simply backed its way to the lair with unerring precision, disappearing for a few seconds, to reappear and repeat the performance. On one trip out the shrimp found that the fish was a little further down the burrow and was consequently blocking the gangway more than before, so it touched the fish with its unoccupied nipper, causing it to move enough to allow the shrimp to pass.

Wondering what the relations were between the two, we dropped a shell near them and as quick as a flash both disappeared down the same burrow.

Portunus (Achelous) granulatus is the common swimming crab seen moving about the surface of the silt, while the several species of *Thalamita* occurring in this zone seem to prefer the shelter of pieces of dead coral under which they excavate shallow pits.

The Hermit Crabs are numerous and are dealt with in the special section on Hermits.

(d). Where dead bivalve shells take the place of the silted beach are to be found more *Calappa hepatica* than elsewhere, the rugged floor matching their carapaces, and the mossy-brown algae so abundant on the shells and dead coral, offering opportunities for feeding not to be ignored. Here, too, are the Bailer shells, *Cymbium flammeum*, roaming about with siphons erect, or lying buried beneath the surface of the shelly floor.

Living Coral on Sand.

One of the most striking things about coral reef crabs is their localisation, certain species selecting special corals to which they bear close resemblance. Thus we find *Trapezia cymodoce* associated with a Crangonid shrimp in the branches and crevices of a living Madrepore (Mr. G. P. Whitley found the same selection of habitat amongst the fish at N.W. Islet). The carapaces of both Crustaceans show similar colour markings, no doubt in mimicry of the polyps.

Characteristic of the living coral is the genus *Trapezia*, each of the three species being found in different corals, always in association with weird little prawns. Some species of these *Macrura* are transparent, and seem to take the colour of the background on which they rest.

In the Staghorn coral, the crabs are more rugged of outline,; the open grouping of the coral branches allows freedom, not only for crabs, but for various fish that no doubt feed upon them. In consequence both *Cymo andriossi* and *Phymodius ungulatus* are well shaped and coloured for their environment. The former is much slower than the latter, and is therefore more protectively marked: also it does not leave the shelter of the home coral.

Growing upon the living coralla of the Staghorn and other robust corals is the Organ Pipe Coral, *Tubipora musica* Linn., proving a veritable treasure trove of crabs for those who take the time to smash it. The corallum is red and about the shape of a cauliflower, and is honeycombed with twisting caverns in which *Gonadactylus chiragra* and a host of other interesting invertebrates have their lairs.

The crabs here are all slower than those inhabiting *Acropora* and belong, of course, to different genera, *Pilumnus*, *Actumnus* and a few *Anomura* being characteristic of this coral.

It is surprising how many crabs sit out on the surface of the reef at low tide, most of them entirely out of the water, while others, such as *Atergatis ocyroe*, take advantage of the tiny pools. Perhaps the largest of these basking types is *Eriphia sebana*, usually found on the conglomerate rock points near shore. On one or two reefs visited these crabs were very numerous, there being as many as six to the square yard, and all moving about, some feeding, others wooing. In very much the same manner as the mangrove types of the mainland. When approached, they tilt back and offer the malignant embrace of their large chelae as they sidle towards a cranny, and, as the haven is neared, the weapons are folded and the last few inches covered in a rather hasty and undignified manner.

One of these crabs was observed while in a small sandy floored pool on the conglomerate in the midst of its feeding activities; the body was braced between the walls of the pool by the massive chelae, more fitted to rend and tear than act as passive supports, while the ferocious red eyes alertly erect gave the animal an expression of continual vigilance. The only action made was by the walking legs; these are covered in long sensory hairs, which become very numerous on the claws; each of the legs vigorously combed the sand, first stretching out to the side, then digging down deeply and folding up so that when the claw came out of the sand directly beneath the mouth parts, it was easy for the maxillipeds to clean the microscopic provender off the hairs.

On N.W. Islet these crabs wander along the beach at the edge of the water, quite an unusual thing for a rock-loving animal to do. However, the cause of this peregrination was soon located; it was found that the turtle hunters, after slaughtering, bury the offal in the sand, and it is not an uncommon sight to see a few feet of intestine washing about in the waves, providing a most tempting morsel for crabs and fish.

Reef Crest.

We have seen how the zones change from sand to silt, the gradual encroaching on to the latter by the coral on sand, these solitary pieces become more numerous and crowded until they join into a solid mass over which the sea rushes at low tide in miniature cascades.

Out towards the edge of the reef crest beautiful big pools abound, with white sandy floors and many coloured live corals. As may be expected, the crabs living in these are the same as those in like habitat on the coral on sand zones, but the Crustacean fauna, taking shelter under the "nigger heads," belongs to a series of altogether different genera.

Bombies or nigger heads are held in place by living coral and in some cases sponges. These sponges are many coloured and give to the under surface of a "head" the glory of a Joseph's coat; some have large canals and in these the Porcelain Crabs *Pachycheles pisum* and *Pachycheles sculptus* are to be found; usually the male and female of one or the other species and with them a small Crangonid. Where the nigger head is not resting on the surface *Petrolisthes lamarchii* is abundant, the crannies in the rocks affording safe refuge.

Spider Crabs *Schizophrys aspera* abound and clothe themselves with pieces of the sponges.

The much sought Cowries and a host of other invertebrates use these ideal refuges. Crinoids, Brittle Stars, worms and sea urchins are all in intimate contact. The Ear Shell *Haliotis asinina* spends the day beneath and prowls on the surface during dull weather and at night; it is in the mantle of this mollusc that *Pinnixa faba* is found, usually a male and female in the same animal. Another related form of commensal crab is found within the mantle of the coral clam *Tridacna*. This small, remarkably shaped Crustacean is *Xanthasia murigera*. Even after death the clams are much used as havens of refuge: the valves remain joined and lie upon, or half buried in the sand. In one a small octopus was found with nest and extruded capsules, each of which contained a single octopus ready to burst out and take up its separate existence. In another a goby, and so on.

Hermit Crabs.

Probably the greatest part of the Crustacean fauna is represented by the Hermit crabs. They appear in all the zones except the beach exposed at low tide. However, at high tide they wander freely over the glistening sand in only a few inches of water.

On the silted or mud zone which, as we know, occurs a few yards below low tide, several species abound in small colonies. One is a very small *Diogenes* of pure white colour, and numbers are to be found in the shelter of fragments of dead coral. The large species *Dardanus deformis* is also a denizen of the mud, and single specimens were found at several of the islands visited. The oft recorded habit of placing anemones on the shell in which it lives belongs to this particular crab, though other closely related species on the reefs of Hawaii also adopt the same habit. One large specimen of *Dardanus megistos* found wandering on the coral on sand zone seemed to have acquired the habit of *Dardanus deformis*, for two anemones were on the shell, no doubt placed there by the crab.

To return to the mud flat Hermit crabs. Another gregarious species of large *Dardanus* is commonly found on the zone on most of the islands. It uses the dead shells of a *Comus* commonly found on both the beach and mud zones; while the live cones have clean smooth shells, those inhabited by the Hermit crabs are covered in a growth of weed.

Conglomerate Zone.

Between tides the rocks become greatly heated by the sun, and even though pools abound the Hermits *Clibanarius virescens* and *Clibanarius corallinus*, both remain out of the water on the parched rocks until the return of the tide. These two species are typical of the conglomerate, the former occurring nearer to the shore than the latter.

As we gradually pass from the mud to the coral on sand we find *Dardanus euopsis*, a pretty plum and white speckled crab, seated on the coral and moving about in the sandy channels; it was also found sheltering under the large masses of living Staghorn of the zone.

Further out a species of *Eupagurus* makes its appearance in large numbers, colonies being found under the same coral. These are by far the fastest of the Hermit crabs encountered.

Amongst the living coral of the reef crest *Calcinus terrae-reginae* is to be found; the beautiful brown nippers and brilliantly coloured antennae make this species a thing of beauty.

Of our special finds amongst these quaint little Crustaceans the most outstanding was the presence of *Coenobita*, land Hermits, on Lady Musgrave Island. Two species are present: a large vividly red animal and a small dull coloured one. The former *Coenobita perlata* inhabits three species of marine shells; one, a *Tonna*, being only found as the refuge of this species. Both kinds of crab are to be found in company under the same log or tree trunk. These offer quite a good illustration of distribution, for on none of the other islands do they occur, either in the Bunker or Capricorn Groups. A number of our specimens are females, in berry, and I remember remarking the presence of water in the shell carried by several individuals when they were captured; unfortunately, I did not immediately examine them, and so cannot say whether the water was for respiration or to keep the eggs moist. From previous experience I am inclined to think that it was the females with eggs that carried the water; specimens kept in captivity did not seem to miss the use of water as a means of respiration.

Species of *Coenobita* are sometimes herbivorous, as in the case of some collected in Panama. However, the Lady Musgrave Island species would hardly utilise this diet on account of the extreme barrenness of the island; it is quite probable that during the breeding season of the Terns the wily Hermits prey upon the eggs and young of the birds. At other times, beach combing at night along the edge of the tide, or what little they can steal from the goats amongst the pieces of coral that are scattered over the island forms their scant diet.

Another quaint habit is the destruction of the inside pillar of the shell by the crab, which is characteristic of the genus. It would appear to be caused by the action, either of the animal's body or of an acid secretion.

Amongst the Marine Hermits our most interesting find was made at One Tree Island; this consisted of a single specimen of *Calcinus herbstii*. It was very close to the shore and was almost passed over in our hurry; its large white tipped claw gave it away and we joyfully added it to the collection. The species ranges from the Indian Ocean, through the Pacific to Hawaii, where it is common.

The Crustacean fauna of the Barrier Reef is extremely vast; a short time spent on any of the zones dealt with will convince the most sceptical of the truth of this statement.

The majority of the genera and species have a wide range through the Indian and Pacific Oceans, and straggling representatives of quite a number appear during the summer on the reefs in the vicinity of Sydney.

THE MACROPUS ROBUSTUS GROUP OF KANGAROOS.

By A. S. LE SOUEF, C.M.Z.S.

Plate xxx.

The Wallaroos form a very distinct group of kangaroos. They are robust in form and share with the Red Kangaroos in having the sexes dissimilar in colour. The skull can be distinguished at a glance, as the posterior palate is not perforated, or, at most, by a few pinholes.

They range widely over Australia, being absent only from the south-west, but, owing to their particular habitat being mountains and hills, they have a discontinuous distribution. This has led to the establishment of many sub-species in various parts of the Continent. The typical species *M. r. robustus* found on the Dividing Range throughout its length is well known, but other kinds, especially those found in northern Australia, have been little studied for lack of material. The types of several forms, and in some cases the only specimens that have been collected are in the British Museum of Natural History, or in Lord Rothschild's Museum at Tring.

Having had the advantage of examining these types, it is evident to me that several of them form well marked sub-species. The original descriptions often consisted of a few comparative references to *M. r. robustus*, from which a given variety was not readily recognised. Schwarz, however,* has given a careful and exact description of the whole group, based on specimens in England. As this paper, being in German, is not available to many workers, a translation of part of that portion relating to the series of *M. r. robustus* is here given, for which work I am indebted to Mr. O. Von Drehnen.

The group will probably be subject to further alteration. The examination of a larger series may lead to some of the named forms being relegated to synonymy, and it is very likely that other types will be described. There is in the Tring Museum a large blackish Wallaroo, that is unlike any other kind, while in the Australian Museum there are skins and skulls of a species from Queensland that apparently does not conform to any published description, and in the Perth Zoological Gardens is a dark rufous animal that I cannot place.

With a view to establishing the value of some of the characters given for sub-species, a series of skulls of *M. r. robustus* in the Australian Museum was examined to see what variations could be noted.

This series shows that the skull alters in shape with age. Immature crania are comparatively broad, with large teeth. As age advances, the skull contracts in width, the frontals and parietals grow together, the junction ultimately forming a ridge in aged animals. The postero-superior section, which, in juveniles is depressed, comes more into line, so that in adults the profile forms a fairly even, slightly convex line. The infra-zygomatic process tends to become elongated and recurved, and the coronoid process of the lower jaw seems to lengthen and become more produced backwards. The shape of the nasals is also apparently subject to variation, for, although five skulls in the Museum collection are similar in this

* Die grossen Känguruhs und ihre geographischen Formen. *Novitates Zoologicae*, xvii., 86-109, 1910.

respect, one specimen (No. M 3333) has these bones narrower, straighter and much more attenuated in front. Two skulls of *M. r. erubescens* also have the nasals different in shape. The diastema in *M. r. robustus* is fairly uniform. In six skulls examined the least breadth of the fore part of the palate goes into the length of the diastema one and two-thirds in four specimens, twice in one, and a fraction over twice in another. The presence or absence of the premolar teeth causes some variation in this feature.

As the teeth wear they become proportionately smaller, particularly the upper incisors. The premolars are shed early in adult life, while the posterior molars are erupted in middle life.

Examination of the types shows that the outstanding forms appear to be:—

M. r. isabellinus, a small pale coloured form found on Barrow Island and adjacent Mainland.

M. r. woodwardi, of the Kimberley district, which seems to be closely related to *cervinus*, *rubens* and *alligatoris*.

M. r. erubescens, which may be allied to *reginae* and perhaps to *argentatus*.

The descriptions and remarks of Mr. Schwarz follow, to which I have added such comment as appears necessary.

"The general characteristics of the group are typified in *Macropus robustus* Gould.

"Body thickset, with legs shorter than in *M. rufus* or *giganteus*. Rhinarium large, naked, and with no cleft. Hair on the ears usually sparse, being thicker at the base. Centre claw of hind leg short and generally hidden by hair; nails fairly long, rather straight, and rounded terminally. The female is smaller, has longer hair, and is different in colour.

"*Skull*: Nasals short and broad, interorbital region convex, with a concave depression anteriorly. Eye socket sharp and well defined above, post orbital process sometimes indicated. Wall of the eye socket smooth. Zygomatic arch very broad, the highest point being above the posterior part of the zygomatic process; foramina incisiva may be either short or long; palate complete, with exception of the palatine foramina or a few small pinhole perforations; fore part of the palate generally well defined laterally. Nasal openings comparatively large, more or less expanded, although not definitely bowed at the sides. Interorbital region narrow. The lower jaw does not vary in shape, being thickset. Coronoid process rounded terminally.

"*Teeth*: Upper incisors comparatively short, generally placed vertically as in *giganteus*; I₁ usually curved inwards; I₃ long and in young animals has a well defined notch, which is often not well indicated in old specimens. P₃ small with sharp edge, reduced in the middle, and smaller posteriorly. Molars narrow, but with well developed transverse ridge, which sometimes carries an indistinct longitudinal ridge, which readily gets abraded. Under jaw I₁ stout, generally with flat surface. Molars with high transverse and longitudinal ridges.

"The nearest relative is *M. antilopinus*; it also has certain characters in common with *M. hagenbecki*, which is intermediate between *robustus* and *rufus*.

"MACROPUS ROBUSTUS ROBUS Goult.

"*Macropus robustus* Thos., *Cat. Mars. Mon. Brit. Mus.*, p. 22 (1888).

"Hair rather coarse and long, directed downwards on the back, with no whorl on the neck. Male black above, back of the ears, nasal region, face, neck and under parts of the body lighter; a dark spot on the chin. Fingers, toes and tail black; under and inner sides of the limbs greyish-brown, breast whitish and the corner of the mouth white; ears lined inside with white hairs. Female resembles the male, but is lighter in colour and smaller. The upper parts, head and ears are

grey; cheeks, corner of the mouth, limbs and under parts lighter; fingers and toes smoky colour; a dark spot on chin. Tail yellowish-grey, with upper terminal part smoky colour.

"*Skull*: The face is fairly long in proportion to the brain case. Nasal openings a little bowed at the sides; nasals broad posteriorly, reducing to the front, narrower in centre, produced to a long terminal point. Infra-zygomatic short and broad. Opening of tear channel lies in front of the lachrymal, near suture; foramina incisiva short; fore part of the palate broad, the least breadth going twice into length of diastema. Profile of the head is rather a flat convex curve, with its highest point nearly over the middle of the zygomatic process. Under jaw broad and thickset, the ramus and corpus making a blunt angle; condyles slightly curved, coronoid process broad, and on the top slightly bent and rounded.

"*Teeth*: I₃ long and slightly curved.

"The head generally resembles that of *M. r. cervinus* from which it differs in the shape of the anterior palate, the shape of I₃ and the coronoid process of the lower jaw."

This species is coloured in harmony with the forest covered hills, among which it dwells. Some seasonal variation is shown, in that at the end of the summer a more or less rusty wash is apparent in both sexes. The base of the hairs on the throat of the male is often pink in colour. This colour appears also on the throat of *M. rufus* and on the neck of two species of Rock Wallabies—*P. rothschildi* and *P. purpureicollis*—I have noted that a gelded male did not develop the black coat, but remained a pale grey throughout life.

"MACROPUS ROBUSTUS CERVINUS THOS.

"Thos., P.Z.S., 1900, p. 113; *Nov. Zool.*, viii., p. 395 (1901).

"*Macropus cervinus* Cahn, *Zool. Beob.*, xlvi., p. 2 (1907).

"Hair long and soft, adpressed on the back, no whorl on neck. Ears long and broad. The male has the whole of the upper parts and the hair of the head deep rusty red, the cheeks, sides of the body and upper parts of the limbs somewhat lighter; eyes bordered whitish, ridge of the nose blackish-brown, corners of the mouth white; back of the ears (sparsely haired) somewhat darker than the crown, and having on the inside long white hairs; forehead and cheeks yellowish-red; rhinarium bordered blackish-brown; arms light yellowish-red, with base of the hairs dark greyish-brown, fingers blackish-brown; thighs yellowish-grey, gradually changing to blackish-brown of the toes; under parts of the body white, hairs having reddish bases.

"Female: Upper parts soft reddish-isabelline, the hairs at the base being vividly yellowish-red, with dark brown tips; sides of the body lighter, the hairs without dark brown tips; ridge of the nose dark brown, mottled white, hairs of cheeks dark grey at base, with distal half white, which gives a greyish tint to the face; chin, throat and remaining parts of the under surface white, the hairs having reddish bases. Otherwise same as the male, with limbs somewhat lighter in colour. The young of both sexes, more brightly coloured, the male light chestnut-red.

"*Skull*: Facial part in comparison to the brain case long, nostrils enlarged at the sides, more so at the posterior end of the maxilla; nasals for a kangaroo of the *robustus* type are long, ending in a long drawn out point, the edges S-shaped, converging to the front; opening of the tear channel is bordered in front by the maxilla; foramina incisiva is short; front part of palate long, the narrowest width goes about two and a half times into length of diastema; the line of profile is the same as in *robustus*, only a little more convex. The crest of the skull

differs somewhat from the typical construction, posteriorly it is lower, and in general very small. Lower jaw slender, the corpus forming a moderately large angle with the ramus, condyles convex, coronoid process narrow, and at the top turned sharply to the back and rounded off.

Teeth: Some as in *robustus*. I₃ usually very short in horizontal direction.

"Living examples show that in winter the hair is considerably longer, and in the male lighter in colour. This kangaroo in particular is distinguished by the long soft hair, and the large ears (length of ears in adult *cervinus* 110 mm.), and the deep red colour of the male."

A wallaroo, identified as this species, that lived in Taronga Park for some years, was a large powerful animal, with a dark tan, very deer-like, colouration. The hair was long and softer than in *woodwardi*, so we would expect the species to be subject to greater extremes of climate. Its habitat is probably the ranges, some distance from the coast in the mid-west.

"MACROPUS ROBUSTUS RUBENS Schwarz.

"*Macr. rob. cervinus* Thos., *Nov. Zool.*, xi., 365 (1904).

"Hair on the dorsal region short, that on the sides materially longer and softer. No whorl on neck, ears shorter than in *cervinus*. Male similar to male *cervinus*, but with much shorter hair, somewhat lighter in colour (particularly on head and neck) with a yellowish sheen; belly whitish, not white as in *cervinus*, chest and throat white; back of ears blackish-brown, sparingly haired like *isabellinus*. The female is very different from the female *cervinus*, being light yellowish-red, greyer on neck, the hairs having no dark points; sides of body lighter, and the belly has only a narrow white strip in the centre; forehead, cheeks, back of ears (lightly haired) somewhat lighter than the back; inside of ears white; tip of nose light brown, mixed with a little black; arms and legs yellowish, turning darker towards toes, which are black, paws light brown.

Skull: Facial portion short in proportion to brain case; nostrils enlarged at the sides (especially the part before the posterior end of premaxilla, which is further forward than in *cervinus*) and narrow at the point; nasals are much narrower in front than posteriorly, they are reduced in the middle and have a much shorter point than *cervinus*; infra-zygomatic process narrow and considerably recurved; opening of the tear channel lies in the lachrymal; incisive foramina short; fore part of palate is longer and somewhat broader than in *cervinus*, the narrowest width goes about three times into length of diastema, the bend of the arch is the same as in *robustus*, but more rounded off; line of profile is similar to *cervinus*, but higher and more strongly convex, with the highest point further forward, and in consequence the facial portion is steeper; interorbital region not arched; lower jaw more slender than in *cervinus*, coronoid process hardly bent at the top, and less rounded terminally.

Teeth: I₃ as a rule shorter than in *robustus*, similar to *cervinus*. The female skull has an extraordinarily small facial index.

"This kangaroo differs considerably from its nearest relative *cervinus*. Both sexes, particularly the female, are lighter, have shorter hair and shorter ears. The skull differs through its different form of nasals, and the mouth, as well as the small facial index. Habitat: Box Soak, North-west Australia. Type measured in the flesh, head and body 1,505, tail 925, hind foot 300, ear 100."

I believe that some of the characters given for *rubens* may be due to seasonal variation, and that skull differences might be accounted for by age. The sub-species appeared to me to be very close to *woodwardi*.

"MACROPUS ROBUSTUS WOODWARDI THOS.

"Thos., *Nov. Zool.*, viii., p. 395 (1901).

"*Macr. woodwardi* Cahn, *Zool. Beob.*," xlviii., p. 2 (1907).

"Hair on male short, thin, coarse, and adpressed. There is a whorl on the neck, and the hairs of the neck are pointed forwards. Male has the upper parts, including the head, cheeks, superior part of tail and back of ears rusty-red, with hair uniformly coloured nearly to the base, which is somewhat lighter, but not white as in *antilopinus*; arms and legs reddish-yellow, getting darker towards fingers and toes, which are blackish-brown; chin reddish-yellow, with a pronounced rusty-red spot, corners of the mouth white, ridge of nose dull reddish; sides of the body somewhat paler, sharply defined from the reddish-yellow belly; inside of ears reddish-yellow. Female similar to male, hair longer and softer, isabelline reddish; hairs on the neck with darker tips, outside of ears brighter than head, inside dull white; ridge of nose dull brownish-grey; chin with an indistinct blackish spot; fingers and toes white; everything which in the male is yellowish or reddish is white in the female.

"*Skull*: Facial portion short in comparison to the brain case, mouth at sides not enlarged, width of arch very great; nasals broad in front, being hardly less than at the back, and only a little narrower than in the middle, then running to a short point, arching from right to left pronounced; infra-zygomatic process long, broad and strikingly recurved; opening of the tear channel lies in the lachrymal; foramina incisiva long, reaching the sutura incisiva; front part of the palate broad, the narrowest width goes twice into length of diastema; line of profile rises from the back in an S-shaped line to highest point, above fore part of zygomatic arch, and from there runs in a nearly straight line to the point, with a small kink at the back of nasals. Lower jaw very compressed, corpus very high, and ramus broad, condyles convex, coronoid process very broad at the top, not bent or rounded.

"*Teeth*: Is shorter than in *robustus*, without notch, and with indistinct vertical rill.

"*Habitat*: Grant Range, Kimberley, Western Australia."

Woodward's Wallaroo appears to be the common species in North-west Australia. It is fairly often represented in zoological collections. Live specimens observed have been uniform in colour; they seem also to be a little smaller and lighter in form than *robustus*. Examination of a proper series will probably show this form to be worthy of specific rank, with *rubens* and *alligatoris* as subspecies.

"MACROPUS ROBUSTUS ISABELLINUS Gould.

"*M. isabellinus* Gould, P.Z.S., p. 81 (1841); Waite, *Rec. Austr. Mus.*, iv., p. 131 (1901); Thos., *Cat. Mars. Mon. Brit. Mus.*, p. 25 (1888); id., *Nov. Zool.*, viii., p. 394 (1901).

"*Macropus robustus isabellinus* Rotsch, *Nov. Zool.*, xii., p. 510 (1905).

"Hair thick and soft, longer on the sides and belly. Tail with longer hairs on the point. Male, above isabelline, with sides lighter, head coloured like the back, ridge of nose grey, corners of the mouth whitish, and a black spot on the chin; cheeks reddish, ears outside reddish, strongly mixed with black, inside sparingly haired white; limbs dull light reddish, hairs with dark points, hands rusty-brown, darkening into blackish on the fingers and toes; tail at base like the back, then reddish-brown; throat and chest pure white, belly reddish-white. Female similar, but lighter in colour, belly pure white.

"*Skull*: Facial portion in comparison with the brain case very short. On the median wall of the eye socket is a sloping pad, similar to that found in

antilopinus, upper wall of eye socket sharp edged, and interorbital region strongly concave; opening of the tear channel bordered by the maxilla; foramina incisiva long, broad, and at the back formed by the maxilla, the same as with *antilopinus*; palate broad, the narrowest width goes twice into length of diastema; line of profile rises steeply from the back, and is then strongly convex, with a kink at the posterior end of the nasals, then nearly straight to the front, the highest point lying about the middle of the zygomatic process; infra-zygomatic process long and narrow. Lower jaw short and compressed, the corpus and the ramus nearly forming a right angle; ramus very broad, condylus nearly level; coronoid process slender, at the top fairly broad, sharply turned and rounded off.

"Teeth: Same as in *M. r. woodwardi*.

"This species is the most aberrant of the whole *robustus* group. It most probably represents a stunted island form. The difference in sexes is not nearly so marked as in other species, and the animals are smaller. The skull shows a number of characters which are also in *antilopinus*, such as the shape of the mouth, the interorbital region and the foramina incisiva, the position of the opening of the tear channels, and the smaller facial index. In general, however, the skull shows characters which are decided like *M. r. robustus*. These are the form of the arch, the infra-zygomatic process, the palate, and especially the teeth. I therefore consider it to be a member of the *robustus* group, although strongly specialised."

M. isabellinus was described many years ago, when the lumping of species was rather carried to extremes. It is, however, quite distinctive, apparently not subject to variation, and has many characters which differentiate it from the dominant type and other sub-species. These are the smaller size, distinctive colour, long soft hair, and similarity of the sexes. There are also definite skull characters, akin to *M. antilopinus*. As it could not possibly be mistaken for anything else, it should be given full specific rank.

"MACROPUS ROBUSTUS ALLIGATORIS THOS.

"Thos., *Nov. Zool.*, xi., p. 224 (1904).

"Hair thick, short, coarse and adpressed. A whorl on the neck. Male coloured above dark reddish isabelline, hair of the dorsal region having dark brown tips; sides of the body lighter, under parts reddish-white, darkening posteriorly, a dark spot on the chin; crown similar in colour to the neck, back of ears thickly covered with short hair, inside reddish-white; limbs paler than the body, getting lighter terminally, fingers and toes dark brown; tail evenly coloured light reddish-isabelline; bridge of nose dark brown, cheeks light reddish.

"Skull: Facial portion short in comparison to the brain case; nostrils not broadened out laterally; nasals short and broad, the sides converging in slightly bent lines to the front, without any angle to the front; infra-zygomatic process short and narrow; opening of the tear channel in the lachrymal; foramina incisiva short; front part of palate broad, the narrowest width goes twice into length of diastema; line of profile rises from the back to highest point of cranial ridge, and from there gradually falls to back of nasals, thence sharply to the point; posterior part of premaxilla very short, reaching only as far back as one-third of the nasals.

"Teeth: Same as *robustus*. Lower jaw very compressed, corpus very high and ramus broad, nearly forming an angle of 45°; condylus convex, coronoid process broad, a little bent, then quite rounded.

"This kangaroo in colour and character of the fur is nearest to *woodwardi*, and resembles closely *erubescens*, from which it is distinguished by the short hair,

red back of the ear, and more yellowish-red colour. The skull is closest to *woodwardi* from which it is distinguished by the coronoid process of the lower jaw."

It seemed to me that this sub-species might have been founded on specimens showing seasonal variations from *woodwardi*. The coronoid process mentioned by Schwarz is apparently a feature, varying in shape according to the age of the animal.

"MACROPUS ROBUSTUS ALEXANDRIAE Schwarz.

"*Nov. Zool.*, xvii., p. 192 (1910).

"*Skull*: Facial portion short in comparison to the brain case, nasal openings not expanded laterally, the muzzle narrows towards the front; nasals broad, somewhat narrower in front, contracted in the middle, and having a short point; anterior part of the interorbital region somewhat arched, and in the median wall of the orbit there is a small protuberance; opening of the lachrymal canal lies in the lachrymal, near the suture of the premaxilla, foramina incisiva reaches almost to the sutura incisiva; anterior part of the palate is short and broad, the least breadth going twice into length of diastema; the profile line rises posteriorly, slightly concave to the highest point over the posterior process of the jugal arch, and from thence runs slightly downwards to the posterior portion of the nasals, then more sloping to the point; posterior end of the premaxilla much extended, going about three-quarter the length of the nasals. Lower jaw similar to *robustus* but with broader ramus and shorter corpus, which forms a smaller angle than in *robustus*; condyles convex, coronoid process slender, scarcely curved backwards, and ending in a somewhat truncated point.

"The skull differs from *robustus* to which it is allied, by the form of the nasals, short and compressed lower jaw and somewhat pointed coronoid process. It differs considerably from its two nearest allies *alligatoris* and *reginae*; firstly, by the rounded coronoid process; and, secondly, by the almost rectangular nasals.

"Habitat: Alexander, North-west Australia."

This sub-species was, I understand, founded on a single skull from North-west Australia. Judgment as to its value must be suspended until more material is obtained from that region. Two features relied upon by Schwarz (nasals and coronoid process) are apparently subject to variation.

"MACROPUS ROBUSTUS REGINAE Schwarz.

"*Nov. Zool.*, xvii., p. 103 (1910).

"Hair long, thick and coarse, sometimes a whorl on the neck. Male above light wine-red, strongly mixed with slate grey, the hairs except on the neck have slate-grey points, belly hairs are ash-grey at base, with white tips, which are absent at the sides, so that an indistinct ash-grey band is formed, which goes from the shoulder, along the belly to the hips. Chest and throat yellowish-white, a blackish spot on the chin, base of the ears more brightly coloured than the neck, ridge on the nose, forehead and cheeks dark-brown, mottled white; rhinarium bordered whitish, back of the ears thickly covered with long blackish hairs, and the inside with long yellowish-white hairs; arms yellowish, mixed on the upper part with blackish, paws scarcely darker; legs yellowish and the foot strongly mixed with blackish hairs, toes black; base of the tail similar to the back, but more greyish, the hairs have a little red at the base, tip pale yellowish, mixed with a little black.

"Female: Upper side light red, on the dorsal region the hairs have ash-grey and on the sides white points; top of the head and face dark-grey, spotted white; cheeks whitish, hair at the base and back of the ears dark grey, and at the tip

greyish-white, inside whitish; in front of the opening there is a striking whorl; belly pure white, the hairs being slightly grey at the base; base of tail like the back, otherwise similar to the male, but smaller. Sometimes one finds fairly red females, which, however, always show the grey ear base.

"Skull: Facial part in proportion to the brain case short, the sides of the nostril cavity not enlarged, the mouth reduced to a point, and is considerably smaller than in *erubescens*; nasals are short and broad, reducing evenly to the front, and ending in a short point; infra-zygomatic process longer and broader than in *erubescens*; on the position of the post-orbital process is a small unevenness; opening of the tear channel is mostly bordered in front by the maxilla; foramina incisiva long and reaching to the sutura incisiva; front part of the palate short and very broad, reducing decidedly to the front, its narrowest breadth goes a little more than twice into length of diastema; line of profile is an even convex line, its highest point lying above the posterior third of the zygomatic process. Lower jaw short and compressed, the corpus nearly forms a right angle with the ramus, coronoid process is compressed at the top of the short, blunt hind continuation.

"Teeth: Same as in *robustus*, but the secature is somewhat shorter.

"This kangaroo in outward appearance is close to *erubescens*, although separated geographically by long distances. It is, however, more wine-red, and the muffle is bordered with whitish, and not brown, the tips of the hairs on the back are slate-grey and not blackish-brown, and the paws are hardly darker than the arms. In summer it is more brightly coloured with a yellowish tinge, and the dark tips of the hairs are not so marked. The skull differs from *erubescens* in having a smaller mouth, reducing to the front, comparatively large width of the arch, breadth of the front palate, and small facial index."

Although this sub-species is very close to *erubescens*, its skull characters, if consistent, are sufficient to give it sub-specific rank.

"MACROPUS ROBUSTUS ERUBESCENS Scl.

"Halmaturus erubescens Scl., P.Z.S., p. 126 (1870).

"Macropus robustus Thos., *Cat. Mars. Mon. Brit. Mus.*, p. 23 (1888).

"Macropus rob. erubescens Thos., P.Z.S., p. 113 (1900); Rotsch, *Nov. Zool.*, xii., p. 510 (1905).

"Hair fairly long, coarse and thick; there is sometimes a whorl on the back of the neck. Male: wine-red washed with black, hair of lower back with black or blackish-brown tips, head and base of ears similar to the neck, back of ears black, inside covered with sparse grey hairs, ridge of nose dark grey, corners of the mouth white, rhinarium bordered blackish-brown, cheeks light reddish, chin with black spot; limbs reddish-white to reddish-grey, which finally turns to black on the extremities; upper side of the tail like back, strongly mixed with black, under side pale yellow.

"Skull: Facial part in proportion to the brain case long; cavity of the nose evenly enlarged at the sides, the mouth therefore appears cylindrical at the top. The nasals for a kangaroo of the *robustus* group are long and narrow, scarcely reducing to the front, and hardly enlarged at the back, the front ends in a short point, and the sides are nearly parallel; infra-zygomatic process narrow and fairly long; opening of the tear channel lies in the lachrymal, but well in front, nearly at the sutura lachrymo-maxillaris; foramina incisiva moderately long; front part of the palate rather long and narrow, the narrowest breadth going but $2\frac{1}{2}$ times into length of diastema; posteriorly the line of profile rises rather sharply to back of the zygomatic arch, and from thence runs in a faintly convex not quite even line to the front. Lower jaw slender, the corpus forms a con-

siderable angle with the ramus, condyles convex, the coronoid process long and narrow, running fairly to a point.

"Teeth: Same as in *robustus*."

A male in the Australian Museum has the upper parts rufous-fawn, overlaid with greyish-black on the dorsal area, the base of the hairs being rufous-fawn and the tips either black or grey; belly dull greyish-white; arms and legs grey, which changes to greyish-brown on the feet and paws; cheeks grey, and superior fore part of face black; tail dark brown, mixed with grey hairs.

The female of this species does not appear to have been previously described. A specimen in the Australian Museum, from Crystal Brook, South Australia (M. 865) has the upper parts brownish-grey, overlaid with black on the dorsal area; belly light grey, with fawn tints; legs and arms whitish with a yellowish wash; feet black, hands brown; back of ears sparsely covered with either grey or white hairs; tail greyish-brown superiorly, sides yellowish-buff.

Mr. H. H. Finlayson, Honorary Zoologist of the South Australian Museum, has kindly sent the following notes on *erubescens*:—"The females are extremely variable. On an area of 20 miles square, in the north-east of the State, I have shot females which were in turn almost black, almost white, and again others in which the rufous suffusion was so marked and the black hairs so scanty, that they appeared almost uniformly pink. The bucks are much more constant, and are nearly always much darker on the lower back, and the red of their shoulders and neck is of a shade not represented on the female at all."

M. r. erubescens is in my opinion distinct from the typical *robustus*, and worthy of specific rank. The two species are very distinct in colour and do not overlap in this respect; the difference in the proportion of the breadth of the fore part of the palate to the length of the diastema also distinguishes the skulls. This proportion is always greater than in the dominant species.

"MACROPUS ROBUSTUS ARGENTATUS Rotsch.

"*Macropus argentatus* Rotsch., *Nov. Zool.*, xii, p. 509 (1905).

"Hair long, thick and coarse. Anterior part of the body bright rusty-red, dorsal region darker, strongly mixed with black; posterior part of the nostrils grey, anterior part brown, cheeks dark grey, somewhat mixed with white, eyes bordered with white, a black spot on chin; on the under sides the hairs have dark grey bases; arms dark grey, mixed with white, paws black; upper part of thigh like the back, lower part grey, toes black; tail dark greyish-brown above, lighter below, tip black; ears covered with long brownish-black hair outside, yellowish-white inside.

"Female: Middle of the back and top of the head brownish-grey, sides and under parts white; cheeks yellowish-grey, angle of the mouth yellowish, with a black stripe above anteriorly; limbs whitish-grey, paws and toes black.

"Skull: Facial part in comparison to the brain case very long, nostrils bowed at the sides, and reducing to a point, nasals short and narrow, broadest posteriorly, and reducing anteriorly, being sharply drawn in at the middle; post-orbitals distinctly developed; infra-zygomatic process short and narrow; opening of the tear channel lies in the lachrymal; foramina incisiva short; occipital process short and narrow; anterior palate long and narrow, the narrowest width goes $2\frac{1}{2}$ times into length of diastema; line of profile rises steeply concave to highest point of the arch, and from thence runs fairly straight to the front. Lower jaw, corpus moderately long, and with the ramus forms a comparatively rounded corner; condyles concave, coronoid process very long and narrow, and at the top sharply bent back with long continuation.

"This kangaroo in outward appearance, as well as owing to the fact that the female is grey, is close to *erubescens* and *reginae*. The skull is characterised by the shape of the nasals, the coronoid process and the large facial index. Habitat reported Northern Australia: exact locality unknown."

M. r. argentatus is a striking form in that the hair is very long and dense, much more so in this respect than any other members of the group that I have seen. The male resembles in colour *reginae* and *erubescens*. The female, however, shows no red or yellowish colouration characteristic of the females of these two forms. It is light silvery-grey, with a brownish wash on the dorsal region, much lighter than the female of *M. r. robustus*. The skull shows close affinity to *erubescens*, differing mainly in the shape of the nasals, a character which is seemingly liable to variation.

The specimens in the Tring Museum were, I understand, procured for Lord Rothschild, together with *M. hagenbecki*, by one of the late Carl Hagenbeck's collectors. Beyond the fact that both these types were supposed to have come from Northern Australia, the exact locality is unknown. *M. hagenbecki* like *argentatus* has a very dense coat, indicating a cold bleak region, probably some of the higher ranges in Arnheim Land.

TARONGA PARK AQUARIUM.

For the first twelve months, July 19, 1927, to July 18, 1928, the attendances at the Aquarium totalled 334,993 persons, of whom 267,414 were adults, and 67,579 were children. The weekly average attendance was 6,442 persons. As compared with the London Zoological Society's Aquarium, with an attendance of 436,000 for 1926, the above result can only be described as remarkable. Sydney and suburbs have a population of about about one-ninth of the population of London and suburbs. On Easter Sunday, 6,858 persons visited the Aquarium, a record attendance! During the summer months the Sunday attendances ranged from 3,000 to 3,500, while those of the winter Sundays were from 2,000 to 2,500. That there is never any overcrowding or congestion speaks well for the admirable design of the Aquarium, in which ample space is provided for visitors in front of the numerous tanks, and the double exits obviate any risk of collision between the moving streams of visitors.

The gross takings at the turnstiles for the year amounted to £7,372, and a very considerable amount of revenue was derived from the refreshment room in addition.

The second or tropical section is now approaching completion. It will be nearly as large as the first section, and will contain a very attractive seal pond, as well as large series of tanks specially designed to accommodate the beautiful fishes of the Coral Reef Regions.

NOTES ON NEW ZEALAND AND AUSTRALIAN GYMNOLASTIC
HYDROIDS.

By H. J. FINLAY, D.Sc.

(Communicated by Edwin Ashby.)

The loan of the type specimen of *Tubiclava rubra* Farquhar, from the Canterbury Museum, induced an examination, first of this species, then of any other gymnolastic material from New Zealand. No comments can be offered on *rubra* until fresh specimens are gathered, as the type material is much shrivelled and hardened by the preservative. But perusal of the literature concerned brought to light so many interesting points in connection with other New Zealand *Athecata*, that some of them are here gathered together in a short preliminary contribution.

The most recent check-list of New Zealand Hydroids is that of Bale (1924), and in this only half a page is allotted to the gymnolastic forms. This interesting division has been little studied in New Zealand, and there are a few matters omitted by Bale which are here brought to notice.

HEMITHECA INTERMEDIA Hilgendorf (1898, p. 202).

Bale has apparently missed an important reference to this interesting transitional form. Its author noted that the genus "markedly partakes of the characters of both gymnolasts and calyptolasts," but the "irretractability of the zooids, and the conical hypostome, with its single row of tentacles," led him finally to refer it to the Family BOUGAINVILLIIDAE of the GYMNOLASTEA. Bale is content to leave this opinion and location unaltered, but there is an important discussion of the genus by Stechow (1913, p. 23) where a different conclusion is reached. In a resumé of the Family HALECHIDAE, Stechow remarks:—

"The important genus *Hemitheca* seems to be more nearly related to the HALECHIDAE than to the BOUGAINVILLIIDAE. Its thecae, to be sure, have not the typical form of this Family; its hydranths, on the other hand, resemble *halecium* throughout. Since, however, they all show the sharp jointing of stem and twig, which in no *athecate* genus is so well marked, this form indubitably belongs to the *Thecata*. I give a new figure [in text] of this interesting form from an original drawing kindly lent to me by the author, F. W. Hilgendorf, for which I give him my best thanks." [translation].

Stechow, therefore, places this curious genus in the HALECHIDAE, between *Hydranthea* Hinks, 1868 and *Melicertum* Oken, 1835 (1913, p. 41).

Family CLAVIDAE.

This name is untenable, since the genus name *Clava* Gmelin. is preoccupied. It dates from 1791 (*Linn. Syst. Nat.*, ed. 13, pt. 1, p. 3131), while Martyn had already proposed the name *Clava* for a genus of gastropods in 1784 (*Univ. Conch.*, vol. 1, fig. 12). This has probably been overlooked by recent systematic writers on Hydroids, such as Stechow and Kirchenpauer, for Martyn's name has only lately gained wide recognition, and is omitted from Sherborn's *Index Animalium*, Pt. I. (though included at the end of the volume, and in Pt. II.).

Stechow (1913, p. 39) has given a tabular arrangement of the CLAVIDAE, including twelve genera. The name *Rhizogeton* Agassiz, 1862 (monotype *R. fusiformis* Ag.) is usually considered, and is given by him, as equivalent to *Clava* Gmelin, 1791 (not in 1788, as he gives). If this is really so, it must now displace it. There are no New Zealand species of *Clava* at present, but von Lendenfeld described an Australian species (1884, p. 349) as *Clava simplex*, from Port Jackson. This has lately been dealt with and figured by Stechow (1925, p. 197), who retains it in *Clava*. It should become *Rhizogeton simplex* (von Lend.), unless the specific name also is preoccupied; it is quite likely that the combination *Clava simplex* already existed for a shell when von Lendenfeld chose it for a Hydroid. I have shown (*Trans. N.Z. Inst.*, vol. 57, p. 516, 1927) that the reverse case has occurred, the name *Turris neglectus* having been proposed for both a shell (Suter, 1917) and a hydroid (Lesson, 1837). Conflict from this cause is liable to occur in specific names in both these genera. Stechow in his earlier tabulation of the CLAVIDAE (1909, p. 10) allowed *Turris*, *Clava* and *Rhizogeton* separate generic rank, but, as in the case of *Clava*, *Turris* Lesson, 1837, is preoccupied by *Turris* Mueller, 1766, also for a gastropod, and by several other authors. However, in his second list, Stechow (1913, p. 39) has replaced *Turris* by *Clavula* Wright, 1859, probably on this account.

Of the generic names included by Stechow in the CLAVIDAE, the earliest are "*Cordylophora* Allman, 1844," and "*Corydendrium* van Beneden, 1844." But the former, according to Sherborn, was published in 1843 (*Proc. R. Irish Acad.*, ser. 2, vol. 40, p. 395), and is thus the earliest valid generic name in the Family. I therefore propose to replace the Family name CLAVIDAE by that of CORDYLOPHORIDAE. I base this action on the sanest, and now almost universally adopted procedure whereby the earliest genus-name in any Family automatically provides the derivation for the Family name.

Amongst the other genera given by Stechow as belonging to this Family are two more preoccupied names: *Crypta* Fraser, 1911 (*non* Gray, 1850, *nec* Stephens, 1830, *nec* Humphrey, 1797), and *Balea* Nutting, 1906 (*non* Agassiz, 1846, *nec* Turton, 1831, *nec* Gray, 1824), the earlier names being again in these cases given to gastropods. The replacement of these names may be left to those more directly interested.

CORDYLOPHORA FLUVIATILIS Hamilton, 1883.

The genus *Cordylophora* should not only be made the basis of the Family name, but should also be credited with a New Zealand species. All reference to this has been omitted by Bale. Yet a name for it exists, and, as it is on a somewhat doubtful standing, I propose here to validate it.

Augustus Hamilton has recorded (1883, pp. 419, 420) the discovery of a *Cordylophora* in the "Petane (Esk) River, Hawke's Bay, at a point near to the Napier-Taupo road, and about a mile from the place where, under ordinary circumstances, the river flows into the upper portion of the Napier Harbour." As this journal is somewhat difficult of access, I quote the essential parts of his description:—

"Being now in brackish water . . . I saw some rotten leaves of raupo covered with an interlacing network. . . . The animal contained in the little horny tubes differed chiefly from *Hydra* in having a firm outer case or coenosarc. . . . The tentacles . . . presented the same granulated appearance as those of the common *Hydra*. . . . The polypite is, in shape, that of a more or less elongated oval, having . . . from 15-20 tentacles, varying in length, disposed irregularly round it. The . . . neck is inserted into a chitinous tube. . . . I collected several colonies with gonophores in all stages . . . the fully developed gonophore containing the oval-shaped embryos."

"Professor Allman . . . thus describes the species most closely resembling the specimen under notice:—*Cordylophora lacustris*." [Allman's description in Ann. Nat. Hist., vol. 13, p. 330 follows].

It has been considered that Hamilton was merely reporting the English *lacustris* from New Zealand, but his next paragraph makes this highly doubtful, and needs close attention.

"Its name is a rather unfortunate one for a New Zealand species, as in the first place we have no newts, and in the second *fluviatilis* would be more appropriate for the description of the habitat. However, when the Marine Hydrozoa come to be worked up in this country, I have no doubt but that this beautiful little species will be duly recognised and stand in the proper place with an appropriate name, and that the above title will be given as its equivalent. This is, as far as I am aware, the first record of this species south of the line, and adds another to the long list of species represented by identical forms in both the northern and southern hemispheres."

Although this is confusedly written, no other scientific interpretation is possible but that *Cordylophora lacustris* Hamilton is a validly proposed specific name. It is evident that he was doubtful of the application of the name *lacustris* to our species, and, if he could have rejected it with certainty, would have proposed *fluviatilis* as a definite new species. Under the present rules of nomenclature, his name can only be construed as covering two distinct species (*lacustris* Allman, and the New Zealand species), which are separately defined; and under these same rules any subsequent writer is at liberty to select one of these species as having a right to the name. I therefore here define the name *Cordylophora fluviatilis* Hamilton as applicable to the New Zealand species of *Cordylophora*, living in the Petane River (and probably many other localities in New Zealand). In the absence of minute comparative specific details (as is frequent with the older writers), I accept the definite locality as of specific value, as is done by palaeontologists, noting also that Allman states that the large *C. lacustris* has "hydranths with about sixteen tentacles," while Hamilton's species, though much smaller, has 15-20 tentacles.

Hamilton's record has been practically passed over. Farquhar (1895, p. 209) notes it and says that "Mr. Hamilton doubtfully identified [it] as the European form *C. lacustris*, quoting Professor Allman's description of the genus. It is more likely to be identical with the Australian species *C. whiteleggei* v. Lendenf. (*Zool. Jahrbücher*, bd. ii., p. 97, 1886). When rediscovered, however, it will probably prove to be distinct from both the European and Australian forms."

The original description of *C. whiteleggei* is unfortunately not available in New Zealand, nor have I been able to find any mention of it in Australian literature. Stechow (1912, pp. 343-347) gives a long discussion of *C. lacustris*, and its geographical occurrence as fully as known, with about forty references to literature. He notes as synonyms only *C. albicola* Busk and *C. whiteleggei* v. Lend.; other workers, in Germany, Holland, Denmark, Sweden, Belgium, France, Russia, Africa, and America, have been content to identify their discoveries as *lacustris*. He includes Farquhar's record with a query, and says of *C. albicola* and *C. whiteleggei*. "The material from the freshwater lake [west of Halle, Saxony], sent to me in large quantities, is only a little ramified, of small habit, not over 8 mm. high, and seems from the appearance of the periderm to be of the type of *C. albicola*, which in the opinion of Allman, Schulze, and Bedot is only a variety of *C. lacustris*. Also *C. whiteleggei* v. Lend. (1886) agrees from the description and figure so well with my material from the lake at Halle that at the most it can only be placed as a variety of *C. lacustris*, but altered in some other direction than Kirchenpauer's var. *albicola*." [translation]

If *albicola* from Saxony (the type is from the R. Elbe, England) is small and less ramified than the English *lacustris* and varies into it, and if *whiteleggei* is classed by so keen an observer as Stechow as practically indistinguishable from *albicola*, there is certainly some support for the opinion that *Cordylophora* is a world-wide genus containing only one species. Stechow judged only from figures and descriptions, and this is notoriously unsafe; but still it is quite evident that before the status of the New Zealand species can be finally fixed and descriptive work attempted, it will be necessary to compare it very carefully with *whiteleggei* and *albicola*. I am averse to giving New Zealand species English names where the identity is not absolutely proven, but it seems to me highly probable that *C. fluviatilis* Hamilton will at least become a synonym of the Australian *C. whiteleggei* v. Lend., as Farquhar suspected.

Hedley (1912, p. 141) has described an ecological assemblage (a freshwater gastropod *Potamopyrgus ruppiae* Hed.; a freshwater mussel *Stavelia suborta* Dkr.; and the marine grass *Ruppia maritima* Linné) from the Deewhy brackish water lagoon near Manly, Port Jackson. This invites comparison with that noted by Hamilton, and tempts one to suggest that search there for a *Cordylophora* might not go unrewarded. The original locality for *whiteleggei* was the Parramatta River, Sydney, so that "*fluviatilis*" would be as appropriate in Australia as here, and the identity of the two is rendered still more probable.

The only other species of *Cordylophora* that I have been able to trace are *C. pusilla* and *C. annulata*, both of Motz-Kossowska, 1905 (*Arch. Zool. exper.*, pt. 4, vol. 3, pp. 63 & 66). Both of these are, however, subsequently referred to *Tubiclava* by Stechow (1912, p. 343; and 1919, p. 10).

Thus *C. lacustris* Allman still remains the only species of the genus universally recognised as valid.

I wish to express my thanks to Mr. Speight, Curator of the Canterbury Museum, for kindly lending me the type of *Tubiclava rubra* Farq. for study; also to Dr. Stechow and Mr. Bale for the very generous gift of much literature.

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REVIEW.

Contribution a l'étude des Nudibranches Néo-Calédoniens, by Jean Risbec,
Docteur ès-sciences.

[Paris: Societé d'Editions Géographiques, Maritimes et Coloniales, 1928]

Nudibranchiate Molluscs are the despair of every malacologist as, owing to their soft shell-less bodies they cannot be easily preserved, and, while in nature they are naiads of exquisite beauty, their spirit-conserved corpses are wretched, shapeless, disappointing, not to say disgusting, caricatures of their former splendour.

The only method of treatment yet determined is the one followed by Dr. Risbec in their pursuit, and in the preparation of this fascinating volume. It needs an enthusiast of the first order to spend endless hours searching rock pools, or dredging, in the hope of seeing one or two of these slugs, then collect, keep alive until paintings are made from nature, and then dissect and determine their relationship. Nothing must be allowed to distract the attention of the specialist from this task, and thus it is beyond the power of the ordinary student of the Mollusca to give these animals the attention they deserve.

The results, however, are fully commensurate to the sacrifice when viewed pictorially in such a beautiful production as the essay here noted.

Searching and studying the Nudibranchs of New Caledonia during a period of three years, Dr. Risbec has secured the amazing total of one hundred and one species, nearly all of them new to science. These are all well and clearly described and figured in colour, the important internal features being illustrated by drawings in the text. In addition to this necessary work an account of their habits, station and life-history is incorporated, as well as a review of the general classification of the forms studied and the conclusions thereby arrived at.

As a work of reference, this book will prove invaluable, and the thanks of the Australian malacologists are due and are herewith tendered to Dr. Risbec for this interesting and very acceptable account of a rich and hitherto unknown fauna of a region so close to our land. Although Dr. Risbec suggests that the species are very local and will therefore possibly not occur on the Australian coast, there can be little doubt that many of the forms will later be identified on the Great Barrier Reef. The fauna of the outer edge of that enormous coral formation shows a very close relationship as regards the Mollusca to that of New Caledonia. It remains to be noted that in addition to 328 pages of text, four plain plates, one map, nearly one hundred text-figures, illustrating some hundreds of dissections, there are twelve coloured plates, showing the external features and form, the whole constituting a work which commands the envy of the Australian malacologist, and publication of which demands our congratulations of the most sincere kind.

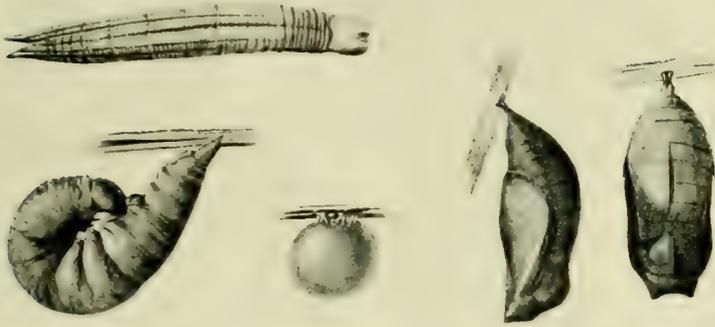
TOM IREDALE.

THE GREAT BARRIER REEF.

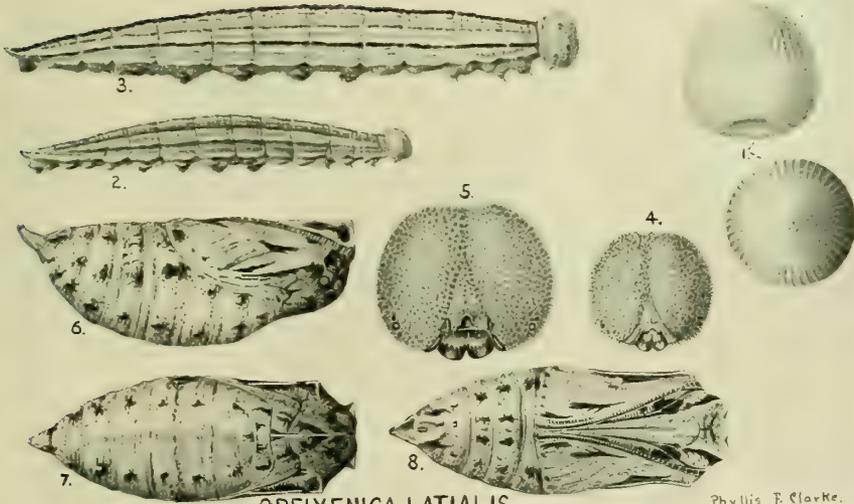
Much publicity has recently been given to the remarkable natural feature of the North Queensland coast known as the Barrier Reef, owing to the investigations now being carried out by the British scientific party. There are, however, some misconceptions as regards this feature, and the nature of the investigations to be carried on, owing to the tendency to speak in general terms of the "Barrier Reef," when the "Barrier Reef Region" is intended. The "Great Barrier Reef" is rarely seen by any of the numerous writers who use the term as a heading to their articles. This submerged wall, facing the deep waters of the Pacific, only shows portions of its surface at low tide; at other times its presence is merely indicated by a line of white breakers. The islands, atolls, and cays which are most visited lie well within the Barrier—often from ten to forty miles inside. Those most often visited and which form the subject of newspaper and other accounts are at the extreme southern limit of the Barrier.

The conception of the Barrier Reef Region by writers (in extra-Australian magazines) is largely imaginative, though based on extracts from Saville Kent, mixed up with articles describing the West Indian coral reefs, and interwoven with the special fancy of the writer. Thus a writer in an American magazine speaks of the glassy calm of the coral seas! Any traveller through these seas will testify that they are more often rough and even tempestuous than calm.

Here is a delightful example of the "stuff" that one writer on "The Great Barrier Reef" feeds to an Australian journal: "Commercially useful in making lime, coral has little value otherwise; but in olden times it was classed among the most precious gems, and fabulous sums were given for it . . . by the people of India and other eastern nations. The Romans, too, valued it for ornamental uses, and children wore necklaces of it as a reminder that coral stood for purity, and their aim in life was to attain a pure and moral character." This writer has some hazy idea, apparently, that the gem coral of the Mediterranean is common to the Barrier Reef!



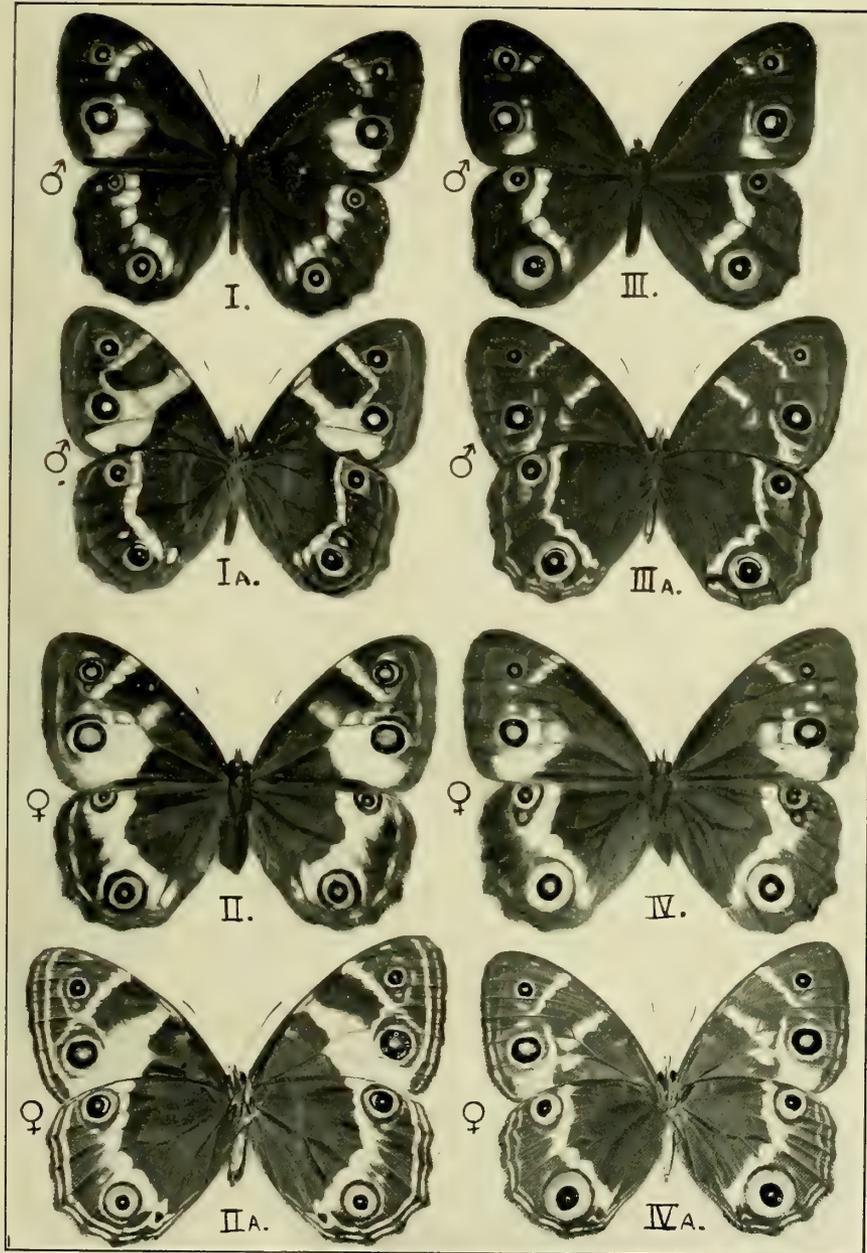
TISIPHONE ABEONA.



OREIXENICA LATIALIS.

OREIXENICA LATIALIS.

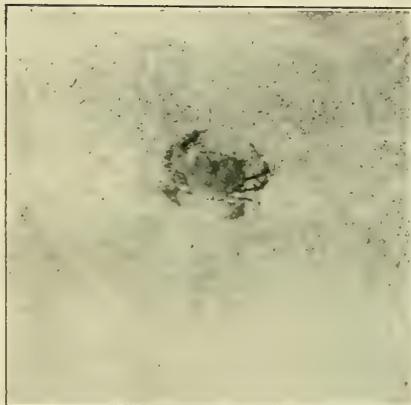
Phyllis F. Clarke.



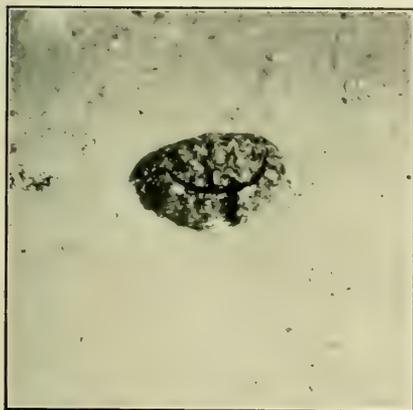
TISISPHONE REGALIS and T. MORRISONI.



Crimson Land Hermit Crab, *Coenobita perlata*, carrying a "Tun" shell (*Tonna perdx*).



The little Swimming Crab, *Portunus (Achelous) granulatus*, a nomad of the Beach Zones.



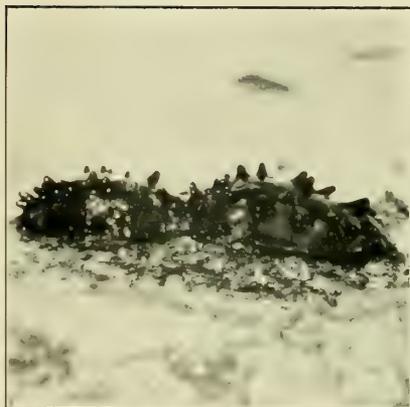
The Box Crab, *Calappa hepatica*, common on some of the Mud Zones.



The Red-eyed Rock Crab, *Eriphia sebana*, the largest of the common Crabs, in typical fighting pose.



Edible Holothurian, found on the Coral Sand Zone.



Holothurian, resting upon the surface of the Reef Crest.



The Alcyonarian *Xenia*.

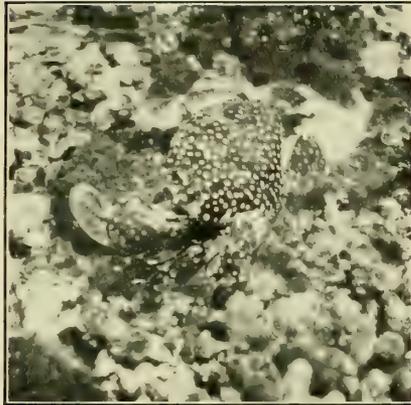
Amongst the waving filaments of the Coral the little Crab, *Caphyra laevis*, has its home.



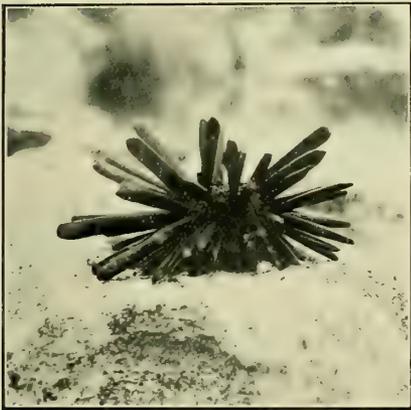
Small Wobbegong Shark, *Orectolobus devisi*, found under heads of Coral on Sand.



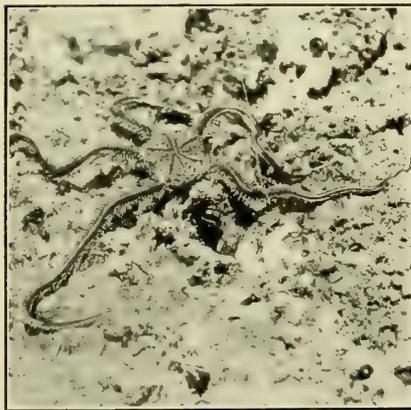
Spiny Lobster, *Palinurus versicolor*, a dandy of the Reef Crest, whose emerald-green body is lined with yellow.



The large Reef Crab, *Lophozozymus octodentatus*, a denizen of the Niggerhead Zoue on the Reef Crest.



The Slate Pencil Urchin, *Heterocentrotus mamillatus*, under Niggerheads.



Ophiarachna incrassata, the largest of the Brittle Stars, matching the Spiny Lobster in colour.



MACROPUS ROBERTSONI'S ROBUSTUS Gould
Male.

Photograph by E. B. Studios, Sydney.

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THE SOCIETY'S JUBILEE.

Fifty years ago, on 24th March, 1879, a meeting was held at the Chamber of Commerce, Sydney, His Worship the Mayor (Mr. C. J. Roberts) being in the chair. At this meeting it was resolved, on the motion of Mr. Walter Bradley, seconded by Mr. Edward Lee: "That a Society be formed, to be called The New South Wales Zoological Society, consisting of life members at £5/5/- and annual subscribers of £1/1/-, for the introduction and acclimatisation of song birds and game, and for other objects set forth in the prospectus."

A grant of £500 was made by the Government, augmented by private donations, and steps were taken to import pheasants, Californian quail, English song larks and salmon ova. Early in 1880 plans were drawn up for the erection of aviaries and a keeper's residence, in Moore Park, on the enclosure known as "Billy-goat Swamp." In July, 1880, the City Council granted a lease of the area to the Council of the Society, and the preparation of the ground and erection of the necessary buildings was proceeded with. From this modest beginning the Society gradually expanded until in a few years the small but well-laid out Zoological Gardens at Moore Park formed one of the attractions of the city. The Gardens were opened to the public in 1884, under the direction of Mr. Catlett, who held office as secretary until his death in 1903. Mr. A. S. Le Souef succeeded him, and directed the gardens during the remainder of their existence on the Moore Park site.

By the granting of additional areas up to a total of 11 acres the City Council did much to allow of the improvement of the Gardens, but after twenty years of gradual expansion it was felt that the site was too small and not ideally suitable for the purpose. Efforts made to interest the Government in the Society's aims at last met with a full measure of encouragement, and in 1911 the Council was offered a choice of several sites in the neighbourhood of Sydney. The committee appointed to inspect these sites unanimously reported in favour of a large area near Bradley's Head, on the northern shore of Port Jackson, and this area was set apart for the purpose by the Government.

From the Council of the Society seven members were selected at the request of the Government for appointment as Trustees of the new site. These included the two Government representatives, the Hon. Fred. Flowers, M.L.C., and the Hon. Harry C. Hoyle, at that time Treasurer in the Holman Ministry, Dr. R. H. Todd, Col. A. Spain, Messrs. A. E. Nash, W. J. Green, and J. M. Smail. Operations in preparation of the site were commenced, and by the end of 1913 £6,000 had been expended. The area was fenced, partially cleared, and planted with about 2,000 trees, shrubs, palms and ferns. By the beginning of 1916 the aviaries and enclosures for the various animals were nearly completed. In order to prepare for the transfer of the Society's collection of animals and plant to the Trust, the Rules of the Society were amended to give the Council the necessary powers, and on 13th July, 1916, the transfer was made in consideration of an agreement under which the Trust authorised the Society to issue passes and admission tickets to the Park to its members, not exceeding 300. Provision was also made for the Society's library, and a room for meetings in the Park offices.

The Society then proceeded to register under the Companies Acts as an Association not carrying on business for profit, and it was duly registered on 19th July, 1917, the right to the prefix "Royal" having been duly granted. From the date of the transfer of its collection of animals, the Society has devoted its energies

to the promotion and advancement of the science of zoology. To that end it has published five volumes of "The Australian Zoologist," comprising upwards of 1,500 pages, 190 plates (some in colour) and 150 text-figures. Two monographs have also been issued: "The Fishes of New South Wales" (two editions), and "The Australian Loricates," both profusely illustrated, and published at prices within the reach of all.

Sections have also been established for the intensive study of various branches of our science, namely, the Entomological, the Ornithological, the Marine Zoological and the Biological Sections. The monthly meetings of these Sections are largely attended by ordinary and associate members, many of whom are doing good practical work in the field and cabinet.

Congratulations.

The congratulations of the Council are extended to Drs. G. A. Waterhouse and I. M. Mackerras upon their appointment to the Commonwealth Bureau of Entomology, and to Mr. W. R. B. Oliver, upon his appointment to the important position of Director of the Dominion Museum, Wellington, New Zealand. Dr. Waterhouse is a life member of this Society, and his active service commenced as a member of the Council of the original Society. Upon its incorporation he occupied the positions, in succession, of honorary treasurer, honorary secretary, and president. He had accepted the position of honorary secretary for a second time this year, but his appointment necessitating his removal to Canberra, he had to relinquish that position. His activity in establishing and conducting the Entomological section has been attended with most gratifying success, and his contributions to *The Australian Zoologist* have been of the greatest scientific interest. In the new field of endeavour, Dr. Waterhouse will no doubt find a congenial atmosphere and a wide scope for the exercise of his scientific energies. Dr. Mackerras has been a member of the Society for some years, and has done much useful work in connection with the Biological Section. Mr. Oliver is an associate member of the Society. His contributions to science have mostly appeared in the Transactions of the New Zealand Institute, and include papers on botanical, ecological, and malacological subjects.

Further Representation on Taronga Park Trust.

The vacancy caused by the death of the Hon. Frederick Flowers, M.L.C., chairman of Taronga Park Trust, has been filled by the appointment of Mr. Aubrey Halloran, B.A., LL.B. Mr. Halloran is a life member of this Society, a member of Council, and a past president. His association with the Society commenced many years ago, and he has at all times been a most active member.

New Members.

The following new members have been elected since the publication of the last list (August 17, 1928):—

Life Member.—E. L. Troughton.

Ordinary Members.—Professor W. J. Dakin, John W. Fell, W. B. Foy, R. Fallick, J. A. Ferguson, Mrs. C. F. Hill, Guy H. Heath, H. G. Kilby, F. E. Morgan, A. J. McDowell, C. L. McDonald, Geo. Robertson, H. A. Sagar, W. H. Sagar, H. Tanner.

Life Associate Members.—Dr. C. E. R. Bucknill (New Zealand), Dr. E. Newton Drier (New Zealand), Dr. H. J. Finlay (New Zealand), Dr. W. D. R. MacGillivray (Broken Hill).

Associate Members.—Miss M. Boyd, Miss M. Fuller, B. E. Gostelow, G. R. Gannon, A. Gwynne, K. A. Hindwood, C. E. Witheford, Rev. B. J. Weeding.

A CHECK LIST OF THE AUSTRALIAN BUPRESTIDAE.

By H. J. CARTER, B.A., F.E.S.

With Tables and Keys to Sub-families, Tribes, and Genera, by ANDRE THERY,
Correspondant de Muséum de Paris; and Figures (Plates xxxi. to xxxiii.)
drawn by CEDRIC DEANE, A.M.I.E. (Aust.)

PREFACE.

The Catalogue of Australian Coleoptera, published by Masters, in 1886, enumerated 34 genera and 412 species of BUPRESTIDAE, but omitted any reference to Sub-families or Tribes. The present Check List is arranged under two Sub-families, seven Tribes, ten Sub-tribes, forty-eight Genera, ten Sub-genera, and contains the names of 812 species. This increase in the number of recorded species has been accompanied in recent years by a numerous list of synonyms, due to the great amount of uncoordinated systematic work that has been done in this attractive family of insects. This regrettable feature in the systematic work of entomology would be less prevalent if authors would always append a note to their descriptions stating the nearest allies to the alleged new species, with the special characters that differentiate such species from these allies. Such a note at least suggests reasonable care, and some knowledge of the group in question on the part of the author.

The range of each species, so far as at present known, is given, the following abbreviations being used:—A.: Australia generally. N.S.W.: New South Wales. N.Q.: Northern Queensland. N.A.: Northern Australia. N.W.A.: North-western Australia. Q.: Queensland. S.A.: South Australia T.: Tasmania. V.: Victoria. W.A.: Western Australia. Woodlark Island has been included in the Australian region, as well as Banks Island and others that are mere outliers of the Continent.

Thirty-one out of forty-eight Genera in our List of Australian BUPRESTIDAE are endemic, *i.e.*, above 65.5 per cent. This is a smaller proportion than the 75 per cent. of the TENEBRIONIDAE, but the habits and structure of the BUPRESTIDAE account for this. The larvae, in general, being wood-borers, are able to be conveyed in mercantile timber, or to float great distances by sea, while the imago possesses strong powers of flight. I have recorded the capture of living specimens of the North American *Buprestis aurulenta* L. in Victoria and New South Wales, evidently from imported timber. As to the powers of flight, my daughter captured specimens of *Merimna atrata* on the deck of s.s. *Montoro* which ran ashore on a coral sandbank in Torres Strait. In this case the beetles were attracted by the searchlight of H.M.S. *Geranium* which stood by during the night. This sandbank was at least fifty miles from the mainland, the presumable home of the beetles.

The six Genera most largely represented by species are:—

<i>Stigmodera</i> (Sub-genera <i>Themognatha</i> and <i>Castiarina</i>)	333 species.
<i>Melobasis</i> (Sub-genera <i>Briseis</i> and <i>Diceropygas</i>)	74 species.
<i>Cisseis</i> (Sub-genera <i>Hypocisseis</i> , <i>Pachycisseis</i> and <i>Neospades</i>)	74 species.
<i>Neocuris</i>	34 species.
<i>Astraeus</i>	23 species.
<i>Agrius</i>	20 species.

Of these six four are endemic, while of the other two *Melobasis* only extends to the Austro-Malay regions, with a few individuals in Oceania; *Agrilus* is world-wide. While including the very large *Stigmodera* group in the endemic genera, Monsieur Théry has sent me for examination a few undescribed species as from New Guinea. It is notable that the South American genus *Conognatha* is the nearest relation to *Stigmodera*, while of the neighbouring genus *Curis*, there exist at least four species in South America.

The following table shows the range of our Genera that are not confined to Australia:—

	Europe.	Asia.	Africa.	America.	Oceania or Indo-Malay		Europe.	Asia.	Africa.	America.	Oceania or Indo-Malay
<i>Agrilus</i>	*	*	*	*	*	<i>Polycesta</i> . . .			*	*	
<i>Aphanisticus</i>						<i>Melobasis</i>					
<i>Endelus</i>	*	*	*	*	*	and S.G. . . .					*
<i>Habroloma</i> and						<i>Calodema</i> . . .					*
<i>Trachys</i>	*	*	*	*	*	<i>Metarymorpha</i>					*
<i>Mastogenius</i> . .				*	*	<i>Curis</i>				*	
<i>Belionota</i> . . .		*	*		*	<i>Cyphogastra</i> .					*
<i>Chrysobothris</i>	*	*	*	*	*	<i>Chrysoderma</i> .	*				*
<i>Castalia</i>		*			*	<i>Paracupta</i> . . .					*

The following Genera have disappeared from Australian lists since the publication of Masters' Catalogue:—

Chalcophora. This in Masters' Cat. included the whole Tribe *Chalcophorini*.

Eurybia. Erroneously used for the earlier *Euryspilus*.

*Cinyra**. Erroneously used for *Cisseis*.

Anthaxia. Erroneously applied. See App. for possible Aust. record.

Notograptus. Mis-spelling for *Notographus*.

Conognatha. No. 2737 Masters' Cat. is an *Astræus*.

Coræbus. The 3 spp. in Masters' Cat. are *Neospades*, *Hypocisseis* and *Cisseis* respectively.

Discoderes. Doubtfully applicable.

Acherusia. No. 2978 Masters' Cat. is a Brazilian species.

Sphenoptera. Erroneously applied to species now *Neobuprestis*.

* *Cinyra spilota* Hope (Macleay MSS). Mr. Blair writes: "I have seen the alleged type bearing this label in the Hope Coll. The specimen is *Cisseis bicolor* C. & G. The description does not fit this species, and I can only conclude, either that the label has been misplaced, or that Hope had hold of the wrong insect when writing his description. Walker sends the type of *C. signaticollis* suggesting that the labels have been transposed, as the description appears to fit this insect as well as anything, but the description of *C. signaticollis* undoubtedly fits the type. As these markings, with the pair of discal white spots on the thorax are comparatively rare in the genus, and the spots are more often than not missing in *signaticollis*, it rather seems as though Hope must have described the same insect twice. If we can assume this, I think the best thing will be to sink the name *spilota* as a synonym of *signaticollis*."

Classification (by ANDRE THERY.)

A study of the general classification of the BUPRESTIDÆ of the world that I have recently carried out lead me to the following conclusions:—

The classification of organic life is subject to two laws:—

1. The non-reversibility of acquired characters.
2. The progressive development of such in phyletic branches.

It follows from this that highly differentiated form, having acquired special characters, not phyletic, cannot give birth to a form deprived of these characters. For example: *Metaxymorpha* could not have given birth to *Stigmodera*, whilst the contrary is possible; a further result is that the large species of a family are the summits of the phyletic branches, consequently the more recent, while the smaller species are the more ancient.

It is rational that a classification should commence with the more archaic forms and pass on to the more recent.

The characters which indicate primitiveness in the BUPRESTIDÆ are:—

In general, small size. The pores of the antennæ concentrated in foveæ on the toothed segments. Prothorax more or less bordered.

The sternites of the abdomen are bordered by rectangular plates (pleural plates) separated from the sternite by a furrow, or simply bordered.

Consequently a classification should exhibit the progress of the evolution of the group by commencing with the lower forms and terminating with the higher.

Classification of Australian BUPRESTIDÆ.

Sub-families.

1. Antennæ having the pores concentrated in a fovea on the toothed segments (primitive forms) BUPRESTINÆ.
2. Antennæ having the pores distributed over both surfaces of the toothed segments (recent forms) CHALCOPHORINÆ.

I. BUPRESTINÆ.

Key to the Tribes.

1. Scutellum not at all covered by pronotum, anterior femora generally unarmed, eyes never converging on vertex 2.
Scutellum inserted under pronotum, not abruptly terminated at its margin: eyes strongly converging on vertex, or, if not, the anterior femora strongly dentate on their internal edge 3. CHRYSOBOTHRINI.
2. Forehead not narrowed between the antennal cavities, these placed near the border of the eyes 3.
Forehead narrowed between the antennal cavities, these close together. 1. AGRILINI.
3. Pronotum bordered for the greater part by a carina, its posterior border more or less sinuous, rarely straight 4.
Pronotum bordered by two lateral carinae, its base truncate 2. MASTOGENINI (*).
4. Mesosternum divided or subdivided, meso-metasternal suture entire or interrupted 5.
Mesosternum entire, the base of the sternal cavity not touching the anterior border of the metasternum 4. POLYCESTINI.
5. Labrum short, transverse, truncate or bilobed, the mouth not produced into a muzzle; mentum transverse, short 5. BUPRESTINI.
Labrum rather long, or longer than wide, rounded or subacuminate in front, overlapping the mandibles, the mouth produced into a muzzle; mentum wide, rounded 6. STIGMODERINI.

(*) In the *Mastogenini* the antennal cavities converge more strongly than in the *Polycestini* and less so than in the *Agrilini*. They are easily recognised by their truncate base of pronotum.

I. AGRILINI.

Table of Sub-tribes.

1. Intermediate coxae rather close, front margin of posterior coxae very concave, their lateral branches continued between the sides of metasternum and the lateral prolongation of the abdomen; tarsi more or less elongate . . . *Agrili*.
2. Intermediate coxae distinctly more widely separated than the anterior; front margin of posterior coxae scarcely concave; tarsi very short . . . *Traches*.

A. *Agrili*.

1. Eyes large, touching the pronotum 2.
Eyes small, situated at some distance from the pronotum 9.
2. Prosternum without "mentonnière" (*) or with a very short one, generally with two lateral lobes; suture of the two first abdominal sternites visible; first segment of the posterior tarsi scarcely as long as the following two combined 3.
Prosternum with large mentonnière, entire or sinuate; suture of two first abdominal segments invisible, at least in the middle; tarsi long, their first segment at least as long as the following three combined *Agrilus*.
3. Antennae dentate from the 5th segment onward (**). 4.
Antennae dentate from the 4th segment onward, pronotum never furrowed. 5.
4. Very elongate, depressed, pronotum flat, forming a disc, prosternal process separated from the anterior margin of the metasternum and compressed between the branches of the mesosternum *Synechocera*.
Moderately elongate, pronotum strongly furrowed longitudinally or very uneven, surface irregular, prosternal process touching the metasternum. *Alcinous*.
5. Antennae in repose partly received within a genal scrobe (groove), situated between the genal tooth and the eye, thence free 6.
Antennae completely free, no genal scrobe, forehead cleft in front throughout its whole length *Ethon*.
6. Forehead almost flat or very deeply furrowed throughout, pronotum convex, even 7.
Forehead very uneven, with deep impressions, or fasciculate, pronotum very uneven, often without the upper carina S.G. *Hypocisseis*.
7. Forehead flat or lightly furrowed, tarsal hooks simply toothed at the base. 8.
Forehead deeply furrowed, tarsal hooks bifid S.G. *Neospades*.
8. Anterior margin of prosternum truncate, without trace of mentonnière. S.G. *Pachycisseis*.
Anterior margin of prosternum with short mentonnière, very strongly sinuate, or reduced to a lobe on each side of the anterior margin of the prosternum *Cisseis*.
9. Pygidium normal, not or scarcely extending beyond the elytra; epipleural fold of the elytra defined on its internal margin by a carina 10.
Pygidium with a conical apex strongly extending beyond the elytra and surmounted by a carina; forehead very convex, epipleural fold of the elytra not differentiated S.G. *Dinocephalia*.
10. Forehead simple, or feebly furrowed *Paracephala*.
Forehead cleft as in *Ethon* S.G. *Meliboethon*.

(*) Mentonnière has no equivalent English word and is applied to the advanced medial lobe of a bisinuate apical margin.

(**). In *Gen. Ins.* Kerremans erroneously gives the antennae of *Alcinous* as dentate from the 6th segment, though correctly in the original description.

B. *Traches*.

1. Antennae toothed before the 8th segment, not clavate 2.
Antennae toothed from the 8th segment, 8-11 forming a club . *Aphanisticus*.
2. Rather short, form more or less triangular and depressed above, margins of pronotum always more or less dilated, coloration metallic 3.
Form cylindric, coloration blackish, scarcely metallic *Germanica*.
3. Tarsi free in repose 4.
Tarsi received, in repose, in a cavity of the femora *Endelus*.
4. Form more or less triangular; elytra with a carina extending from the humeral callus towards the apex; prosternum with a well-developed mentonnière *Habroloma*.
Form more or less oval, elytra without carina, prosternum without mentonnière *Trachys*.

II. MASTOGENINI.

(Monotypic.)

Mastogenius.

III. CHRYSOBOTHRINI.

Key to Sub-tribes.

1. Third segment of tarsi simple, not extending beyond the fourth.
. *Chrysobothres*.
2. Third segment of tarsi deeply emarginate and terminated on each side by a long spine *Actenodae*.

A. *Chrysobothres*.

(Monotypic.)

Chrysobothris.B. *Actenodae*.

1. Eyes strongly converging on the vertex (subcontiguous), scutellum very long, anterior femora unarmed *Belionota*.
2. Eyes distant at vertex, scutellum short, anterior femora strongly dentate *Merimna*.

IV. POLYCESTINI.

Table of Sub-tribes.

- A. Metathoracic episterna exposed *Polycestae*.
- B. Metathoracic episterna completely hidden by the epipleuro-humeral lobe of the elytra, base of pronotum received under the elytra, covered with fine fluting corresponding to a similar fluting under the base of elytra. *Ptosimae*.

A. *Polycestae*.

1. Elytra denticulate at apex 2.
Elytra bidentate at apex, their disc regularly striate *Prospheres*.
2. The 2nd and 3rd segments of antennae equal, elytra without red markings. 3.
The 3rd segment of antennae much longer than the 2nd, elytra generally with a red marking *Castalia*.
3. Lateral prolongation of the abdomen hidden *Polycesta*.
Lateral prolongation of the abdomen exposed and partly concealing the epimera *Microcastalia*.

B. *Ptosimae*.

(Monotypic.)

Xyrosclis.

V. BUPRESTINI.

Table of Sub-tribes.

- A. Metathoracic epinera completely exposed, lateral prolongation of abdomen generally concealed, wholly or partly, by the elytra; poriferous foveae inferior or terminal *Buprestes*.
- B. Metathoracic epinera at least partly concealed by the lateral prolongation of the abdomen; poriferous foveae terminal *Anthaxiae*.

A. *Buprestes*.

1. Elytra not exposing the pygidium 2.
Elytra rounded at apex, rather short and normally exposing the pygidium, even in the male; elytral costae well marked *Neobuprestis*.
2. Scutellum distinct 3.
Without distinct scutellum *Astreeus*.
3. Posterior margin of elytra finely denticulate 4.
Posterior margin of elytra entire 5.
4. Pronotum rounded at sides, as wide as the elytra; these without distinct markings *Neobubastes*.
Pronotum cylindric, narrower than the elytra, these more or less with yellow or tawny markings *Nascioides*.
5. Entirely metallic, pronotum regularly convex 6
Surface varied with yellow, disc of pronotum very irregular *Nascio*.
6. Pronotum as wide at the base as the elytra 7.
Pronotum narrower at the base than the elytra; elytral apices more or less strongly tridentate *Notobubastes*.
7. Body oval, lightly convex 8.
Body cylindric, acuminate posteriorly 9.
8. Elytral apices conjointly rounded (*) *Buprestina*.
Elytral apices bidentate; surface brilliantly metallic *Buprestodes*.
9. Form robust, elytra striate punctate, with costae *Bubastes*. (**).
Form narrower, elytra with costae *Euryspilus*.

(*) . Teste Obenberger.

(**). The tribe BUBASTINI proposed by Obenberger is, we consider, not sufficiently characterized for retention.

B. *Anthaxiae*.

1. Last abdominal sternite excised between two strong spines 2.
Last abdominal sternite rounded or feebly excised 4.
2. Anterior margin of prosternum without lateral tubercles 3.
Anterior margin of prosternum with a tubercle on each side, form more elongate and more attenuate posteriorly S.G. *Briseia*.
3. Scutellum punctiform *Melobasis*.
Scutellum large and generally transverse S.G. *Diceropygus*.
4. Base of pronotum truncate 5.
Base of pronotum clearly bisinuate 6.
5. Size larger, form wide, margins of elytra raised, channelled within and explanate behind *Torresita*.
Size small, form parallel, not enlarged behind; elytral margin normal. *Anilara*.
6. Pronotum not furrowed, having its greatest width at, or near, the base . . 7.
Pronotum furrowed, constricted at the base and clearly cordiform. *Notographus*.

7. Head narrower than apex of pronotum, last segment of tarsi clearly extending beyond the 4th 8.
 Head wider than apex of pronotum, last segment of tarsi very short, not extending beyond the 4th *Theryaria*.
8. Forehead more or less furrowed or impressed, upper surface often glabrous and very brilliant *Neocuris*.
 Forehead convex, upper surface more or less pubescent and generally opaque *Pseudanilara*

VI. STIGMODERINI.

Table of Sub-tribes.

- A. Body cylindric, like that of the *Julodini*, tarsi wide, 1st segment of the posterior tarsi not longer than the following, the 5th very short, scarcely longer than the 4th; sternal cavity open, not enclosing the prosternal process which overhangs it without fitting into it. Female provided with a very long erectile ovipositor, strongly chitinized and armed; larvae probably earth-dwellers (*) *Julodimorphae*.
- B. Body depressed; 1st segment of posterior tarsi longer than the 2nd, the 5th elongate and clearly longer than the 4th; prosternal process fitting into the sternal cavity, that it fills completely, except sometimes at the base. Females provided with a sessile and unarmed ovipositor; larvae endophytes *Stigmoderae*.

B. *Stigmoderae*.

1. Prosternum very convex, forming in front a conical process 2.
 Prosternum flat or feebly convex, its anterior margin not forming a conical process 3.
2. Posterior margin of pronotum strongly bisinuate with a very prominent medial lobe; scutellum small *Calodema*.
 Posterior margin of pronotum feebly bisinuate, without a prominent medial lobe; scutellum large *Metarymorpha*.
3. Lateral prolongation of the abdomen hidden, not concealing or very slightly concealing the metathoracic epimera; apex of elytra variable, but never denticulate 4.
 Lateral prolongation of the abdomen clearly seen, more or less concealing the metathoracic epimera; elytra sometimes abbreviated, separately rounded and finely denticulate *Curis*.
4. Elytra striate or striate punctate, sometimes with costae
 Elytra hollowed out with large foveoles, sometimes (*S. cancellata* Don.) striate-punctate *Stigmodera*.
5. Tarsal hooks lobed and toothed at the base, size generally large
 S.G. *Themognatha*.
 Tarsal hooks simple, size generally small S.G. *Castiarina*.

(*) The larvae are found in the trunks as well as in the roots of the stunted Eucalyptus trees (mallee) of inland Australia. In the latter case they would have to bore through hard soil to emerge. [H.J.C. from observations by Mr. John Clark].

II. CHALCOPHORINAE.

Represented in Australia by the single tribe Chalcophorini.

Table of Genera.

- | | |
|-------------------------------------------------------------------------------------------------------------|----------------------------|
| 1. No scutellum visible | 2. |
| A scutellum visible | 3. |
| 2. Pronotum partly furrowed, apices of elytra simple | <i>Cyria</i> . |
| Pronotum furrowed throughout, apices of elytra bidentate | <i>Cyrioides</i> . |
| 3. Pronotum more or less furrowed or carinate, surface of body metallic | 4. |
| Pronotum even, without furrow; surface non-metallic and with some testaceous markings | <i>Diadoxus</i> . |
| 4. Intercostal process of the first abdominal sternite without prominent plate. | 5. |
| Intercostal process of the first abdominal sternite, with a prominent plate, rounded behind | <i>Cyphogastra</i> . |
| 5. Pronotum even or furrowed | 6. |
| Pronotum with a medial longitudinal relief | <i>Chrysodema</i> . |
| 6. Pronotum more or less distinctly furrowed | 7. |
| Pronotum even, without furrow, sometimes with a smooth longitudinal band (<i>quadrisignata</i>) | <i>Pseudotaenia</i> . |
| 7. Tarsi metallic | 8. |
| Tarsi testaceous | <i>Paracupta</i> . |
| 8. Elytra with discal impressions or entirely furrowed | S.G. <i>Chalcotaenia</i> . |
| Elytra with a single longitudinal furrow | <i>Iridotaenia</i> . |

Observations (by ANDRE THERY.)

In the classification of Kerremans, partly following that of Le Conte and Horn, the POLYCESTINI come immediately after the JULODINI—a group in which the pores are diffused over the two faces of the antennae—and immediately before the CHALCOPHORINI in which the antennae are similarly constructed. But since the POLYCESTINI have the pores concentrated in foveae on the toothed segments such a classification appears to me illogical.

Agrilini. *Synechocera elongata* Thoms. The author's description is so inadequate, that it seems useful to complete it, which I do, with a paratype of the author before me.

Long. 5-6 mm. Elongate, subparallel, depressed, wholly blue black with the pronotum dull, its sculpture very finely granulose, visible only with a strong lens; elytra rather nitid; antennae short, black.

Head convex, globular, eyes not prominent; without distinct punctures, narrowly and deeply incised longitudinally, but not furrowed; epistoma constricted between antennal cavities, these large; antennae with last six segments toothed.

Pronotum widest at anterior third, sides obliquely and strongly converging to the base, front margin strongly and angulately produced in the middle, obtuse, disc without impressions, but a little depressed transversely behind the anterior margin. Scutellum small, and round, with a transverse carina.

Elytra subparallel for the greater part; rather suddenly and arcuately converging at apex; without any marginal denticulation, and dehiscence at the suture; covered with series of large, punctiform impressions, with a rather strong ground sculpture. The pygidium does not extend beyond the elytra.

Alcinous. The antennae are here dentate from the 5th segment outwards, yet it seems advisable to include *Cisseis fossicollis* Kerr. in it, though the antennae are dentate from the 6th segment. (In *Cisseis* usually dentate from the 4th).

Ethon. This genus, usually placed very near *Cisseis*, is really rather widely removed by the following characters: head without genal scrube, lateral branches

of the mesosternum much reduced, compressed laterally and not contributing to the formation of the sternal cavity.

Cisseis. Contrary to the statement of Kerremans in his dichotomous table (Gen. Ins.), the antennae are not entirely free in repose and do not differ in this respect from those of *Hypocisseis* (*Cisseoides*). Also the sternal cavity is formed at base by the metasternum and laterally by the mesosternum.

Pachycisseis n. subgen. It is necessary to separate those *Cisseis* that are provided with a mentonnière from those that are without it, an important systematic character. After an examination of this subgenus established for *C. bicolor* C. & G., I discovered in one of my examples of this species an extraordinary development of the palpi (probably labial) which are as long as the antennae. This character has never, to my knowledge, been noted and makes this insect one of the most curious of the BUPRESTIDÆ. Out of eight examples, I have only found one provided with this character that I suppose belongs to the male. (Found in all male examples examined, H.J.C.).

Neospades. The species have no special facies that separate them generically from *Cisseis* of which *Neospades* may be considered a subgenus.

Hypocisseis. The close similarity of the tarsi, the similar possession of a genal scrobe for the reception of the antennae as in *Cisseis* and the existence of a series of passages between extreme forms suggests a relegation of *Hypocisseis*, also to subgeneric rank. Kerremans' observation as to the special dilation of the posterior coxæ is a mistake.

Paracephala. The genera *Dinocephala* and *Meliboeithon* of Obenberger can only be considered as subgenera of *Paracephala*, although their author makes no mention of the similarity of their facies to Thomson's genus. Moreover *Dinocephala gigantea* Oben. appears to be very near *Paracephala thoracica* Kerr., while *Meliboeithon fissus* Oben. probably does not differ from *Paracephala intermedia* Kerr.

The deep longitudinal furrow of the forehead is an archaic character which is found in all the genera of the Australian AGRILINI except *Agrilus*. This character is found sometimes in all the species of a genus, sometimes only in some; one cannot therefore regard it as an absolute generic character.

2. MASTOGENINI.

I have placed the MASTOGENINI near the AGRILINI, which they approach in the pronotum bordered by two carinae, but I find them still nearer the *Polycestini*, Sub-tribe *Ptosimæ*. They appear to have an evident relationship with *Sponsor*, on which I will expatiate elsewhere.

CHRYSOBOTHRINI.

Kerremans was mistaken as to the sternal cavity of *Belionota*. The meso-metasternal suture is quite or nearly perfect in many species. *Belionota* shows no special character in this direction.

POLYCESTINI.

I am not sure that there is any phyletic affinity between the two Sub-tribes *Polycestæ* and *Ptosimæ*, and their grouping under Polycestini may be artificial. I will endeavour to elucidate this later.

BUPRESTINI.

As will be seen from my tables, I have taken the disposition of the antennal pores as the principal character as appearing to me the most absolute. The form-

of the sternal cavity is not sufficiently constant. Thus in the JULODINI, certain species of the same genus (*Amblysterna*) have the mesosternum entire or completely subdivided.

In order to differentiate the BUPRESTINI from the STIGMODERINI, I find the characters indicated by Kerremans (the lateral branches of the mesosternum elongate or very short) impracticable. I therefore employ an important character hitherto unused though indicated—namely, the form of the mouth prolonged into a muzzle, the mandibles are little bent, the labrum is longer than wide, mentum the same, the maxillae have a very peculiar disposition and their lobes have a mass-like termination; further, they appear to be composed of a greater number of sclerites than with many other Buprestidae in which a certain number of these primary sclerites are soldered together. I have discovered that *Curis* has this same arrangement and ought, without any doubt, to be regrouped with the STIGMODERINI, a tribe localized in Australia and South America. I have been obliged to remove *Julodimorpha* from POLYCESTINI. The sternal cavity is not entirely formed by the mesosternum, and the meso-metasternal suture is divided, further the *Julodimorpha* are the only BUPRESTIDAE having the sternal cavity open, as with certain CERAMBYCIDAE; the females are furnished with an elongate ovipositor, strongly chitinized and armed at the extremity, which indicates that the habits of the larvae are more or less earthdwellers; as with the tribe JULODINI. The ovipositor of the females of *Julodimorpha* is wholly similar to that of the females of *Julodis* from the Cape of Good Hope which appears to indicate a relationship between these insects.

The POLYCESTINI have no ovipositor of this nature and there is no evidence that permits their association with *Julodimorpha*, but the latter have a probable connection with the STIGMODERINI, since they have a similar mouth structure and a certain similarity of facies.

I have suppressed the Sub-tribe *Dicercites* created by Kerremans; I have found no character that is peculiar to it. The inferior periferous foveae are found in the *Buprestes*. The genera *Pseudhyperantha*, *Ectinogonia*, *Trachykele*, *Poecilonota*, *Lampira*, *Neobuprestis*, *Cinyra* have not the eyes converging above as with certain *Buprestes*, on the other hand certain *Dicercites* of which the eyes are convergent above, as *Cardiaspis*, have a very large scutellum, quite different from that of the *Buprestes* and ought to form a special group. *Neobuprestis* has the first segment of the posterior tarsi longer than the second and its forehead is only slightly contracted at the vertex, especially in the male, but this character is found also in the *Buprestes* and since its facies approaches that of the *Neobubastes*, *Notobubastes* and *Bubastes*, I believe it preferable to place it near these.

ANTHAXIAE.

Pseudanilara seems rather near *Neocuris*, but has a very special facies, and certain small constant characters. The genus ought to be maintained.

STIGMODERINI.

I have not utilized the internal periferous foveae for separating *Calodema* from the STIGMODERINI, because this character is in general difficult to observe and it must be acknowledged that it often falls short of preciseness.

CHALCOPHORINAE.

I have suppressed the genus *Chalcophora* as not definitely belonging to the Australian fauna. One cannot, as I previously considered, remove *Chrysodema subfasciata* Carter to this genus for the following reasons. *Chrysodema* are merely southern forms of the genus *Chalcophora*, without any very decisive char-

acter to separate them from holarctic forms. This is moreover the opinion of Lacordaire who refused to separate the two genera, not being able to find appreciable limits between them. We shall preserve them, however, but on the condition of not introducing into the genus *Chalcophora* species unprovided with the characteristic facies of the holarctic species.

The genus *Chalcotaenia* differs from *Chrysodema* by the presence of a furrow on the pronotum—this furrow being replaced by a carina in *Chrysodema* as in *Chalcophora*. Morphologically there is no difference between a carina and a furrow—paradoxical as it may appear. The carina often originated at the bottom of a furrow, it is produced by the thickening at the suture of the two median sclerites of the pronotum. It is then probable that the forms furnished with a carina are the more recent, but the most recent of all are those in which the pronotum is perfectly even, without a trace of suture between the sclerites which have served to build it up. The form of the anterior margin of the prosternum which has been used to separate genera has little value, since we can show that it is not a constant character and that in *Chalcophora virginienis* Drury the interior margin of the pronotum does not differ from that of *Chrysodema subfasciata* Cart.

I have rejected the tribe CHRYSOCHROINI, admitted by Kerremans. To establish a tribe on the presence or absence of a scutellum is to give this character undue importance. Certain genera (*Chalcophora*, *Trachys*) include species furnished with a scutellum and others that are deprived of one. The absence of a scutellum is notable in groups in which the scutellum is reduced to a minimum. If one raises the elytra of a CHRYSOCHROINI one sees that this organ is simply shortened and does not reach the level of the elytra. In admitting this character one is led to placing in different tribes genera which have clearly the same phyletic origin.

Paracupta bellicosa Blkb. cannot, in my opinion, be retained in the genus in which it has been described, and would be better placed in the genus *Iridotaenia* Deyr. In this genus also we can admit, at least provisionally *P. albivittis*, though it may be necessary to create for this and some allied species a new genus.

Post-scriptum.

Jacobson has shown that the name *Buprestis* ought to revert to the genus that we call *Chalcophora*. From this would result a complete overthrow of our classification and that our Sub-family *Chalcophorinae* ought to take the name *Buprestinae*, and our Sub-family *Buprestinae* that of *Acylocheirinae*. This would be a regrettable disturbance in our system, and since the majority of authors have used the names *Chalcophora* and *Buprestis* as we thus defined them for nearly a century, we think it preferable to retain the *status quo*, as more inconvenience than advantage would result from the change.

Rabat. le 6 mai, 1928.

A. THERY.

Sub-family BUPRESTINAE.

Tribe AGRILINI.

Sub-tribe AGRILL.

AGRILUS. Stephens, Ill. Brit. Ent., iii., 1830, 239.

1. *anachetus* Obenb., Archiv für Naturg., 1924, 535. . . . Somerset, N.A.
2. *archaicus* Obenb., Zeitsch. für Wissen. Ins., 1916, 21. A.
3. *aurovittatus* Hope, Tr. Ent. Soc. Lond., 1846, 218. S.A.
4. *australasiae* L. & G., Mon., ii., 1839, 21. All States.
hypoleucus L. & G., l.c., 37; *assimilis* Hope, Tr. Ent. Soc. Lond., 1846, 217; *purpuratus* Hope, l.c.; *flavotaeniatus* Thoms., Typ. Bup. App. Ia., 1879, 73; *cooki* Obenb., Sbor. Ent. Mus. Praze,

- 1923, 77; *tasmanicus* Obenb., l.e.; *danesi* Obenb., l.e.; *domini* Obenb., l.e.; *raphelisi* Obenb., l.e.; *van diemeni* Obenb., l.e.
5. *australis* Thoms., Typ. Bup. App. 1a, 1879, 74 A.
 6. *bispinosus* Cart., Linn. Soc. N.S.W., 1924, 28 Johnstone R., Q.
 7. *brevis* Cart., l.e. Johnstone R., Q.
 8. *deauratus* Macl., Ent. Soc. N.S.W., 1872, 249. Gayndah, Q.
 9. *doddi* Cart., Linn. Soc. N.S.W., 1924, 28. Townsville, Q.
 10. *frenchi* Blkb., Roy. Soc. S.A., 1891, 302. V.
 11. *macleayi* Cart., Linn. Soc. N.S.W., 1924, 535. Cairns, Q.
 12. *mastersi* Macl., Ent. Soc. N.S.W., 1872, 249. Gayndah, Q.
 13. *nesigena* Obenb., Archiv. für Naturg., 1924, 127. Somerset, N.A.
 14. *nitidus* Kerr., Ann. Soc. Ent. Belg., 1898, 179. N.Q.
kurandæ Obenb., Sbor. Ent. Mus. Praze, 1923, 80.
var. *korenskyi* Obenb., l.e.
 15. *semiviridis* Cart., Linn. Soc. N.S.W., 1924, 29. Q. & N.S.W.
 16. *solemnis* Obenb., Archiv. für Naturg., 1924, 127. Somerset, Q.
 17. *terracreginae* Blkb., Roy. Soc. S.A., 1892, 220. Q.
 18. *walesicus* Obenb., Sbornik. Ent. Mus. Praze, 1923, 81. Tweed R., N.S.W.
 19. *woodlarkianus* Kerr., Mem. Soc. Ent. Belg., 1900, 82 Woodlark Is.
 20. *zonatus* Kerr., Ann. Soc. Ent. Belg., 1898, 180. A.
- SYNECHOCERA.** Deyr., Ann. Soc. Ent. Belg., 1864, 115.
21. *albohirta* Cart. (Aphanisticus) Arkiv. für Zool., 1920, 5. N.W.A.
 22. *cyaneipennis* Cart., Linn. Soc. N.S.W., 1924, 30. N.Q.
 23. *cupripes* Cart., l.e., 31. N.Q.
 24. *elongata* Thoms., Typ. Bup. App. 1a, 1879, 56. W.A.
occidentalis Macl. (Aphanisticus) Linn. Soc. N.S.W., 1888, 1227.
 25. *longior* Cart., Linn. Soc. N.S.W., 1928, 274. V., S.A., W.A.
 26. *setosa* Cart., l.e., 1924, 31. W.A.
 27. *tasmanica* Théry, l.e., 1923, 517. Tas.
- ALCINOUS.** Deyr., Ann. Soc. Ent. Belg., 1864, 115.
28. *fossicollis* Kerr. (Cisseis), Gen. Ins., 1902, 229. N.S.W., Q.
 29. *nodosus* Kerr., Ann. Soc. Ent. Belg., 1898, 175. Q., N.S.W., V.
minor Kerr., l.e., 176.
- ETHON.** L. & G., Mon. Bup., ii, 1839, 1.
30. *affine* L. & G., l.e., 4. Q., N.S.W., V.
auriflum Hope, Bup., 1836, 12; *purpurascens* Hope. l.e., 12;
proxima Boh., Res. Eugen., 1858, 62; *reichei* Chev., Silb.
Rev. Ent., 1839, 82.
 31. *breve* Cart., Linn. Soc. N.S.W., 1923, 160. W.A.
 32. *corpulentum* Boh. Res. Eugen., 1858, 62. N.S.W., V., S.A.
fissiceps L. & G. (nec Kirby), Mon., ii, 1839, 4.
 33. *fissiceps* Kirby, Tr. Linn. Soc., 1818, 458. N.S.W., V.
viride L. & G., Mon. Bup., ii, 1839, 6.
diversum Kerr., Ann. Soc. Ent. Belg., 1898, 156.
 34. *leai* Cart., Linn. Soc. N.S.W., 1924, 26. S.A.
 35. *maculatum* Blkb., Roy. Soc. S.A., 1887, 250. Q., N.S.W., S.A.
 36. *roei* Saund., Tr. Ent. Soc. Lond., 1868, 54. W.A.
subfasciatum Saund., l.e., 55.
- S. G. **HYPOCISSEIS** Thoms., Typ. Bup. App. 1a, 1879, 49.
maschalix Waterh., Ann. Mag. Nat. Hist., 1887, 293.
Cisseoides Kerr., Ann. Soc. Ent. Belg., 1893, 118.

37. **blackburni* Obenb. (Cisseoides) Archiv. für Naturg., 1924, 107. . . . A.
 38. *brachyformis* Deyr. Ann. Soc. Ent. Belg., 1864, 117. . . . Mysole & Q.
 39. **carteri* Obenb. (Cisseoides) Archiv. für Naturg., 1924, 106. . . . A.
 40. *cyanura* Kerr (Cisseoides) Ann. Soc. Ent. Belg., 1898, 172.
 modesta Kerr., l.c., 173.
 41. *gebhardti* Obenb., Archiv. für Naturg., 1924, 108. Q.
 42. *latipennis* Macl. (Cisseis) Ent. Soc. N.S.W., 1872, 248. Q.
 cornuta Gestro., Ann. Mus. Genov., 1877, 457.
 laticornis Thoms., Typ. Bup. App. 1a, 1879, 49.
 43. *madari* Obenb. (Cisseoides) Archiv. für Naturg., 1924, 107. Q.
 44. *minuta* Cart., Linn. Soc. N.S.W., 1923, 175. Q.
 45. **nigrosricea* Obenb. (Cisseoides) Archiv. für Naturg., 1924, 109. . . Q.
 46. *ornata* Cart., Linn. Soc. N.S.W., 1923, 175. S.A., W.A.
 47. *pilosicollis* Blkb. (Coraebus) Roy. Soc. S.A., 1891, 301. Q.
 murina Kerr. (Cisseoides) Ann. Soc. Ent. Belg., 1893, 118.
 48. *suturalis* Saund. (Cisseis) Tr. Ent. Soc. Lond., 1868, 60.
 Q., N.S.W., V., S.A., W.A.
 marmoratus Macl. (Coraebus) Ent. Soc. N.S.W., 1872, 248.
 albopicta Kerr. (Cisseoides) Ann. Soc. Ent. Belg., 1898, 171.
 aeneipes Kerr. (Hypocisseis), l.c., 173.

*The descriptions of the five species described by Obenberger show little distinction from the common and variable *H. suturalis* Saund.

S.G. *NEOSPADES*. Blkb., Roy. Soc. S.A., 1887, 251.

49. *chrysopygia* Germ. (Coreabus) Linn. Ent., 1848, 178. Q., W.A.
 dimidiata Macl. (Cisseis) Ent. Soc. N.S.W., 1872, 248.
 apicalis Macl. (Cisseis) Linn. Soc. N.S.W., 1888, 1227.
 purpureotincta Macl. (Cisseis), l.c.
 semirugosa Thoms. (Cisseis) Typ. Bup. 1a, 1879, 51.
 ? *semiscabrosa* Thoms. (Cisseis), l.c., 53.
 50. *cruciata* F., Sys. Ent., 1774, 222. N.Q.
 51. *cupricanda* Cart., Linn. Soc. N.S.W., 1927, N.T.
 52. *cuprifera* Gestro. (Cisseis) Ann. Mus. Genova, 1876, 357. . . C. York.
 cuprifera Thoms. (Cisseis) Typ. Bup. App. 1a, 1879, 51.
 53. *gouldi* Hope (Cisseis) Tr. Ent. Soc. Lond., 1846, 220. N.T.
 54. *lateralis* Blkb., Linn. Soc. N.S.W., 1888, 860. N.Q.
 splendida Kerr. (Cisseis) Ann. Soc. Ent. Belg., 1898, 160.
 55. *nigroaenea* Kerr. (Cisseis), l.c., 162. Q.
 56. *niveosparsa* Cart., Linn. Soc. N.S.W., 1927. Bogan R., N.S.W.
 57. *picta* Cart., l.c., 1923, 173. Brisbane, Q.
 58. *simplex* Blkb., l.c., 1888, 860. Q., N.S.W., V.
 bella Blkb. (Cisseis) Roy. Soc. S.A., 1891, 298.
 ? *nigripennis* Macl. (Cisseis) Linn. Soc. N.S.W., 1888, 1227.
 ignicolis Kerr. (Cisseis) Ann. Soc. Ent. Belg., 1898, 164.
 59. *terraereginae* Obenb. (Cisseis) Ent. Mitteil. Berlin, 1919, 21.
 60. *viridiaurea* Macl. (Cisseis) Ent. Soc. N.S.W., 1872, 248. Q.
 nitida Kerr. (Cisseis) Ann. Soc. Ent. Belg., 1898, 164.
 61. *viridis* Kerr. (Cisseis), l.c., 163. Q.
 viridicuprea Kerr. (Cisseis), l.c., 160.

S.G. *PACHYCISSIS*. Théry.

62. *bicolor* L. & G. (Cisseis) Mon., ii., 1839, 3. N.S.W., V., S.A.
CISSEIS L. & G., Mon. Bupr., ii., 1839, 1.
 63. *acuducta* Kirby, Faun. Bor. Amer., 1836, 162. Q., N.S.W., V., S.A.
 marmorea L. & G., Mon. ii., 1839, 4.

- lata* Hope, Ans. Bup., 1836, 11.
aenea Hope, l.c., 12.
cuprifrons Kerr., Ann. Soc. Ent. Belg., 1898, 157.
laeta Kerr., Gen. Ins., 1902, 227.
64. *albosparsa* L. & G., Mon., ii, 1839, 3. Q.
 albertisi Gestro., Ann. Mus. Genov., 1876, 357.
 cupriventris Kerr., Ann. Soc. Ent. Belg., 1898, 161.
65. *atroviolacea* Thoms., Typ. Bup. App., 1a, 1879, 52. N.S.W.
 66. *aurulenta* Kerr., Ann. Soc. Ent. Belg., 1898, 159. A.
 67. *careniceps* Cart., Linn. Soc. N.S.W., 1923, 167. W.A.
 68. *constricta* Blkb., ♂, Roy. Soc. S.A., 1887, 254. N.W.A.
 lindi Blkb., ♀, l.c.
69. *cupreicollis* Hope, Tr. Ent. Soc. Lond., 1845, 219. . . . N.S.W., V., S.A.
 aeneicollis Hope, l.c., 220.
 morosa Kerr., Ann. Soc. Ent. Belg., 1898, 158.
70. *cupripennis* Guér., Voy. Coq., 1836, 65. N.S.W.
 71. *cyanura* Kerr., Ann. Soc. Ent. Belg., 1898, 163. A.
 72. *duodecimmaculata* F., Sys. Eleuth., 1801, 191. N.S.W., V., T.
 duodecimguttata Guér., Voy. Coq., 1836, 65.
 quatuordecimnotata Hope, Tr. Ent. Soc. Lond., 1846, 218.
 xanthosticta Hope, Bup., 1832, 11.
 pustulata Thoms., Typ. Bup. App., 1a, 1879, 51.
73. *elliptica* Cart., Linn. Soc. N.S.W., 1923, 170. W.A. & N.Q.
 ? *carteri* Obenb., Archiv. für Naturg., 1924, 109.
74. *elongatula* Blkb., Linn. Soc. N.S.W., 1888, 862. N.T.
 75. *fulgidicollis* Macl., l.c., 1231. N.-W.A. & Q.
 76. *inflammata* Cart., l.c., 1923, 167. N.Q.
 77. *laticollis* Cart., l.c., 169. Q.
 78. *leucosticta* Kirby, Tr. Linn. Soc. Lond., 1818, 382.
 Q., N.S.W., V., S.A., W.A.
 stellulata Dalm., Anal. Ent., 1823, 54.
 fulgidifrons Kerr., Ann. Soc. Ent. Belg., 1898, 161.
79. *maculata* L. & G., Mon. ii., 1839, 5. N.S.W., V., T., S.A.
 irrorata L. & G. (nee Hope), l.c., 4.
 tasmanica Kerr., Ann. Soc. Ent. Belg., 1895, 165.
 pauperula Kerr., l.c., 167.
80. *marmorata* L. & G., Mon., ii., 1839, 4. N.S.W., V.
 irrorata Hope (nee L. & G.), Bup., 1832, 8.
 similis Saund., Tr. Ent. Soc. Lond., 1868, 59.
 viridicollis Thoms., Typ. Bup. App. 1a, 1879, 50.
 aenea Kerr., Ann. Soc. Ent. Belg., 1898, 189.
 var. *prasina* Cart., Linn. Soc. N.S.W., 1923, 168.
81. *minutissima* Thoms., Typ. Bup. App. 1a, 1879, 54. S.A., W.A.
 82. *nitidicollis* Kerr., Ann. Soc. Ent. Belg., 1898, 162. Q.
 83. *notulata* Germ., Linn. Ent., 1848, 178. N.S.W., V., S.A.
 inops Kerr., Ann. Soc. Ent. Belg., 1898, 168.
 semiobscura Kerr., l.c., 170.
 ? *nigrita* Kerr., l.c., 168.
 ? *violacea* Kerr., Gen. Ins., 1902, 228.
84. *nubeculosa* Germ., ♀, Linn. Ent., 1848, 176. S.A.
 chalcoptera Germ., ♂, l.c., 177.
85. *obscura* Blkb., Roy. Soc. S.A., 1887, 252. S.A., W.A.
 undulata Kerr., Gen. Ins., 1902, 227.
 purpurea Kerr., l.c., 228.

86. *occidentalis* Blkb., Roy. Soc. S.A., 1887, 255. W.A.
 87. *opima* Thomas, Typ. Bup. App. 1a, 1879, 50. W.A.
 88. *oralis* Cart., Linn. Soc. N.S.W., 1923, 170. W.A.
 89. *parva* Blkb., Roy. Soc. S.A., 1887, 255. S.A., W.A.
 simplex Kerr., Ann. Soc. Ent. Belg., 1898, 171.
 90. *perplexa* Blkb., Roy. Soc. S.A., 1891, 300. W.A.
 91. *puella* Kerr., Ann. Soc. Ent. Belg., 1898, 170. Q., N.S.W.
 curta Kerr., Gen. Ins., 1902, 229.
 92. *pulchella* Cart., Linn. Soc. N.S.W., 1923, 171. N.Q.
 93. *pygmaea* Blkb., Roy. Soc. S.A., 1891, 299. N.S.W., V.
 94. *regalis* Thoms., Typ. Bup. App. 1a, 1879, 50. N.Q.
 95. *roseocuprea* Hope, Tr. Ent. Soc. Lond., 1846, 219. N.S.W., V., S.A., W.A.
 impressicollis Macl., Ent. Soc. N.S.W., 1872, 248.
 dispar Blkb., Roy. Soc. S.A., 1891, 297.
 cuprea Kerr., Gen. Ins., 1902, 228.
 fairmairei Kerr., Ann. Soc. Ent. Belg., 1898, 169.
 96. *rubicunda* Kerr., l.e. N.S.W., V.
 modesta Kerr., l.e., 170.
 97. *rugiceps* Thoms., Typ. Bup. App. 1a, 1879, 52. W.A.
 98. *scabiosa* Boisd., Voy. Astrol., 1835, 96. A.
 99. *scabrosula* Kerr., Ann. Soc. Ent. Belg., 1898, 167. N.S.W., V.
 100. *signaticollis* Hope, Tr. Ent. Soc. Lond., 1844, 219. N.T.
 ? *spilota* Hope (Cinyra) Tr. Ent. Soc. Lond., 1846, 219.
 101. *stigmata* L. & G., Mon. ii., 1839, 3. W.A.
 102. *sub-bifasciata* Cart., Linn. Soc. N.S.W., 1927, Bogan R., N.S.W.
 103. *subcarenicifrons* Thoms., Typ. Bup., App. 1a, 1879, 53. W.A.
 cincta Kerr., Ann. Soc. Ent. Belg., 1898, 166.
 104. *tyrrhena* Cart., Linn. Soc. N.S.W., 1923, 168. W.A.
 105. *uniformis* Thoms., Typ. Bup. App. 1a, 1879, 53. V., T.
 coraeoides Kerr., Ann. Soc. Ent. Belg., 1898, 166.
 106. *vicina* Kerr., Ann. Soc. Ent. Belg., 1898, 165. Q., N.S.W.
 ? *collaris* Kerr., Gen. Ins., 1902, 229.
 ? *ornata* Kerr., l.e.
 107. *viridiceps* Kerr., Ann. Soc. Ent. Belg., 1898, 165. Q., N.S.W.
 oblonga Kerr., Gen. Ins., 1902, 229.
 108. *viridipurpurea* Cart., Linn. Soc. N.S.W., 1924, 27. Geraldton, W.A.
 109. *westwoodi* L. & G., Mon., ii., 1839 (Coraeus), 15. V., T.
 verna Blkb., Roy. Soc. S.A., 1891, 299.
 viridana Kerr., Ann. Soc. Ent. Belg., 1898, 175.
 theryi Kerr., Gen. Ins., 1902, 229.
 S.G. *DINOCEPHALIA*. Obenb., Sbor. Ent. Mus. Praze, 1923, 39.
 110. *gigantea* Obenb., l.e., 40. Q.
PARACEPHALA. Thoms., Typ. Bupr., 1878, 91.
 111. *aenea* Blkb., Roy. Soc. S.A., 1891, 302. N.W.A.
 112. *bicostata* Cart., Linn. Soc. N.S.W., 1928, 274. Q. & W.A.
 113. *crassa* Kerr., Ann. Soc. Ent. Belg., 1898, 176. Gayndah, Q.
 ? *intermedia* Kerr., l.e., 177.
 114. *cyaneipennis* Blkb., Roy. Soc. S.A., 1893, 130. Sydney.
 115. *cylindrica* Kerr., Ann. Soc. Ent. Belg., 1898, 177. . . . Port Denison, Q.
 116. *murina* Thoms., Typ. Bup., 1878, 83. Sydney.
 117. *pistacina* Hope (Agrilus) Tr. Ent. Soc. Lond., 1846, 218. S.A.
 Saund., l.e., 1868, 63, t. 4, f. 31.
 canaliculata Germ., Linn. Ent. 1848, 180.
 minuta Kerr., Ann. Soc. Ent. Belg., 1898, 177.

118. **strandii* Obenb., Archiv. für Naturg., 1924, 155. Q.
niveiventris Obenb., l.c.
119. *thoracica* Kerr., Ann. Soc. Ent. Belg., 1900, 343. W.A.
120. *transsecta* Cart., Linn. Soc. N.S.W., 1921, 306. S.A. & Q.
impressicollis Obenb., Archiv. für Naturg., 1924, 155.
121. *vitticeps* Cart., Linn. Soc. N.S.W., 1924, 535. W.A.

* The three descriptions by Obenberger contain no reference to previously described species, nor any comparison to show a knowledge of them. Thus they are possible synonyms, which seems evident with *P. impressicollis*—the other two being close to *crassa* Kerr.

S.G. *MELIBOEITHON*. Obenb., Entom. Mitteil., 1920, 170.

122. *fissus* Obenb., l.c., 171. A.
- APHANISTICUS*. Latr., Règne Anim., 1829, 448.
123. *blackburni* Cart., Linn. Soc. N.S.W., 1924, 536. A.
124. *browni* Cart., l.c., 32. Johnstone R., Q.
125. *endeloides* Cart., l.c., 31. Cairns, Q.

GERMARICA. Blkb., Roy. Soc. S.A., 1887, 257.

126. *abbreviata* Cart., Linn. Soc. N.S.W., 1926, 59. W.A.
127. *blackburni* Obenb., Entom. Blatter, 1923, 114. Q.
128. *carteri* Obenb., l.c. Q.
129. *elata* Cart., Linn. Soc. N.S.W., 1926, 58. Q.
130. *lilliputana* Thoms., Typ. Bup. App. 1a, 1879, 75. Q., N.S.W., V. S.A., T.
casuarinae Blkb., Roy. Soc. S.A., 1887, 257.

ENDELUS. Deyr., Ann. Soc. Ent. Belg., 1854, 227.

131. *subcornutus* Kerr., l.c., 1900, 344. New Guinea & C. York, A.

HABROLOMA. Thoms., Skaud. Col., V. 6, 42.

132. *australasiae* Gestro. (Trachys) Ann. Mus. Genov., 1877, 362. . . . N.Q.
133. *australis* Macl. (Trachys) Linn. Soc. N.S.W., 1888, 1227. . . . N.W.A.
134. *frenchi* V.d. Poll. (Trachys) Not. Leyd. Mus., 1887, 126. . N.Q. & N.W.A.
nigra Macl., Linn. Soc. N.S.W., 1888, 1227.
 ? *hackeri* Obenb., Sbor. Ent. Mus. Praze, 1923, 81.
135. *pauperula* Kerr. (Trachys) Ann. Soc. Ent. Belg., 1896, 313. . . N.S.W.
136. *socialis* Lea. (Trachys) Linn. Soc. N.S.W., 1893, 592. N.S.W.

TRACHYS. F., Sys. Eleuth., ii., 1801, 218.

137. *blackburni* Kerr., Ann. Soc. Ent. Belg., 1896, 313. N.S.W.

Tribe MASTOGENINI.

MASTOGENIUS. Sol., Hist. Chile, 1850, 507.

138. *frenchi* Théry, Linn. Soc. N.S.W., 1928, 456. N.S.W. & V.

Tribe CHRYSOBOTHRINI.

CHRYSOBOTHRIS. Eschscholtz., Zool. Atl., 1829, 9.

139. *amplicollis* Thoms., Typ. Bup. App. 1a, 1879, 47. S.A., W.A.
140. *australasiae* Hope, Tr. Ent. Soc. Lond., 1846, 916. W.A.
141. *caelatus* Cart., Linn. Soc. N.S.W., 1925, 227. N.S.W.
142. *incana* Macl., l.c., 1888, 1227. N.W.A.
interioris Blkb., Roy. Soc. S.A., 1895, 46.
143. *mastersi* Macl., Ent. Soc. N.S.W., 1872, 247. Q. N.S.W., V., S.A., W.A.
 ? *blackburni* Obenb., Sborn. Ent., 1923, 77.
 ? *perroni* L. & G., Mon., ii., 1838, 11,

144. *octomaculata* Cart., Linn. Soc. N.S.W., 1925, 228. Q.
 145. *saundersi* Macl., Ent. Soc. N.S.W., 1872, 246. Q. & W.A.
 hopei Obenb., Sborn. Ent., 1923, 77.
 146. *subsimilis* Thoms., Typ. Bup. App. 1a, 1879, 47. Q., W.A. & V.
 147. *viridis* Macl., Ent. Soc. N.S.W., 1872, 247. Q., N.S.W., W.A.
 frenchi Kerr., Gen. Ins., 1902, 187.
 ? *simplicifrons* Kerr., l.c., 188.
 ? *carteri* Obenb., Sborn. Ent., 1923, 76.
- BELIONOTA.** Eschscholtz., Zool. Atl., 1829, 9.
148. *aenea* Deyr., Ann. Soc. Ent. Belg., 1864, 82. N.G. & N.T.
 ? *Saundersi* Waterh., Ann. Mag. Nat. Hist., 1894.
- MERIMNA.** Thoms., Typ. Bup., 1878, 42.
149. *atrata* Hope, Bupr., 1836, 10. Q., N.S.W., V., S.A., W.A.
 corporea Obenb., Arch. für Naturg., 1924, 119.
- Tribe POLYCESTINI.
 Sub-tribe *Polycestae*.
- PROSPHERES.** Thoms., Typ. Bup., 1878, 16.
150. *aurantiopicus* L. & G., Mon., i, 1837, 132. N.S.W., Q.
 decemnotata L. & G., l.c., 133.
 decostigma Hope, Bup., 7.
 guelmi White, Proc. Zool. Soc., 1859, 120.
 151. *discoideus* L. & G., Mon., i, 1837, 130. A.
 152. *moestus* Cart., Linn. Soc. N.S.W., 1915, 77. N.S.W.
 (Probably melanic var. of 150.)
- CASTALIA.** L. & G., Mon., ii, 1837, 1.
- strigoptera* Dej., Cat., 89.
153. *bimaculata* L., Sys. Nat., 1758, I., 40. Malaya & A.
 pacifica Boisd., Voy. Astrol., 1831, 83.
 bipustulata Boisd., l.c.
 obsoleta Chev., Rev. Zool., 1841, 221.
 annamica Nonfried, Ent. Soc. Lond., 1867, 513.
- POLYCESTA.** Sol., Ann. Soc. Ent. Fr., 1833, 281.
154. *mastersi* Macl., Ent. Soc. N.S.W., 1872, 246. Q.
 155. *scintillans* Cart. (Castalia), Linn. Soc. N.S.W., 1924, 523. W.A.
- MICROCASTALIA.** Heller., Deuts. Ent. Zeit., 1891, 135.
- Bubastodes* Blkb., Roy. Soc. S.A., 1892, 212.
156. *globithorax* Thoms., Typ. Bup., 1878, 46. V., S.A.
 sulcicollis Blkb. (Bubastodes) Roy. Soc. S.A., 1892, 212.
- Sub-tribe PTOSIMAE.
- XYROSCELIS.** Thoms., Typ. Bup., 1878, 56.
157. *crocata* L. & G., Mon., ii, 1837, 13. N.S.W., W.A.
 nodosa Hope (Acmaeodera) Tr. Ent. Soc. Lond., 1845, 217.
 melanosticta Hope, l.c.
- Tribe BUPRESTINI.
 Sub-tribe *Buprestes*.
- NEOBUPRESTIS.** Kerr., Gen. Ins., 1902, 136.
158. *albosparsa* Cart., Linn. Soc. N.S.W., 1924, 523. N.Q.
 159. *australis* Blkb. (Strigoptera), l.c., 1891, 501. S.A.

160. *frenchi* Blkb. (Strigoptera), l.c., 500. Alpine, Vic. & N.S.W.
 161. *marmorata* Blkb. (Strigoptera), l.c., 501. N.W. Vic. & S.A.
- ASTRAEUS.** L. & G., Mon. I., 1837, 2.
162. *aberrans* V. de Poll., Not. Leyd. Mus., 1886, 176. W.E.A.
 var. *picticollis* V. de Poll. Tijdschr. Ent., 1889, 91.
 163. *badeni* V. de Poll., l.c., 93. S.A.
 meyricki Blkb., Linn. Soc. N.S.W., 1889, 1256.
 164. *crassus* V. de Poll., Tijdschr. Ent., 1889, 95. N.S.W.
 flavopictus V. de Poll., Not. Leyd. Mus., 1886, 180.
 165. *cyaneus* Kerr., Ann. Soc. Ent. Belg., 1900, 295. N.S.W.
 166. *dilutipes* V. de Poll., Not. Leyd. Mus., 1886, 180. A.
 167. *elongatus* V. de Poll., l.c., 177. W.A.
 168. *flavopictus* L. & G., Mon. I., 2. W.A.
 169. *fraterculus* V. de Poll., Tijdschr. Ent., 1889, 92. V.
 170. *intricatus* Cart., Linn. Soc. N.S.W., 1925, 229. N.S.W.
 171. *irregularis* V. de Poll., Tijdschr. Ent., 1889, 86. W.A.
 172. *jansoni* V. de Poll., l.c., 94. Blue Mts., N.S.W. & S.A.
 tepperi Blkb., Linn. Soc. N.S.W., 1889, 1258.
 173. *lineatus* V. de Poll., Tijdschr. Ent., 1889, 87. W.A.
 174. *multinotatus* V. de Poll., Tijdschr. Ent., 1889, 89. N.W.A.
 175. *navarchis* Thoms., Rev. Mag. Zool., 1856, 115. V.
 var. *major* Blkb., Linn. Soc. N.S.W., 1889, 1247.
 176. *oberthuri* V. de Poll., Tijdschr. Ent., 1889, 100. Q.
 177. *prothoracicus* V. de Poll., l.c., 98. Clarence R., N.S.W.
 178. *pygmacus* V. de Poll., Not. Leyd. Mus., 1886, 178. N.S.W.
 subfasciatus V. de Poll., Tijdschr. Ent., 1889, 104.
 179. *samouelli* Saund., Tr. Ent. Soc. Lond., 1868, 10. N.S.W. & Q.
 mastersi Macl., Ent. Soc. N.S.W., 1872, 239.
 180. *simplex* Blkb., Roy. Soc. S.A., 1892, 211. S.A.
 181. *simulator* V. de Poll., Tijdschr. Ent., 1889, 102. Q.
 182. *splendens* V. de Poll., l.c., 108. Q.
 183. *vittatus* V. de Poll., l.c., 99. N.W.A.
- NEOBUBASTES.** Blkb., Roy. Soc. S.A., 1892, 213.
 Castelnaudia (*) Obenb., Sborn. Ent., 1923, 14.
184. *aureocincta* Blkb., l.c., S.A. & C.A.
 australasiae Obenb., Sborn. Ent., 1923, 14.
 185. *flavovittata* Cart., Linn. Soc. N.S.W., 1922, 66. Kellerberrin, W.A.
- NASCIOIDES.** Kerr., Gen. Ins., 1902, 147.
186. *carissima* Waterh., Ann. Mag. Nat. Hist., 1882, 51. N.S.W., Q.
 187. *costata* Cart., Linn. Soc. N.S.W., 1913, 482. N.S.W.
 188. *multesima* Oll., l.c., 1886, 862. N.S.W.
 189. *munda* Oll., l.c., N.Q.
 190. *pulchra* V. de Poll., Not. Leyd. Mus., 1889, 122. Q.
 191. *quadrinotata* V. de Poll., l.c., 123. T.
 192. *tillyardi* Cart., Linn. Soc. N.S.W., 1913, 483. N.S.W.
 193. *viridis* Macl., Ent. Soc. N.S.W., 1872, 239. Q.
- NASCIO.** L. & G., Mon. I., 1837, 2.
194. *chydaea* Oll., Linn. Soc. N.S.W., 1886, 861. N.S.W. & Q.
 195. *lunaris* Kerr., Ann. Soc. Ent. Belg., 1900, 294. N.S.W.
 196. *simillima* V. de Poll., Nat. Leyd. Mus., 1889, 121. Q.

(*) . Nom. praeocc. later changed to *Castelnaudina*.

197. *vetusta* Boisd., Voy. Astrol., 1832, 85. N.S.W., V.
 198. *xanthura* L. & G., Mon., i., 1837, 2. N.S.W.
- NOTOBUBASTES.** Cart., Linn. Soc. N.S.W., 1924, 24.
199. *aurosulcata* Cart., l.c., 26. N.W.A.
 200. *costata* Cart., l.c., 526. Kookynie, W.A.
 201. *occidentalis* Cart., l.c., 25. Cue, W.A.
 202. *orientalis* Cart., l.c., 25. Wide Bay, Q.
- BUPRESTINA.** Obenb., Sborn. Ent., 1923, 16.
203. *prosternalis* Obenb., l.c., 17. Q.
- BUPRESTODES.** Cart., Linn. Soc. N.S.W., 1924, 23.
204. *coruscans* Cart., l.c., 24. Kellerberrin, W.A.
 205. *variegata* Cart., l.c., Kellerberrin, W.A.
- BUBASTES.** L. & G., Mon. I., 1836, 1.
206. *achardi* Obenb., Ann. Soc. Ent. Fr., 1920, 104. Cobar, N.S.W.
 207. *aenea* Obenb., Archiv. für Naturg., 1922, 83. N.Q.
 208. *bostrychoides* Théry (Neraldus) Mem. Soc. Ent. Belg., 1910, 17. . . W.A.
 olivinus Obenb., Ann. Soc. Ent. Fr., 1920, 99.
 209. *cylindricus* MacL., Linn. Soc. N.S.W., 1888, 1227. . . King Sound, W.A.
 210. *formosa* Cart., l.c., 1915, 78. Cue, W.A.
 211. *globoicollis* Thoms., Typ. Bup. Appendix 1a, 1879, 14. . . N.S.W. & Q.
 simillima Obenb., Arch. für Naturg., 1922, 81.
 212. *inconsistans* Thoms., Typ. Bup. App. 1a, 1879, 14. . . N.W.V. & S.A.
 inconstans Blkb., Linn. Soc. N.S.W., 1888, 1414.
 australasiae Obenb., Arch. für Naturg., 1922, 82.
 213. *laticollis* Blkb., Linn. Soc. N.S.W., 1888, 1415. W.A.
 214. *lei* Cart., l.c., 1924, 528. W.A.
 215. *niveiventris* Obenb., Arch. für Naturg., 1922, 82. N.Q.
 216. *obscura* Obenb., l.c., 83. Kuranda, Q.
 217. *occidentalis* Blkb., Roy. Soc. S.A., 1891, 293. . . . Eucla, S.A., & W.A.
 218. *sphenoidea* L. & G., Mon. I., 1836, 2. Cunnamulla, Q.
 219. *splendens* Blkb., Roy. Soc. S.A., 1891, 294. . . . Tennents Cr., C.A.
 persplendens Obenb., Ann. Soc. Ent. Fr., 1920, 107.
 220. *suturalis* Cart., Linn. Soc. N.S.W., 1915, 79. . . Drysdale R. & Cue, W.A.
 strandii Obenb., Ann. Soc. Ent. Fr., 1920, 105.
 221. *vagans* Blkb., Roy. Soc. S.A., 1892, 213. N.W.V. & S.A.
 222. *viridicuprea* Obenb., Arch. für Naturg., 1922, 83. N.Q.
- EURYSPIBUS.** Lac., Gen. Col. IV., 1857, 44.
- Eurybia* L. & G., Mon. ii., 1838, 1.
 Neurybia Théry, Mem. Soc. Ent. Belg., 1910, 18.
223. *australis* Blkb., Roy. Soc. S.A., 1887, 247. S.A.
 trifoveolata Théry (Neurybia) Mem. Soc. Ent. Belg., 1910, 18.
224. *caudatus* Théry, l.c., 19. A.
 225. *chalcodes* L. & G., Mon. ii., 1836, 1. W.A.
 226. *viridis* Cart., Linn. Soc. N.S.W., 1924, 529. W.A.
- S.G. BRISEIS.** Kerr., Gen. Ins., 1902, 161.
227. *buprestoides* Obenb., Arch. für Naturg., 1922, 94. A.
 228. *conica* L. & G., Mon. I., 1837, 118. Q.
 acuminata Kerr., Ann. Soc. Ent. Belg., 1898, 129.
 sagitta Obenb., Arch. für Naturg., 1924, 68.
 229. *curta* Kerr., Gen. Ins., 1902, 162. N.S.W. & Q.
 ♀ *obscurata* Obenb., Arch. für Naturg., 1924, 67.

230. *prolongata* Obenb., l.c., 1922, 93. Q.
? *elongata* Cart., Tr. Ent. Soc. Lond., 1923, 102.
231. *smaragdiformis* Obenb., Arch. für Naturg., 1922, 93. N.Q.
? *cuprea* Cart., Tr. Ent. Soc. Lond., 1923, 101.

MELOBASIS. L. & G., Mon. I., 1837, 118.

232. *abnormis* Cart., Tr. Ent. Soc. Lond., 1923, 83. N.W.V., S.A., Q.
233. *aenea* Kerr., Gen. Ins., 1902, 158. A.
234. *andersoni* Blkb., Roy. Soc. S.A., 1887, 234. S.A., W.A.
235. *apicalis* Macl., Tr. Ent. Soc. N.S.W., 1872, 241. N.S.W., Q.
suturalis Thoms., Typ. Bup., App. 1a, 1879, 17.
236. *bimetallica* Cart., Tr. Ent. Soc. Lond., 1923, 88. W.A.
237. *callichloris* Kerr., Ann. Soc. Ent. Belg., 1898, 125. A.
238. *caudata* Cart., Tr. Ent. Soc. Lond., 1923, 96. Cue, W.A.
239. *chrysolina* Théry, Mem. Soc. Ent. Belg., 1910, 21. Townsville, Q.
240. *costata* Macl., Tr. Ent. Soc. N.S.W., 1872, 240. N.S.W. & Q.
241. *costifera* Thoms., Typ. Bup. App. 1a, 1879, 16. S.A., W.A.
costata Saund., Ent. Mo. Mag., 1876, 155.
Saundersi Mast., Cat. Aus. Col., 1886, 250.
242. *cruentata* Thoms., Typ. Bup. App. 1a, 1879, 16. N.S.W., V.
puncticollis Blkb., Roy. Soc. S.A., 1887, 239.
243. *cupreovittata* Saund., Ent. Mo. Mag., 1876, 155. S.A., N.W.V.
vittigera Thoms., Typ. Bup. App. 1a, 1879, 16.
obsoleta Thoms., l.c., 15.
244. *cupriceps* Kirby, Tr. Linn. Soc. Lond., 1818, 457. N.S.W., Q., V., T.
viridimitens Boisd., Voy. Astrol., 1832, 94.
var. *iridescens* L. & G., Mon. I., 1837, 119.
245. *cupricollis* Kerr., Ann. Ent. Soc. Belg., 1898, 121. A.
246. *cuprifera* L. & G., Mon. I., 1837, 119. Q., N.S.W., V., T., S.A.
propinqua L. & G., l.c., 120.
porteri Hope, Tr. Ent. Soc. Lond., 1846, 215.
verna Hope, l.c., 214.
goryi Saund., Cat. Bup., 1871, 44.
suaveola Germ., Linn. Ent., 1848, 176.
prasina Thoms., Typ. Bup. App. 1a, 1879, 17.
247. *cuprina* Kerr., Ann. Ent. Soc. Belg., 1898, 122. W.A.
248. *cyaneipennis* Boh., Eng. Res. Zool., 1858, 59. Q.
azureipennis Macl., Ent. Soc. N.S.W., 1872, 240.
aureipennis Thoms., Typ. Bup. App. 1a, 1879, 22.
249. *derbyensis* Blkb., Roy. Soc. S.A., 1892, 44. W.A.
250. *dives* Cart., Tr. Ent. Soc. Lond., 1923, 92. N.T.
251. *elderi* Blkb., Roy. Soc. S.A., 1892, 35. Q., W.A.
? *nigrita* Kerr., Ann. Soc. Ent. Belg., 1900, 296.
252. *fairmairei* Kerr., Gen. Ins., 1902, 158. A.
253. *fasciata* Cart., Tr. Ent. Soc. Lond., 1923, 98. N.S.W., V., Q.
254. *formosa* Cart., l.c., 99. Cue, W.A.
255. *fulgurans* Thoms., Typ. Bup. App. 1a, 1879, 20. Q., N.S.W., V., T., S.A.
subfulgurans Thoms., l.c., 21.
placida Kerr. (Thoms. ♀), l.c., 17.
intricata Blkb., Roy. Soc. S.A., 1887, 243.
blackburni Kerr., Gen. Ins., 1902, 159.
beltanensis Blkb., Linn. Soc. N.S.W., 1891, 499.
subcyanea Blkb., l.c., 1892, 287.
caeruleiventris Kerr., Ann. Soc. Ent. Belg., 1898, 123.

256. *gloriosa* L. & G., Mon. I., 1837, 123. W.A.
 var. pulchra Blkb., Roy. Soc. S.A., 1891, 294.
 purpureosignata Thoms., Typ. Bup. App. 1a, 1879, 18.
 thomsoni Blkb., Roy. Soc. S.A., 1890, 146.
257. *gratiosissima* Thoms., Typ. Bup. App. 1a, 1879, 18.
 Q., N.S.W., V., S.A., W.A.
 speciosa Blkb., Roy. Soc. S.A., 1887, 245.
258. *hypocrita* Erichs., Weigm. Arch. Naturg., 1843, 135. . . N.S.W., V., T.
 acuta Kerr., Ann. Ent. Soc. Belg., 1900, 44.
259. *igniceps* Saund., Ent. Mo. Mag., 1876, 156. W.A
260. *ignipicta* Kerr., Ann. Ent. Soc. Belg., 1900, 297. N.S.W., V.
261. *illidgei* Cart., Tr. Ent. Soc. Lond., 1923, 90. Longreach, Q.
262. *incerta* Kerr., Ann. Mus. Stor. Nat. Genov., 1892, 1002. . C. York & N.G.
263. *innocua* Thoms., Typ. Bup. App. 1a, 1879, 20. W.A.
264. *interstitialis* Blkb., Roy. Soc. S.A., 1901, 130. W.A.
265. *intricata* Deyr., Ann. Soc. Ent. Belg., 1864, 70. Q. & Aru Is.
 ignicauda Kerr., Ann. Mus. Genov., 1892, 1002.
266. *iridicolor* Cart., Tr. Ent. Soc. Lond., 1923, 93. N.Q.
267. *lathamii* L. & G., Mon. I., 1837, 120. V., S.A., W.A.
 serrulata Hope, Bup., 1846, 8.
 rubromarginata Saund., Ent. Mo. Mag., 1887, 156.
 laeta Saund., l.c.
 bicolor Blkb., Roy. Soc. S.A., 1891, 295.
 costipennis Kerr., Ann. Soc. Ent. Belg., 1898, 124.
 var. soror Blkb., Roy. Soc. S.A., 1887, 237.
268. *lauta* Macl., Linn. Soc. N.S.W., 1888, 228. N.W.A.
269. *macleayi* Cart., Tr. Ent. Soc. Lond., 1923, 89. N.Q.
270. *melanura* Kerr., Ann. Soc. Ent. Belg., 1900, 121. W.A.
271. *metallifera* Saund., Tr. Ent. Soc. Lond., 1868, 15. W.A.
272. *meyricki* Blkb., Roy. Soc. S.A., 1887, 238. W.A.
273. *monticola* Blkb., Linn. Soc. N.S.W., 1891, 496. V.
274. *nervosa* Boisd., Voy. Astrol., 1832, 77. N.S.W., V., T., S.A.
275. *nitidiventris* Kerr., Ann. Ent. Soc. Belg., 1898, 122. V.
276. *nobilitata* Thoms., Typ. Bup. App. 1a, 1879, 22. W.A.
277. *obscurella* Thoms., l.c., 19. N.S.W., V., S.A., T.
 rotundicollis Blkb., Roy. Soc. S.A., 1887, 241.
 viridiobscura Thoms., Typ. Bup. App. 1a, 1879, 19.
 violacea Kerr., Ann. Soc. Ent. Belg., 1898, 123.
278. *occidentalis* Cart., Tr. Ent. Soc. Lond., 1923, 95. . . . Yallingup, W.A.
279. *picticollis* Cart., l.c., 95. N.S.W. & Vic.
280. *prisca* Erichs., Weigm. Arch. Naturg., 1842, 135. V., T.
 semistriata Blkb., Roy. Soc. S.A., 1887, 235.
281. *purpurascens* F., Sys. Eleuth., 1801, 217. Q., N.S.W., V., T., S.A.
 splendida Don., Ins. Aust., 1805, pl. 1, f. 4.
 purpureosignata L. & G., Mon. I., 1837, 6.
 faceta Thoms., Typ. Bup. App. 1a, 1879, 18.
 var. miranda Kerr., Ann. Soc. Ent. Belg., 1898, 128.
282. *pusilla* Cart., Linn. Soc. N.S.W., 1928, 272. Bowen, Q.
283. *quadrinotata* Cart., Tr. Ent. Soc. Lond., 1923, 84. . . . Townsville, Q.
284. *regalis* Cart., l.c., 97. Albany, W.A.
285. *robusta* Cart., l.c., 85. Kellerberrin, W.A.
286. *rothei* Blkb., Roy. Soc. S.A., 1887, 236. S.A., W.A.
287. *septemplagiata* Cart., Tr. Ent. Soc. Lond., 1923, 91. Cue, W.A.
288. *sexplagiata* L. & G., Mon. I., 1837, 124. V., S.A., W.A.

- pyritosa* Hope, Tr. Ent. Soc. Lond., 1846, 214.
pretiosa Blkb., Roy. Soc. S.A., 1887, 244.
auronotata Kerr., Ann. Soc. Ent. Belg., 1898, 127.
 289. *subconica* Cart., Tr. Ent. Soc. Lond., 1923, 86. Geraldton, W.A.
 290. *simplex* Germ., Linn. Ent., 1848, 175. V., T., S.A.
 viridis Saund. Ent. Mo. Mag., 1876, 158.
 var. *obscura* Saund., l.c., 157.
 sordida Blkb., Roy. Soc. S.A., 1887, 238.
 semisuturalis Blkb., l.c., 246.
 concolor Kerr., Ann. Soc. Ent. Belg., 1898, 125.
 viridiventris Kerr., l.c., 124.
 vicina Kerr., l.c., 126.
 291. *superba* L. & G., Mon. I., 1837, 123. N.S.W.
 292. *terminata* Kerr., Ann. Soc. Ent. Belg., 1898, 127. W.A.
 293. *thoracica* Blkb., Roy. Soc. S.A., 1887, 246. V.
 294. *uniformis* Cart., Tr. Ent. Soc. Lond., 1923, 87. W.A.
 295. *vertebralis* Cart., l.c., 83. N.S.W. & Q.
 296. *viridiceps* Saund., Ent. Mo. Mag., 1876, 157. N.S.W.
 297. *vittata* Blkb., Roy. Soc. S.A., 1881, 242. Q., N.S.W., V., S.A.
S.G. DICEROPYGUS. Deyr., Ann. Soc. Ent. Belg., 1864, 68.
 298. *australis* Thoms., Typ. Bup. App. 1a, 1879, 15. C. York.
 299. *maculatus* Deyr., Ann. Soc. Ent. Belg., 1864, 68. N.T., & Key Is.
 quadritinctus Obenb., Arch. für Naturg., 1922, 93.
 300. *suturalis* Macl. (Melobasis) Linn. Soc. N.S.W., 1886, 158. . . N.Q. & N.G.
 301. *viridiauratus* Deyr., Ann. Soc. Ent. Belg., 1864, 72. . . . Woodlark Is.
 302. *viridis* Kerr., Mem. Soc. Ent. Belg., 1900, 70. Woodlark Is.
 303. *woodlarkiana* Théry, Ann. Mus. Stor. Nat. Genova, 1923, 18. Woodlark Is.
 [The last three are closely allied and need comparison.]
TORRESITA. Gemm. & Har. Cat., 1869, 1382.
 304. *cuprifera* Kirby, Tr. Linn. Soc. Lond., 1818, 457. N.S.W.
 var. *chrysochloris* L. & G., Mon. I., 1837, 122.
 var. *dilatata* Redt., Reise Novara, 1867, 85.
 var. *aenea* Thoms., Typ. Bup. App. 1a, 1879, 23.
 chrysoptera Latr., Dep. Cat., 3 Ed., 90.
 305. *parallela* Kerr., Ann. Soc. Ent. Belg., 1898, 120. Q.
ANILARA. Thoms., Typ. Bup. App. 1a, 1879, 28.
 306. *adelaidae* Hope, Tr. Ent. Soc. Lond., 1846, 216. N.S.W., V., S.A., W.A.
 ? *deyrollei* Thoms., Typ. Bup. App. 1a, 1879, 29.
 307. *aeraria* Cart., Linn. Soc. N.S.W., 1926, 55. W.A.
 308. *angusta* Blkb., Roy. Soc. S.A., 1887, 296. N.S.W., V., S.A.
 cuprescens Kerr., Ann. Soc. Ent. Belg., 1898, 131.
 cyphogastra Théry, Mem. Soc. Ent. Belg., 1910, 29.
 309. *anthaxoides* Théry, l.c., 31. N.S.W.
 310. *antiqua* Théry, l.c., 30. Townsville, Q.
 311. *convexa* Kerr., Ann. Soc. Ent. Belg., 1898, 132. A.
 312. *doddi* Cart., Linn. Soc. N.S.W., 1928, 273. Kuranda, Q.
 313. *laeta* Blkb., Roy. Soc. S.A., 1891, 294. S.A.
 314. *longicollis* Théry, Mem. Soc. Ent. Belg., 1910, 26. . . N.S.W., V., S.A., Q.
 315. *nigrita* Kerr., Ann. Soc. Ent. Belg., 1898, 130. A.
 316. *obscura* Macl. (Melobasis) Ent. Soc. N.S.W., 1872, 241.
 Q., N.S.W., V., S.A.
 platessa Thoms., Typ. Bup. App. 1a, 1879, 29.
 soror Blkb., Roy. Soc. S.A., 1891, 296.

- uniformis* Kerr., Ann. Soc. Ent. Belg., 1898, 131.
deyrollei Kerr. (nec Thoms.) Ins. Gen., 1902, 170.
deplanata Théry, Mem. Soc. Ent. Belg., 1910, 28.
 ? *australis* Théry, l.c., 27.
317. *olivia* Cart., Linn. Soc. N.S.W., 1926, 54. N.Q.
 318. **pagana* Obenb., Col. Runds., 1915, 75. Vic.
 319. *planifrons* Blkb., Roy. Soc. S.A., 1887, 247.
 320. *purpurascens* Macl., Linn. Soc. N.S.W., 1888, 1229. N.W.A.
 321. *subcostata* Blkb., Roy. Soc. S.A., 1891, 296. S.A.
 322. *sulcicollis* Kerr., Ann. Soc. Ent. Belg., 1898, 129. N.S.W., Q.
 ? *tasmanica* Kerr., Gen. Ins., 1902, 170.
 323. *sulcipennis* Kerr., Ann. Soc. Ent. Belg., 1898, 129. N.S.W., Q.
 324. *viridula* Kerr., Jahrb. Hand. Wiss. Aust., 1902, 60. N.S.W., Q.
Anthaxia obscura Macl., Ent. Soc. N.S.W., 1872, 242.
macleayi Cart., nov. nom. (redundant) Tr. Ent. Soc. Lond., 1923,
 70.

* *A. pagana* Obenb., by an oversight, was omitted from my Revision (Linn. Soc. N.S.W., 1926).

NOTOGRAPHUS. Thoms., Typ. Bup. App. 1a, 1879, 26.

- Notograpus* Macl., Ent. Soc. N.S.W., 1872, 243.
Anthaxoschema Obenb., Sbornik. Ent. Mus., Praze, 1923, 23.
325. **deyrollei* Obenb., Ent. Blätter, 1922, 73. C. York.
 326. *hieroglyphicus* Macl., Ent. Soc. N.S.W., 1872, 243. Q.
 327. **macleayi* Obenb., Ent. Blätter, 1922, 73. W.A.
 328. *sulcipennis* Macl., Ent. Soc. N.S.W., 1872, 244. Q.
 329. *uniformis* Macl. (Anthaxia) Linn. Soc. N.S.W., 1888, 1227. N.W.A.
thomsoni Obenb., Ent. Blätter, 1922, 73.
 330. *yorkensis* Obenb., l.c., 73. C. York.
 ? *terraereginae* Obenb. (Anthaxoschema) Sborn. Ent. Mus.
 Praze, 1923, 23.

Obenberger's species are only scantily indicated by a table. As he himself says "Alle sind einander sehr ähnlich und schwer zum Bestimmen." I think I have been able to determine two of them—*yorkensis* Ob. and *thomsoni*—the latter as above.

THERYAXIA. Cart., Linn. Soc. N.S.W., 1928, 549.

331. *suttoni* Cart., l.c., 550. Stanthorpe, Q.

NEOCURIS. Fairm., Ann. Soc. Ent. Fr., 1877, 334.

332. *aenescens* Cart., Linn. Soc. N.S.W., 1928, 281. Bogan R., N.S.W.
 333. *anthaxioides* Fairm., Ann. Soc. Ent. Fr., 1877, 336. S.A. & W.A.
 var. *livida* Cart., Linn. Soc. N.S.W., 1924, 532.
 334. *asperipennis* Fairm., l.c., 339. S.A.
 335. *auroimpressa* Cart., Linn. Soc. N.S.W., 1924, 536. Wide Bay, Q.
 336. *browni* Cart., l.c., 1915, 80. Cue, W.A.
luteotincta Obenb., Col. Rundsch., 1917, 104.
 337. *carteri* Obenb., Sbornik. Ent. Nat. Mus. Praze, 1923, 74. N.Q.
 338. *coerulans* Fairm., Ann. Soc. Ent. Fr., 1877, 335. N.S.W.
pilosula Obenb., Sborn. Entom., 1923, 73.
 339. *crassa* Obenb., l.c., 76. N.S.W.
 340. *cuprilatera* Fairm., Ann. Soc. Ent. Fr., 1877, 336. N.S.W.
 ? *indigacea* Obenb., Sbornik. Entom., 1923, 75.
 341. *dichroa* Fairm., Ann. Soc. Ent. Fr., 1877, 339. V.
 342. *discoflava* Fairm., l.c. W.A.
 343. *doddi* Cart., Linn. Soc. N.S.W., 1928, 281. Chinchilla, Q.

344. *fairmairei* Blkb., Roy. Soc. S.A., 1887, 249. S.A.
 345. *fortnumi* Hope, Ent. Soc. Lond., 1845, 216. V., S.A.
 346. *gracilis* Macl., Ent. Soc. N.S.W., 1872, 271. N.S.W., Q.
 soror Fairm., Ann. Soc. Ent. Fr., 1877, 387.
 var. *atra* Obenb., Sbornik. Entom., 1923, 74.
 var. *ignota* Obenb., l.c.
 var. *oblongula* Obenb., l.c.
 var. *lepidula* Obenb., l.c.
 347. *guerini* Hope, Ent. Soc. Lond., 1845, 103. N.S.W., S.A.
 348. *monochroma* Fairm., Ann. Soc. Ent. Fr., 1877, 334. N.S.W., S.A.
 349. *nickerli* Obenb., Sbornik. Entom., 1923, 76. Q.
 350. *obscurata* Obenb., l.c., 74.
 351. *ornata* Cart., Linn. Soc. N.S.W., 1912, 509. Q.
 hoscheki Obenb., Col. Randsch., 1917, 104.
 352. *pauperata* Fairm., Ann. Soc. Ent. Fr., 1877, 337. S.A.
 353. *pubescens* Blkb., Roy. Soc. S.A., 1887, 250. S.A.
 354. *smaragdifrons* Obenb., Sbornik. Entom., 1923, 73. N.T.
 355. *thoracica* Fairm., Ann. Soc. Ent. Fr., 1877, 340. S.A. & W.A.
 356. *violacea* Cart., Linn. Soc. N.S.W., 1928, 282. Bellinger R., N.S.W.
 357. *viridiaurea* Macl., Linn. Soc. N.S.W., 1888, 1229. N.W.A.
 358. *viridimicans* Fairm., Ann. Soc. Ent. Fr., 1877, 335. W.A.
 var. *sapphira* Cart., Linn. Soc. N.S.W., 1924, 532.
- PSEUDANILARA.** Théry, Mem. Ent. Soc. Belg., 1910, 32.
Neotorresita Obenb., Sbornik. Entom., 1923, 19.
359. *bicolor* Cart., Linn. Soc. N.S.W., 1924, 524. N.Q.
 360. *cupripes* Macl. (Anthaxia) Ent. Soc. N.S.W., 1872, 242. N.S.W., Q., V.
 dilatocollis Blkb. (Neocuris) Roy. Soc. S.A., 1892, 42.
 laticeps Kerr. (Melobasis) Ann. Soc. Ent. Belg., 1898, 126.
 australasiae Kerr. (Melanophila) Jahrb. Hamb. Wiss. Aust.,
 1902, 59.
 achardi Obenb. (Neotorresita) Sborn. Entom., 1923, 20.
361. *dubia* Cart., Linn. Soc. N.S.W., 1926, 57. Q., W.A.
 362. *occidentalis* Cart., l.c., 1924, 525. W.A.
 363. *piliventris* Cart., l.c., 1926, 58. S.A.
 364. *pilosa* Cart. (Neocuris) Linn. Soc. N.S.W., 1912, 510. Q.
 365. *purpureicollis* Macl. (Anthaxia) Ent. Soc. N.S.W., 1872, 242.
 Q., N.S.W., Vic.
 var. *nigra* Macl., l.c.
 nigricans Blkb. (Neocuris) Roy. Soc. S.A., 1892, 43.
 roberti Théry, Mem. Ent. Soc. Belg., 1910, 32.
- Tribe STIGMODERINI
 Sub-tribe *Julodimorphae*.
- JULODIMORPHA.** Thoms., Typ. Bup., 1878, 51.
366. *bakewelli* White, Ann. Mag. Nat. Hist., 1859, 290. V., S.A., W.A.
 Sub-tribe *Stigmoderae*.
- CALODEMA.** L. & G., Mon. ii., 1838, 70.
367. *plebeja* Jordan, Ann. Mag. Nat. Hist., 1895, 220. N.Q.
 368. *regalis* L. & G., Mon. ii., 1838, 71. N.S.W. & Q.
 Kirbyi Hope, Col. Man., 1840, 173.
 369. **wallacei* Deyr., Ann. Soc. Ent. Belg., 1864, 78. N.Q. & N. Guinea.
 *fide Blkb., Roy. Soc. S.A., 1896, 35.
- METAXYMORPHA.** Parry, Tr. Ent. Soc. Lond., 1848, 82.
370. *gloriosa* Blkb., Roy. Soc. S.A., 1894, 207. N.Q.

371. *grayi* Parry, Tr. Ent. Soc. Lond., 1848, 82. N.S.W. & Q.
rubromarginata Théry, Ann. Soc. Ent. Belg., 1922, 261.
372. *hauseri* Théry, Ann. Soc. Ent. Belg., 1926, 167. N.Q.
- CURIS.* L. & G., Mon. ii., 1838, 47.
Neocuroopsis Obenb., Sborn. Ent. Mus. Praze, 1923, 22.
373. *aurifera* L. & G., Mon. ii., 1838, 49. N.S.W., V., S.A.
aurovittata Boh., Res. Eugen., 1858, 60.
374. *caloptera* Boisid., Voy. Astrol., 1832, 93.
dives (*Anthaxia*) Hope, Bupr., 1846, 9.
var. *formosa* Gestro, Ann. Mus. Genov., 1877, 443.
confusa Obenb., Sborn. Ent., 1923, 72.
375. *chloriantha* Fairm., Ann. Soc. Ent. Fr., 1877, 330. W.A.
376. *carusca* Waterh., Ann. Mag. Nat. Hist., 1882, 51. V.
377. *despecta* Fairm., Ann. Soc. Ent. Fr., 1877, 328. W.A.
378. *discoidalis* Blkb., Roy. Soc. S.A., 1892, 214. W.A.
379. *intercibrata* Fairm., Ann. Soc. Ent. Fr., 1877, 328. W.A.
380. *obscura* Cart., Linn. Soc. N.S.W., 1924, 530. S.A.
381. *olivacea* Cart., l.e., 1912, 510. Q.
382. *peroni* Fairm., Ann. Soc. Ent. Fr., 1877, 327. Kangaroo Island.
383. *regia* Cart., Linn. Soc. N.S.W., 1928, 277. N.T.
384. *spencei* Mannerh., Bull. Masc., 1837, 68. S.A., W.A.
385. *splendens* Mael., Ent. Soc. N.S.W., 1872, 245. N.S.W. & Q.
brachelytra Fairm., Ann. Soc. Ent. Fr., 1877, 333.
fairmairei Cart., Linn. Soc. N.S.W., 1924, 531.
386. *viridicyanea* Fairm., Ann. Soc. Ent. Fr., 1877, 332. Q.
387. *yalgoensis* Cart., Linn. Soc. N.S.W., 1924, 530. W.A.
- STIGMODERA.* Eschscholtz, Zool. Atl., 1829, 9.
388. *cancellata* Don., Ins. N. Holl., 1805, 7. W.A.
dejeani Hope, Bupr., 1836, 7.
dejeaneana Boisid., Voy. Astrol., 1835, 63.
389. *goryi* L. & G., Mon. ii., 1838, 7. N.S.W.
curtisi Hope, Bupr., 1836, 3.
390. *gratiosa* Chevrol., Rev. Zool., 1843, 201. W.A.
smaragdina Hope, Tr. Ent. Soc. Lond., 1847, 283.
391. *jacquinoti* Boisid., Voy. Astrol., 1835, 67. N.S.W.
392. *macularia* Don., Ins. N. Holl., 1805, 8. N.S.W., V.
cicatricosa Dalm., Anal. Ent., 1823, 53.
393. *porosa* Cart., Roy. Soc. S.A., 1916, 110. S.Q.
394. *roei* Saund., Tr. Ent. Soc. Lond., 1868, 24. W.A.
cancellata Boisid., Voy. Astrol., 1835, 62.
vescoei Gehin., Bull. Soc. Moselle, 1855, 6.
395. *sanguinosa* Hope, Tr. Ent. Soc. Lond., 1846, 210. S.A., & N.W. Vic.
- S.G. *THEMOGNATHA.* Solier., Ann. Soc. Ent. Fr., 1833, 291.
396. *aestimata* Kerr., Ann. Ent. Soc. Belg., 1898, 135. V.
397. *affinis* Saund., Jour. Linn. Soc., 1868, 461. N.S.W.
limbata L. & G., Mon. ii., 1838, 36.
adelpha Thoms., Typ. Bup., 1878, 52.
398. *barbiventris* Cart., Roy. Soc. S.A., 1916, 113. N.S.W.
399. *bonvouloiri* Saund., Journ. Linn. Soc., 1868, 460.
400. *brucki* Thoms., Typ. Bup., 1878, 53. W.A.
401. *caroli* Blkb., Roy. Soc. S.A., 1894, 140. W.A.
capucina Blkb., l.e., 1892, 216.
402. *carpentariae* Blkb., l.e., 53. N.Q.

403. *chevrolati* Gehin., Bull. Soc. Moselle., 1855, 10.
imperatrix White, Ann. Mag. Nat. Hist., 1859, 290.
imperator Thoms., Bull. Soc. Ent. Fr., 1879, 14.
404. *chaleodera* Thoms., Typ. Bup., 1878, 52. W.A.
405. *congener* Saund., Ins. Saund., 1869, 1. S.A.
406. *conspicillata* White, Ann. Mag. Nat. Hist., 1843, 344. W.A.
signaticollis Hope, Tr. Ent. Soc. Lond., 1846, 209.
cyanura Hope, l.c., 211.
407. *donorani* L. & G., Mon. ii., 1838, 17. Q.
408. *duboulayi* Saund., Tr. Ent. Soc. Lond., 1872, 253. N.W.A.
409. *ducalis* Cart., Linn. Soc. N.S.W., 1927. W.A.
410. *duponti* Boisd., Voy. Astrol., 1835, 60. S.A. & W.A.
stevensi Gehin., Bull. Soc. Moselle., 1835, 8.
411. *excisicollis* Mael., Ent. Soc. N.S.W., 1862, 31.
addenda Thoms., Typ. Bup., 1878, 52.
sincera Kerr., Ann. Soc. Ent. Belg., 1898, 136.
desperata Oberh., Archiv. für Naturg., 1922, 113.
412. *flavicollis* Saund., Ins. Saund., 1869, 3. S.A.
unicincta Saund., Tr. Ent. Soc. Lond., 1872, 252.
413. *flavocincta* L. & G., Mon. ii., 1838, 6. S.A., W.A.
414. *flavomarginata* Gem. & Har., Cat. Col., 1869, 1400. S.A.
cruentata Murray, Ann. Soc. Ent. Fr., 1852, 253.
415. *fortnumi* Hope, Tr. Ent. Soc. Lond., 1842, 102. N.S.W., V., S.A.
416. *franca* Cart., Roy. Soc. S.A., 1916, 111. N.Q.
417. *gigas* Cart., l.c., 112. W.A.
418. *gloriosa* Cart., l.c., 115. W.A.
419. *grandis* Don., Ep. Ins. N. Holl., 1805, t. 8, fig. 1. N.S.W.
420. *haematica* Hope, Tr. Ent. Soc. Lond., 1846, 210. S.A.
clara Kerr., Ann. Soc. Ent. Belg., 1900, 313.
421. *heros* Gehin., Bull. Soc. Moselle., 1855, 7. N.S.W., V., S.A., W.A.
422. *imperialis* Cart., Roy. Soc. S.A., 1916, 116. W.A.
423. *jansoni* Saund., Jour. Linn. Soc., 1868, 462. Q.
424. *laevicollis* Saund., l.c., 466. N.W.A.
425. *latithorax* Thoms., Arch. Ent., 1857, 112. N.S.W.
426. *lessoni* L. & G., Mon. ii., 1838, 127. W.A.
acutithorax Thoms., Arch. Ent., 1857, 113.
427. *limbata* Don., Epit. Ins. N. Holl., 1805, t. 8, fig. 4. N.S.W.
428. *lobicollis* Saund., Jour. Linn. Soc., 1868, 462. Q.
429. *macfarlani* Waterh., Ann. Mag. Nat. Hist., 1881, 463. Torres Strait, N.Q.
430. *marcida* Blkb., Roy. Soc. S.A., 1892, 52. W.A.
431. **marginalis* Cart., Linn. Soc. N.S.W., 1929. W.A.
432. *martini* Saund., Ins. Saund., 1869, 2. N.W.A.
433. *menalcas* Thoms., Bull. Soc. Ent. Fr., 1879, 14. V.
434. *miranda* Cart., Linn. Soc. N.S.W., 1927. W.A.
435. *mittelli* Hope, Tr. Ent. Soc. Lond., 1846, 209. N.S.W., V., T., S.A., W.A.
stricklandi Hope, l.c., 220.
daphnis Thoms., Arch. Ent., 1857, 112.
ostentatrix Thoms., Bull. Soc. Ent. Fr., 1879, 93.
var 1. *quadrispilota* Saund., Ins. Saund., 1869, 5.
var 2. *tasmanica* Kerr., C.R. Soc. Ent. Belg., 1890, 2.
var 3. *karattae* Blkb., Roy. Soc. S.A., 1890, 149.
436. *miszecki* Saund., Jour. Linn. Soc., 1868, 460.
437. *murrayi* Gem. & Har., Cat. Col., 1869, 1401. King George's Sound, W.A.
trifasciata Murray, Ann. Soc. Ent. Fr., 1852, 254.
imperatrix Thoms., Bull. Soc. Ent. Fr., 1879, 14.

438. *notaticollis* Cart., Roy. Soc. S.A., 1916, 117. Berrima, N.S.W.
 439. *obscuripennis* Mannerh., Bull. Mosc., 1837, 32. W.A.
 rugosipennis Thoms., Arch. Ent., 1857, 111.
 440. *oleata* Blkb., Roy. Soc. S.A., 1894, 142. W.A.
 441. *parryi* Hope, Tr. Ent. Soc. Lond., 1846, 210. S.A.
 fusca Saund., Cat. Bup., 1871, 66.
 parvicollis Saund., Ins. Saund., 1869, 1.
 picea Kerr., C.R. Soc. Ent. Belg., 1890, 40.
 queenslandica Obenb., Arch. für Naturg., 1922, 112.
 442. *particollis* Cart., Linn. Soc. N.S.W., 1929. W.A.
 443. *pascoei* Saund., Jour. Linn. Soc., 1868, 463. W.A.
 444. *pictipes* Blkb., Roy. Soc. S.A., 1894, 140. W.A.
 445. *praececellens* Kerr., C.R. Soc. Ent. Belg., 1890, 140. N.S.W. & V.
 frenchi Blkb., Roy. Soc. S.A., 1890, 150.
 446. *praeterita* Cart., Linn. Soc. N.S.W., 1924, 20. N.S.W.
 447. *princeps* Blkb., Roy. Soc. S.A., 1891, 137. W.A.
 448. *pubicollis* Waterh., Tr. Ent. Soc. Lond., 1874, 539. W.A.
 major Waterh., l.e.
 lateritia Thoms., Typ. Bup. App. 1a, 1879, 30.
 449. *rectipennis* Blkb., Roy. Soc. S.A., 1891, 138. W.A.
 apicerubra Kerr., Ann. Soc. Ent. Belg., 1900, 314.
 450. *regia* Blkb., Roy. Soc. S.A., 1892, 218. N.Q.
 451. *reichei* L. & G., Mon. ii., 1838, 13. W.A.
 funerea White, Ann. Mag. Nat. Hist., 1843, 344.
 marmorea Blkb., Roy. Soc. S.A., 1890, 148.
 452. *rufocyanea* Cart., l.e., 1916, 117. A.
 453. *sanguinea* Saund., Ins. Saund., 1869, 4. N.W.V., S.A.
 pictiventris Kerr., Ann. Soc. Ent. Belg., 1900, 314.
 avuncularis Thoms., Typ. Bup. App. 1a, 1879, 30.
 454. *sanguineocincta* Saund., Jour. Linn. Soc., 1868, 461. Q.
 alcyone Thoms., Bull. Soc. Ent. Fr., 1879, 77.
 coelestis Thoms., Arch. Ent., 1857, 113.
 455. *sanguinipennis* L. & G., Mon. ii., 1838, 16. V.
 cincticollis Kerr., Ann. Soc. Ent. Belg., 1898, 134.
 456. *sanguiniventris* Saund., Jour. Linn. Soc., 1868, 465. S.A.
 457. *saundersi* Waterh., Ann. Mag. Nat. Hist., 1876, 70. Q., N.S.W.
 obesissima Thoms., Typ. Bup. App. 1a, 1879, 32.
 458. *sexmaculata* Saund., Jour. Linn. Soc., 1868, 465. N.S.W.
 459. *similis* Saund., l.e., 463. Q. & N.S.W.
 460. *spencei* L. & G., Mon. ii., 1838, 13. N.S.W.
 egregia Boh., Eng. Res. Ent., 1858, 60.
 sternoceroides Thoms., Bull. Soc. Ent. Fr., 1879, 13.
 461. *suturalis* Don., Epit. Ins. N. Holl., 1805, pl. 8, fig. 5. N.S.W.
 vertebralis Boisd., Voy. Astrol., 1835, 66.
 462. *tibialis* Waterh., Tr. Ent. Soc. Lond., 1874, 440. S.A. & W.A.
 463. *thoracica* Saund., Jour. Linn. Soc., 1868, 464. N.S.W.
 atalanta Thoms., Bull. Soc. Ent. Fr., 1879, 79.
 464. *tricolorata* Waterh., Tr. Ent. Soc. Lond., 1874, 545. N.W.A.
 465. *variabilis* Don., Epit. Ins. N. Holl., 1805, t. 7, fig. 1. N.S.W., V., S.A., Q.
 kingi W. S. Macl., King Surv., 1827, 441.
 var. *nigripennis* L. & G., Mon. ii., 1838, 15.
 unifasciata L. & G., l.e., 20.
 cyaniventris Kerr., Ann. Soc. Ent. Belg., 1900, 315.

* 431 and 442 unpublished at time of going to press.

- ? *quinquefossulata* Théry, Mem. Ent. Soc. Belg., 1910, 54.
 466. *viridicauda* Cart., Arch. für Zool., 1920, 3. N.Q.
 467. *viridicincta* Waterh., Tr. Ent. Soc. Lond., 1874, 543. Q
 468. *vitticollis* Macl., Ent. Soc. N.S.W., 1862, 30. N.S.W., Q.
 delia Thoms., Bull. Soc. Ent. Fr., 1879, 124.
 fallaciosa Kerr., C.R. Soc. Ent. Belg., 1890, 41.
 469. *westwoodi* Saund., Jour. Linn. Soc., 1868, 464. S.A., W.A.
 470. *wimmerae* Blkb., Roy. Soc. S.A., 1890, 151. V.
 471. *yarrelli* L. & G., Mon. ii., 1838, 14. W.A.
 var 1. *flavipennis* Gehin., Bull. Soc. Moselle, 1855, 11.
 var 2. *elegans* Gehin., l.c., 12.
 var 3. *varicollis* Cart., Linn. Soc. N.S.W., 1912, 497.

S. G. CASTIARINA. Lap et Gory, Mon. Bupr., 1838, 22.

472. *abdominalis* Saund., Jour. Linn. Soc., 1868, 467. N.S.W.
 ? *unica* Kerr., Ann. Ent. Soc. Belg., 1898, 150.
 473. *acuminata* Kerr., Ann. Ent. Soc. Belg., 1898, 142. N.Q.
 474. *acuticeps* Saund., Ins. Saund., 1869, 19. W.A.
 475. *acuticollis* Cart., Linn. Soc. N.S.W., 1916, 133. Q.
 476. *aenicornis* Saund., Jour. Linn. Soc., 1868, 472. . . . N.W.A. & N.S.W.
 477. *affabilis* Kerr., Ann. Soc. Ent. Belg., 1898, 141. . . . Stradbroke IS., Q.
 simplex Kerr., Gen. Ins., 1902, 210.
 478. *alternecosta* Thoms., Typ. Bup. App. 1a, 1879, 35. . . . V., N.S.W., Q.
 479. *alexandri* Cart., l.c., 1916, 119. W.A.
 480. *alternata* Lumh., "Amongst cannibals," 1889, 197. . . . N.Q.
 alacris Kerr., Bull. Soc. Ent. Belg., 1890, 47.
 libens Kerr., Gen. Ins., 1902, 209.
 quadrinotata Blkb., Roy. Soc. S.A., 1892, 49.
 481. *amabilis* L. & G., Mon. ii., 1838, 19. W.A.
 482. *analis* Saund., Ins. Saund., 1869, 7. S.Q.
 483. *anchoralis* L. & G., Mon. ii., 1838, 26. W.A.
 agrestis Kerr., Ann. Soc. Ent. Belg., 1898, 140.
 arborifera Blkb., Roy. Soc. S.A., 1892, 51.
 484. *andersoni* L. & G., Mon. ii., 1838, 42. N.S.W., V.
 var. *verax* Kerr., Ann. Soc. Ent. Belg., 1898, 146.
 485. *argillacea* Cart., Roy. Soc. S.A., 1916, 126. N.W.V.
 486. *assimilis* Hope, Tr. Ent. Soc. Lond., 1846, 212. N.S.W., V.
 487. *attenuata* Cart., Roy. Soc. S.A., 1916, 132. V.
 488. *atricollis* Saund., Ins. Saund., 1869, 22. S.A. & W.A.
 tripartita Kerr., Ann. Soc. Belg., 1900, 317.
 489. *atronotata* Waterh., Tr. Ent. Soc. Lond., 1874, 542. Q.
 guttaticollis Blkb., Roy. Soc. S.A., 1890, 158.
 consularis Kerr., Ann. Soc. Ent. Belg., 1900, 149.
 490. *audax* Saund., Ins. Saund., 1869, 5. A.
 491. *aureola* Cart., Linn. Soc. N.S.W., 1912, 499. W.A.
 492. *auricollis* Thoms., Arch. Ent., 1857, 114. N.S.W., Q.
 ochreiventris Saund., Ins. Saund., 1869, 8.
 strigata Macl., Ent. Soc. N.S.W., 1862, 27.
 pallidipennis Blkb., Roy. Soc. S.A., 1890, 154.
 493. *aurifera* Cart., Linn. Soc. N.S.W., 1922, 68. N.Q.
 494. *aurolimbata* Cart., l.c. N.Q.
 495. *australasiae* L. & G., Mon. ii., 1838, 32. N.S.W., V., T., S.A.
 simulata Hope, Bup., 1836, 3.
 melbournensis Thoms., Typ. Bup. App. 1a, 1879, 34.

496. *balteata* Saund., Ins. Saund., 1869, 16. N.S.W.
postica Thoms., Typ. Bup. App. 1a, 1879, 37.
497. *bella* Saund., Cat. Bup., 1871, 71. N.S.W., V.
cruentata L. & G., Mon. ii., 1838, 29.
var. *dixonii* Cart., Linn. Soc. N.S.W., 1926, 57.
498. *bicineta* Boisd., Voy. Astrol., 1835, 89.
bicingulata L. & G., Mon. ii., 1838, 30.
dejeani Gory., Mon. iv., 1841, errata.
trispinosa Kerr., C.R. Soc. Ent. Belg., 1890, 43.
499. *bifasciata* Saund., Jour. Linn. Soc., 1868, 263. W.A.
500. *biguttata* Macl., Ent. Soc. N.S.W., 1862, 24. Q.
terraereginae Blkb., Roy. Soc. S.A., 1893, 295.
triangulosa Kerr., Ann. Soc. Ent. Belg., 1898, 147.
501. *bimaculata* Saund., Jour. Linn. Soc., 1868, 481. . . N.W.V., S.A. & W.A.
punctiventris Saund., l.c., 17.
guttata Blkb., Roy. Soc. S.A., 1890, 158.
var 1. *minor* Blkb., l.c.
var 2. *ignea* Blkb., Roy. Soc. S.A., 1892, 219.
502. *binotata* Saund., Cat. Bup., 1871, 72. N.A.
bimaculata Saund., Ins. Saund., 1869, 7.
503. *blackburni* Cart., l.c., 1916, 118. S.A.
504. *bremei* Hope, Tr. Ent. Soc. Lond., 1845, 102. N.S.W., V.
505. *browni* Cart., Roy. Soc. S.A., 1916, 121. W.A.
506. *brutella* Thoms., Typ. Bup. App. 1a, 1879, 37. N.S.W.
terminalis Kerr., C.R. Soc. Ent. Belg., 1890, 45.
507. *burchelli* L. & G., Mon. ii., 1868, 38. N.S.W., W.A.
508. *campestris* Blkb., Roy. Soc. S.A., 1897, 30. Q.
saundersiana Obenb., Arch. für Naturg., 1922, 120.
509. *cara* Blkb., Roy. Soc. S.A., 1892, 216. Q.
placens Kerr., Ann. Soc. Ent. Belg., 1898, 139.
510. *carinata* Macl., Ent. Soc. N.S.W., 1862, 26. Q.
opacula Obenb., Arch. für Naturg., 1922, 121.
511. *carminea* Saund., Jour. Linn. Soc., 1868, 474. N.S.W.
512. *castelnaudi* Saund., Ins. Saund., 1869, 9. N.W.V., S.A. & W.A.
castelnaudi Thoms., Typ. Bup., 1878, 53.
thomsoniana Mast., Cat. Col., 1886, 273.
laportei Kerr., C.R. Soc. Ent. Belg., 1890, 42.
513. *caudata* Kerr., Ann. Soc. Ent. Belg., 1900, 316. N.S.W.
514. *chobauti* Théry, Bull. Soc. Ent. Fr., 1895, 328. A.
515. *cinnamomea* Macl., Ent. Soc. N.S.W., 1862, 25.
516. *clancula* Obenb., Arch. für Naturg., 1922, 117. Q.
517. *clarki* Cart., Linn. Soc. N.S.W., 1922, 69. S.W.A.
518. *coccinata* Hope, Tr. Ent. Soc. Lond., 1845, 105. S.A. & W.A.
elegantula White, Stokes Journ., 1846, 507.
519. *coeruleipes* Saund., Ins. Saund., 1869, 13. N.S.W., S.A.
520. *cognata* Kerr., Ann. Ent. Soc. Belg., 1898, 136. N.S.W.
521. *colligens* Kerr., l.c., 1890, 44. Q.
522. *commixta* Cart., Linn. Soc. N.S.W., 1924, 26. Sydney, N.S.W.
523. *confinis* Kerr., Ann. Soc. Ent. Belg., 1898, 151. A.
524. *confusa* Waterh., Tr. Ent. Soc. Lond., 1874, 541. Q.
525. *convexa* Cart., Linn. Soc. N.S.W., 1913, 506. W.A.
526. *cordifer* Kerr., C.R. Soc. Ent. Belg., 1890, 44. W.A.
527. *costata* Saund., Jour. Linn. Soc., 1868, 470. N.S.W.
528. *costipennis* Saund., Ins. Saund., 1868, 13. N.S.W.

529. *crenata* Don., Epit. Ins. N. Holl., t. 7, fig. 3. A.
amphichroa Boisd., Voy. Astrol., 1835, 20.
sexspilota L. & G., Mon. ii., 1838, 35;
sieboldi L. & G., l.c., 38.
530. *crocicolor* L. & G., Mon. ii., 1838, 44. W.A.
consanguinea Saund., Tr. Ent. Soc. Lond., 1868, 49.
531. *cruenta* L. & G., l.c., 29. N.S.W.
532. *crux* Saund., Jour. Linn. Soc., 1868, 473. A.
533. *cupida* Kerr., Ann. Soc. Ent. Belg., 1894, 138. N.S.W. & Q.
534. *cupricauda* Saund., Ins. Saund., 1869, 475. N.S.W.
535. *cupricollis* Saund., Jour. Linn. Soc., 1868, 470. N.S.W.
alterzona Thoms., Typ. Bup., 1878, 54.
deyrollei Thoms., Bull. Soc. Ent. Fr., 1879, 125.
julia Thoms., Typ. Bup. App. 1a, 1879, 31.
536. *cyanipes* Saund., Jour. Linn. Soc., 1868, 468. S.A., W.A.
537. *cydista* Rainb., Rec. Aus. Mus., 1904, 246. N.S.W.
538. *cylindracea* Saund., Jour. Linn. Soc., 1868, 476. S.A., W.A.
bucolica Kerr., Ann. Soc. Ent. Belg., 1898, 42.
539. *decemmaculata* Kirby, Tr. Linn. Soc., 1818, 456. . . Q., N.S.W., V., S.A.
inaequalis Kerr., Gen. Ins., 1902, 207.
540. *decipiens* Westw., Mag. Zool. Bot., 1837, 253. Q.
capucina Thoms., Rev. & Mag. Zool., 1856, 116.
tricarinata Macl., Ent. Soc. N.S.W., 1862, 29.
var. *octocostata* Cart., Roy. Soc. S.A., 1916, 130.
541. *delectabilis* Hope, Tr. Ent. Soc. Lond., 1847, 284. . . . N.S.W., V., S.A.
542. *deleta* Kerr., Gen. Ins., 1902, 208. Q.
543. *delta* Thoms., Typ. Bup. App. 1a, 1879, 38. Q., N.S.W.
deceptor Kerr., Gen. Ins., 1902, 209.
544. *delicatula* Kerr., l.c., 209. Q.
? *guttifera* Obenb., Archiv. für Naturg., 1922, 121.
545. *desideria* Cart., Roy. Soc. S.A., 1916, 122. Cue, W.A.
546. *deuqueti* Cart., Linn. Soc. N.S.W., 1927. Armidale, N.S.W.
547. *diana* Obenb., Archiv. für Naturg., 1922, 120. A.
548. *dicax* Obenb., l.c., 119. N.Q.
549. *dilatocollis* Cart., Linn. Soc. N.S.W., 1927. W.A.
550. *dimidiata* Cart., l.c., 1908. N.S.W., T.
var. *leai* Cart., Roy. Soc. S.A., 1916, 136; Linn. Soc. N.S.W.,
1919, 138.
dorsalis Obenb., Archiv. für Naturg., 1922, 120.
551. *disjecta* Kerr., C.R. Soc. Ent. Belg., 1890, 48. Q.
552. *distincta* Saund., Jour. Linn. Soc., 1868, 473. Q.
sternalis Blkb., Roy. Soc. S.A., 1892, 47.
deliciosa Kerr., Ann. Soc. Ent. Belg., 1898, 145.
var. *baliola* Kerr., l.c., 144.
var. *inermis* Kerr., C.R. Soc. Ent. Belg., 1890, 45.
553. *distinguenda* Saund., Ins. Saund., 1869, 9. A.
554. *doddi* Cart., Linn. Soc. N.S.W., 1913, 505. N.Q.
555. **duaringae* Cart., l.c., 1929. Q.
556. *elderi* Blkb., Roy. Soc. S.A., 1892, 36. W.A.
rustica Kerr., Ann. Soc. Ent. Belg., 1898, 154.
diversa Kerr., l.c., 1900, 317.
557. *elongata* Saund., Jour. Linn. Soc., 1868, 408. W.A.
558. *elongatula* Macl., Ent. Soc. N.S.W., 1872, 246. Q., N.S.W., V., S.A., W.A.

* Unpublished at time of going to press.

- uniformis* Kerr., Ann. Soc. Ent. Belg., 1898, 131.
deyrollei Kerr. (nec Thoms.) Ins. Gen., 1902, 170.
deplanata Théry, Mem. Soc. Ent. Belg., 1910, 28.
 ? *australis* Théry, l.c., 27.
317. *olivia* Cart., Linn. Soc. N.S.W., 1926, 54. N.Q.
 318. **pagana* Obenb., Col. Rundsch., 1915, 75. Vic.
 319. *planifrons* Blkb., Roy. Soc. S.A., 1887, 247.
 320. *purpurascens* Macl., Linn. Soc. N.S.W., 1888, 1229. N.W.A.
 321. *subcostata* Blkb., Roy. Soc. S.A., 1891, 296. S.A.
 322. *sulcicollis* Kerr., Ann. Soc. Ent. Belg., 1898, 129. N.S.W., Q.
 ? *tasmanica* Kerr., Gen. Ins., 1902, 170.
 323. *sulcipennis* Kerr., Ann. Soc. Ent. Belg., 1898, 129. N.S.W., Q.
 324. *viridula* Kerr., Jahrb. Hand. Wiss. Aust., 1902, 60. N.S.W., Q.
Anthaxia obscura Macl., Ent. Soc. N.S.W., 1872, 242.
macleayi Cart., nov. nom. (redundant) Tr. Ent. Soc. Lond., 1923,
 70.

* *A. pagana* Obenb., by an oversight, was omitted from my Revision (Linn. Soc. N.S.W., 1926).

NOTOGRAPHUS. Thoms., Typ. Bup. App. 1a, 1879, 26.

Notograptus Macl., Ent. Soc. N.S.W., 1872, 243.

Anthaxoschema Obenb., Sbornik Ent. Mus., Praze, 1923, 23.

325. **deyrollei* Obenb., Ent. Blätter, 1922, 73. C. York.
 326. *hieroglyphicus* Macl., Ent. Soc. N.S.W., 1872, 243. Q.
 327. **macleayi* Obenb., Ent. Blätter, 1922, 73. W.A.
 328. *sulcipennis* Macl., Ent. Soc. N.S.W., 1872, 244. Q.
 329. *uniformis* Macl. (*Anthaxia*) Linn. Soc. N.S.W., 1888, 1227. N.W.A.
thomsoni Obenb., Ent. Blätter, 1922, 73.
 330. *yorkensis* Obenb., l.c., 73. C. York.
 ? *terraereginae* Obenb. (*Anthaxoschema*) Sborn. Ent. Mus.
 Praze, 1923, 23.

Obenberger's species are only scantily indicated by a table. As he himself says "Alle sind einander sehr ähnlich und schwer zum Bestimmen." I think I have been able to determine two of them—*yorkensis* Ob. and *thomsoni*—the latter as above.

THERYAXIA. Cart., Linn. Soc. N.S.W., 1928, 549.

331. *suttoni* Cart., l.c., 550. Stanthorpe, Q.

NEOCURIS. Fairm., Ann. Soc. Ent. Fr., 1877, 334.

332. *aenescens* Cart., Linn. Soc. N.S.W., 1928, 281. Bogan R., N.S.W.
 333. *anthaxioides* Fairm., Ann. Soc. Ent. Fr., 1877, 336. S.A. & W.A.
 var. *livida* Cart., Linn. Soc. N.S.W., 1924, 532.
 334. *asperipennis* Fairm., l.c., 339. S.A.
 335. *auroimpressa* Cart., Linn. Soc. N.S.W., 1924, 536. Wide Bay, Q.
 336. *browni* Cart., l.c., 1915, 80. Cue, W.A.
luteotincta Obenb., Col. Rundsch., 1917, 104.
 337. *carteri* Obenb., Sbornik Ent. Nat. Mus. Praze, 1923, 74. N.Q.
 338. *coerulans* Fairm., Ann. Soc. Ent. Fr., 1877, 335. N.S.W.
pilosula Obenb., Sborn. Entom., 1923, 73.
 339. *crassa* Obenb., l.c., 76. N.S.W.
 340. *cuprilatera* Fairm., Ann. Soc. Ent. Fr., 1877, 336. N.S.W.
 ? *indigacea* Obenb., Sbornik Entom., 1923, 75.
 341. *dichroa* Fairm., Ann. Soc. Ent. Fr., 1877, 339. V.
 342. *discoflava* Fairm., l.c. W.A.
 343. *doddi* Cart., Linn. Soc. N.S.W., 1928, 281. Chinchilla, Q.

344. *fairmairei* Blkb., Roy. Soc. S.A., 1887, 249. S.A.
 345. *fortnumi* Hope, Ent. Soc. Lond., 1845, 216. V., S.A.
 346. *gracilis* Macl., Ent. Soc. N.S.W., 1872, 271. N.S.W., Q.
 soror Fairm., Ann. Soc. Ent. Fr., 1877, 387.
 var. *atra* Obenb., Sbornik. Entom., 1923, 74.
 var. *ignota* Obenb., l.e.
 var. *oblongula* Obenb., l.e.
 var. *lepidula* Obenb., l.e.
 347. *guerini* Hope, Ent. Soc. Lond., 1845, 103. N.S.W., S.A.
 348. *monochroma* Fairm., Ann. Soc. Ent. Fr., 1877, 334. N.S.W., S.A.
 349. *nickerli* Obenb., Sbornik. Entom., 1923, 76. Q.
 350. *obscurata* Obenb., l.e., 74.
 351. *ornata* Cart., Linn. Soc. N.S.W., 1912, 509. Q.
 hoscheki Obenb., Col. Randsch., 1917, 104.
 352. *pauperata* Fairm., Ann. Soc. Ent. Fr., 1877, 337. S.A.
 353. *pubescens* Blkb., Roy. Soc. S.A., 1887, 250. S.A.
 354. *smaragdifrons* Obenb., Sbornik. Entom., 1923, 73. N.T.
 355. *thoracica* Fairm., Ann. Soc. Ent. Fr., 1877, 340. S.A. & W.A.
 356. *violacea* Cart., Linn. Soc. N.S.W., 1928, 282. Bellinger R., N.S.W.
 357. *viridiaurea* Macl., Linn. Soc. N.S.W., 1888, 1229. N.W.A.
 358. *viridimicans* Fairm., Ann. Soc. Ent. Fr., 1877, 335. W.A.
 var. *sapphira* Cart., Linn. Soc. N.S.W., 1924, 532.
- PSEUDANILARA.** Théry, Mem. Ent. Soc. Belg., 1910, 32.
 Neotorresita Obenb., Sbornik. Entom., 1923, 19.
359. *bicolor* Cart., Linn. Soc. N.S.W., 1924, 524. N.Q.
 360. *cupripes* Macl. (Anthaxia) Ent. Soc. N.S.W., 1872, 242. N.S.W., Q., V.
 dilatocollis Blkb. (Neocuris) Roy. Soc. S.A., 1892, 42.
 laticeps Kerr. (Melobasis) Ann. Soc. Ent. Belg., 1898, 126.
 australasiae Kerr. (Melanophila) Jahrb. Hamb. Wiss. Aust.,
 1902, 59.
 achardi Obenb. (Neotorresita) Sborn. Entom., 1923, 20.
361. *dubia* Cart., Linn. Soc. N.S.W., 1926, 57. Q., W.A.
 362. *occidentalis* Cart., l.e., 1924, 525. W.A.
 363. *piliventris* Cart., l.e., 1926, 58. S.A.
 364. *pilosa* Cart. (Neocuris) Linn. Soc. N.S.W., 1912, 510. Q.
 365. *purpureicollis* Macl. (Anthaxia) Ent. Soc. N.S.W., 1872, 242.
 Q., N.S.W., Vic.
 var. *nigra* Macl., l.e.
 nigricans Blkb. (Neocuris) Roy. Soc. S.A., 1892, 43.
 roberti Théry, Mem. Ent. Soc. Belg., 1910, 32.
- Tribe STIGMODERINI
 Sub-tribe *Julodimorphae*.
- JULODIMORPHA.** Thoms., Typ. Bup., 1878, 51.
366. *bakewelli* White, Ann. Mag. Nat. Hist., 1859, 290. V., S.A., W.A.
 Sub-tribe *Stigmoderae*.
- CALODEMA.** L. & G., Mon. ii., 1838, 70.
367. *plebeja* Jordan, Ann. Mag. Nat. Hist., 1895, 220. N.Q.
 368. *regalis* L. & G., Mon. ii., 1838, 71. N.S.W. & Q.
 Kirbyi Hope, Col. Man., 1840, 173.
 369. **wallacei* Deyr., Ann. Soc. Ent. Belg., 1864, 78. N.Q. & N. Guinea.
 *fide Blkb., Roy. Soc. S.A., 1896, 35.
- METAXYMORPHA.** Parry, Tr. Ent. Soc. Lond., 1848, 82.
370. *gloriosa* Blkb., Roy. Soc. S.A., 1894, 207. N.Q.

371. *grayi* Parry, Tr. Ent. Soc. Lond., 1848, 82. N.S.W. & Q.
rubromarginata Théry, Ann. Soc. Ent. Belg., 1922, 261.
372. *hauseri* Théry, Ann. Soc. Ent. Belg., 1926, 167. N.Q.
- CURIS. L. & G., Mon. ii., 1838, 47.
Neocuroopsis Obenb., Sborn. Ent. Mus. Praze, 1923, 22.
373. *aurifera* L. & G., Mon. ii., 1838, 49. N.S.W., V., S.A.
aurovittata Boh., Res. Eugen., 1858, 60.
374. *caloptera* Boisd., Voy. Astrol., 1832, 93.
dives (*Anthaxia*) Hope, Bupr., 1846, 9.
var. *formosa* Gestro, Ann. Mus. Genov., 1877, 443.
confusa Obenb., Sborn. Ent., 1923, 72.
375. *chloriantha* Fairm., Ann. Soc. Ent. Fr., 1877, 330. W.A.
376. *carusca* Waterh., Ann. Mag. Nat. Hist., 1882, 51. V.
377. *despecta* Fairm., Ann. Soc. Ent. Fr., 1877, 328. W.A.
378. *discoidalis* Blkb., Roy. Soc. S.A., 1892, 214. W.A.
379. *intercibrata* Fairm., Ann. Soc. Ent. Fr., 1877, 328. W.A.
380. *obscura* Cart., Linn. Soc. N.S.W., 1924, 530. S.A.
381. *olivacea* Cart., l.e., 1912, 510. Q.
382. *peroni* Fairm., Ann. Soc. Ent. Fr., 1877, 327. Kangaroo Island.
383. *regia* Cart., Linn. Soc. N.S.W., 1928, 277. N.T.
384. *spencei* Mannerh., Bull. Masc., 1837, 68. S.A., W.A.
385. *splendens* Mael., Ent. Soc. N.S.W., 1872, 245. N.S.W. & Q.
brachelytra Fairm., Ann. Soc. Ent. Fr., 1877, 333.
fairmairei Cart., Linn. Soc. N.S.W., 1924, 531.
386. *viridicyanea* Fairm., Ann. Soc. Ent. Fr., 1877, 332. Q.
387. *yalgoensis* Cart., Linn. Soc. N.S.W., 1924, 530. W.A.
- STIGMODERA. Eschscholtz, Zool. Atl., 1829, 9.
388. *cancellata* Don., Ins. N. Holl., 1805, 7. W.A.
dejeani Hope, Bupr., 1836, 7.
dejeaneana Boisd., Voy. Astrol., 1835, 63.
389. *goryi* L. & G., Mon. ii., 1838, 7. N.S.W.
curtisi Hope, Bupr., 1836, 3.
390. *gratiosa* Chevrol., Rev. Zool., 1843, 201. W.A.
smaragdina Hope, Tr. Ent. Soc. Lond., 1847, 283.
391. *jacquinoti* Boisd., Voy. Astrol., 1835, 67. N.S.W.
392. *macularia* Don., Ins. N. Holl., 1805, 8. N.S.W., V.
ciatricosa Dalm., Anal. Ent., 1823, 53.
393. *porosa* Cart., Roy. Soc. S.A., 1916, 110. S.Q.
394. *roei* Saund., Tr. Ent. Soc. Lond., 1868, 24. W.A.
cancellata Boisd., Voy. Astrol., 1835, 62.
vescoei Gehin., Bull. Soc. Moselle, 1855, 6.
395. *sanguinosa* Hope, Tr. Ent. Soc. Lond., 1846, 210. S.A., & N.W. Vic.
- S.G. THEMIGNATHA. Solier., Ann. Soc. Ent. Fr., 1833, 291.
396. *aestimata* Kerr., Ann. Ent. Soc. Belg., 1898, 135. V.
397. *affinis* Saund., Jour. Linn. Soc., 1868, 461. N.S.W.
limbata L. & G., Mon. ii., 1838, 36.
adelpha Thoms., Typ. Bup., 1878, 52.
398. *barbiventris* Cart., Roy. Soc. S.A., 1916, 113. N.S.W.
399. *bonvouloiri* Saund., Journ. Linn. Soc., 1868, 460.
400. *brucki* Thoms., Typ. Bup., 1878, 53. W.A.
401. *caroli* Blkb., Roy. Soc. S.A., 1894, 140. W.A.
capucina Blkb., l.e., 1892, 216.
402. *carpentariae* Blkb., l.e., 53. N.Q.

403. *chevrolati* Gehin., Bull. Soc. Moselle., 1855, 10.
imperatrix White, Ann. Mag. Nat. Hist., 1859, 290.
imperator Thoms., Bull. Soc. Ent. Fr., 1879, 14.
404. *chaleodera* Thoms., Typ. Bup., 1878, 52. W.A.
405. *congener* Saund., Ins. Saund., 1869, 1. S.A.
406. *conspicillata* White, Ann. Mag. Nat. Hist., 1843, 344. W.A.
signaticollis Hope, Tr. Ent. Soc. Lond., 1846, 209.
cyanura Hope, l.c., 211.
407. *donorani* L. & G., Mon. ii., 1838, 17. Q.
408. *duboulayi* Saund., Tr. Ent. Soc. Lond., 1872, 253. N.W.A.
409. *ducalis* Cart., Linn. Soc. N.S.W., 1927. W.A.
410. *duponti* Boisd., Voy. Astrol., 1835, 60. S.A. & W.A.
stevensi Gehin., Bull. Soc. Moselle., 1835, 8.
411. *excisicollis* Macl., Ent. Soc. N.S.W., 1862, 31.
addenda Thoms., Typ. Bup., 1878, 52.
sincera Kerr, Ann. Soc. Ent. Belg., 1898, 136.
desperata Obenb., Archiv. für Naturg., 1922, 113.
412. *flavicollis* Saund., Ins. Saund., 1869, 3. S.A.
unicincta Saund., Tr. Ent. Soc. Lond., 1872, 252.
413. *flavocincta* L. & G., Mon. ii., 1838, 6. S.A., W.A.
414. *flavomarginata* Gem. & Har., Cat. Col., 1869, 1400. S.A.
cruentata Murray, Ann. Soc. Ent. Fr., 1852, 253.
415. *fortnumi* Hope, Tr. Ent. Soc. Lond., 1842, 102. . . . N.S.W., V., S.A.
416. *franca* Cart., Roy. Soc. S.A., 1916, 111. N.Q.
417. *gigas* Cart., l.c., 112. W.A.
418. *gloriosa* Cart., l.c., 115. W.A.
419. *grandis* Don., Ep. Ins. N. Holl., 1805, t. 8, fig. 1. N.S.W.
420. *haematica* Hope, Tr. Ent. Soc. Lond., 1846, 210. S.A.
clara Kerr., Ann. Soc. Ent. Belg., 1900, 313.
421. *heros* Gehin., Bull. Soc. Moselle., 1855, 7. . . . N.S.W., V., S.A., W.A.
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 610. *luteipennis* L. & G., Mon. IV., 1841, 130. N.S.W.
 611. *luteocincta* Saund., Jour. Linn. Soc., 1868, 478. N.S.W.
 612. *macleayi* Blkb., Roy. Soc. S.A., 1892, 48. Q.
 613. *maculicollis* Cart., l.c., 1916, 127. Q.
 614. *maculifer* Kerr., Gen. Ins., 1902, 208. N.S.W. & Q.
 615. *maculipennis* Saund., Jour. Linn. Soc., 1868, 480. N.S.W.
 616. *maculiventris* Macl., Ent. Soc. N.S.W., 1862, 32. Q.
 nickerli Obenb., Arch. für Naturg., 1922, 113.
 strandii Obenb., l.c., 114.
 617. *magnifica* Blkb., Roy. Soc. S.A., 1896, 35. N.Q.
 618. *mansueta* Kerr., Ann. Soc. Ent. Belg., 1898, 155. W.A.
 619. *marginicervex* Thoms., Typ. Bup. App. 1a, 1879, 31. A.
 620. *marginicollis* Saund., Jour. Linn. Soc., 1868, 469. N.S.W. & Q.
 ? *bifasciatella* Obenb., Arch. für Naturg., 1922.
 621. *mastersi* Macl., Ent. Soc. N.S.W., 1872, 245. Q.
 hoblerae Cart., Linn. Soc. N.S.W., 1922, 70.
 622. *militaris* Cart., l.c., 71. N.S.W. & V.
 623. *minuta* Blkb., Roy. Soc. S.A., 1892, 44. Q.
 624. *moribunda* Saund., Ins. Saund., 1869, 18. Q.
 dispar Blkb., Roy. Soc. S.A., 1892, 50.
 625. *mustelamajor* Thoms., Arch. Ent., 1857, 115. N.S.W., V., S.A.
 gibbosa Macl., Ent. Soc. N.S.W., 1862, 26
 626. *nanula* Kerr., C.R. Soc. Ent. Belg., 1890, 48. N.S.W.
 627. *nasuta* Saund., Ins. Saund., 1869, 15. N.S.W.
 628. *neglecta* Cart., Roy. Soc. S.A., 1916, 123. Blue Mts., N.S.W.
 629. *nigriventris* Macl., Ent. Soc. N.S.W., 1862, 27. Q.
 630. *nova* Kerr., Gen. Ins., 1902, 208. N.S.W.
 631. *obscura* Saund., Ins. Saund., 1869, 26. S.A. & W.A.
 var. *transversepicta* Thoms., Typ. Bup. App. 1a, 1879, 35.
 632. *obliqua* Kerr., Gen. Ins., 1902, 209. N.S.W.
 633. *obsepta* Kerr., C.R. Soc. Ent. Belg., 1890, 44. Q.
 634. *observans* Kerr., Ann. Soc. Ent. Belg., 1898, 139. Q.

635. *ocelligera* L. & G., Mon. iv., 1841, 133. T.
 636. *octomaculata* Saund., Jour. Linn. Soc., 1868, 472. N.S.W., V., S.A.
 637. *octosignata* Cart., Linn. Soc. N.S.W., 1919, 139. N.Q.
 638. *octospilota* L. & G., Mon. ii., 1838, 28. Q., N.S.W., V., S.A., W.A.
 femorata L. & G., l.c., 37.
 Adelaidae Hope, Tr. Ent. Soc. Lond., 1846, 212.
 var. *rufipes* Macl., Ent. Soc. N.S.W., 1862, 23.
 639. *opacipennis* Obenb., Archiv. für Naturg., 1922, 116. N.S.W.
 640. *ornata* Blkb., Roy. Soc. S.A., 1892, 53. N.S.W. & V.
 641. *pallas* Blkb., l.c., 1901, 22. Thursday Is.
 642. *pallidiventris* L. & G., Mon. ii., 1838, 42. W.A.
 var. *cincta* Blkb., Roy. Soc. S.A., 1890, 157.
 rubrocincta Kerr., C.R. Soc. Ent. Belg., 1890, 47.
 643. *parallela* Saund., Ins. Saund., 1869, 16. V., S.A.
 crociipennis Hope, Tr. Ent. Soc. Lond., 1846, 292.
 644. *pertyi* L. & G., Mon. ii., 1868, 23. N.S.W.
 var. *minus* Saund., Jour. Linn. Soc., 1868, 471.
 645. *phaeorrhea* Kirby, Trans. Linn. Soc., 1818, 456. N.W.A.
 646. *picta* L. & G., Mon. ii., 1868, 46. W.A.
 purpurea Hope, Tr. Ent. Soc. Lond., 1856, 213.
 var. *laetabilis* Kerr., Ann. Soc. Ent. Belg., 1898, 153.
 647. *pictipennis* Saund., Jour. Linn. Soc., 1868, 471. W.A.
 648. *püiventris* Saund., l.c., 474. N.S.W., V., S.A.
 649. *pisciformis* Cart., Roy. Soc. S.A., 1916, 125. N.W.V., S.A., W.A.
 650. *planata* Cart., l.c., 133. W.A.
 651. *praetermissa* Cart., Linn. Soc. N.S.W., 1921, 306. N.S.W., V.
 652. *producta* Saund., Jour. Linn. Soc., 1868, 482.
 acutipennis Thoms., Typ. Bup. App. 1a, 1879, 38.
 ? var. *sulcicollis* Kerr., Gen. Ins., 1902, 209.
 653. *propinqua* Cart., Roy. Soc. S.A., 1916, 124. S.A.
 654. *puerilis* Kerr., Ann. Soc. Ent. Belg., 1898, 147. N.S.W.
 var. *atrocoerulea* Kerr., C.R. Soc. Ent. Belg., 1890, 47.
 655. *pulchella* Cart., Roy. Soc. S.A., 1916, 135. Q.
 656. *pulchra* Saund., Ins. Saund., 1869, 22. N.W.A.
 rostrata Thoms., Typ. Bup. App. 1a, 1879, 36.
 657. *pulchripes* Blkb., Roy. Soc. S.A., 1897, 31. N.S.W. & V.
 658. *punctatissima* Saund., Ins. Saund., 1869, 24. N.S.W.
 659. *punctatostriata* Saund., Jour. Linn. Soc., 1868, 466. W.A.
 660. *quadrifasciata* Saund., l.c., 477. W.A.
 661. *quadriguttata* Macl., Ent. Soc. N.S.W., 1862, 28. Q.
 662. *quinquepunctata* Waterh., Tr. Ent. Soc. Lond., 1874, 341. Q.
 663. *ravilla* Obenb., Archiv. für Naturg., 1922, 117. N.S.W.
 664. *recta* Saund., Ins. Saund., 1869, 23. S.A., W.A.
 665. *rectifasciata* Saund., Jour. Linn. Soc., 1868, 172. N.S.W.
 666. *robusta* Saund., Ins. Saund., 1869, 6. V., S.A.
 667. *rollei* Kerr., Deut. Ent. Zeit., 1909. N.Q.
 caudata Cart., Linn. Soc. N.S.W., 1908, 418.
 hackeri Cart., l.c., 1915, 82.
 668. *rostralis* Cart., Linn. Soc. N.S.W., 1918, 718. Q.
 669. *rotundata* Saund., Tr. Ent. Soc. Lond., 1868, 19. N.S.W., S.A.
 670. *rubricauda* Saund., l.c., 1872, 252. N.S.W., Q.
 671. *rubriventris* Blkb., Roy. Soc. S.A., 1900, 46. W.A.
 672. *rufipennis* Kirby, Trans. Linn. Soc., 1818, 456. . N.S.W., V., S.A., W.A.
 crociipennis L. & G., Mon. ii., 1868, 21.
 673. *rufolimbata* Cart., Roy. Soc. S.A., 1916, 120. W.A.

674. *sagittaria* L. & G., Mon. ii., 1838, 31. W.A.
gravis Har., Col. Heft., 1869, 124.
obscuripennis Saund., Jour. Linn. Soc., 1868, 475.
tacita Kerr., Ann. Soc. Ent. Belg., 1898, 153.
675. *sancta* Cart., Linn. Soc. N.S.W., 1912, 501. V.
676. *sanguinolenta* L. & G., Mon. ii., 1838, 45. W.A.
677. *scalaris* Boisd., Voy. Astrol., 1835, 89. Q., N.S.W., V., S.A.
cyanicollis Boisd., l.c., 91.
crueigera L. & G., Mon. ii., 1838, 40.
subtrifasciata L. & G., l.c., 41.
media Hope, Tr. Ent. Soc. Lond., 1847, 284.
prudens Kerr., Ann. Soc. Ent. Belg., 1898, 152.
suavis Kerr., Gen. Ins., 1902, 210.
crucioides Obenb., Archiv. für Naturg., 1922, 118.
var. *viridis* L. & G., Mon. ii., 1838, 46.
678. *scutellaris* Kerr., Ann. Soc. Ent. Belg., 1900, 316. A.
679. *secularis* Thoms., Arch. Ent., 1857, 111. W.A.
bizonata Obenb., Archiv. für Naturg., 1922, 114.
680. *semicineta* L. & G., Mon. ii., 1838, 19. N.S.W.
681. *seminigra* Cart., Linn. Soc. N.S.W., 1912, 500. C. York.
682. *septemguttata* Waterh., Tr. Ent. Soc. Lond., 1874, 540. . . N.S.W., Q.
var. *tyrrhena* Blackb., Roy. Soc. S.A., 1903, 306.
683. *septemnotata* Cart., l.c., 1916, 98.
septemmaculata Blkb., l.c., 1892, 45.
684. *septempilota* Cart., Linn. Soc. N.S.W., 1912, 503. W.A.
685. *serratipennis* Cart., Roy. Soc. S.A., 1916, 127. Cue, W.A.
686. *sexguttata* Macl., Ent. Soc. N.S.W., 1862, 29. V., N.S.W. & Q.
var. *puella* Saund., Ins. Saund., 1869, 25.
carteri Obenb., Archiv. für Naturg., 1922, 123.
687. *sexnotata* Cart., Roy. Soc. S.A., 1916, 131. W.A.
688. *sexplagiata* L. & G., Mon. iv., 1841, 152. Q., N.S.W., V., S.A.
plagiata L. & G., l.c.
crenata L. & G., l.c., ii., 1838, 39.
bicruciatata Hope, A. Bup., 1836, 3.
hopei Boh., Eng. Res., 1858, 61.
similata Boh., l.c.
krefftii Macl., Ent. Soc. N.S.W., 1872, 245.
variata Kerr., Gen. Ins., 1902, 209.
689. **sexualis* Cart., Linn. Soc. N.S.W., 1929. Stanthorpe, Q.
690. *signata* Kerr., Gen. Ins., 1902, 210. N.W.V. & N.S.W.
691. *simulata* L. & G., Mon. ii., 1838, 26. N.W.V., S.A., W.A.
helenae Hope, Tr. Ent. Soc. Lond., 1846, 215.
languinosa Hope, l.c.
var. *perplexa* Hope, l.c., 211.
var. *phryne* Thoms., Typ. Bup. App. 1a, 1879, 33.
var. *lais* Thoms., l.c.
triramosa Thoms., l.c., 32.
distinguenda Thoms., l.c., 34.
fraterna Kerr., C.R. Soc. Ent. Belg., 1890, 46.
692. *skusei* Blkb., Roy. Soc. S.A., 1892, 46. N.S.W.
laudabilis Kerr., Ann. Soc. Ent. Belg., 1898, 153.
693. *speciosa* Kerr., l.c., 137. V.
694. *spectabilis* Kerr., l.c., 1900, 315. N.S.W.

* Unpublished at time of going to press.

695. *spilota* L. & G., Mon. ii., 1838, 24. N.S.W.
septemmaculata Mannerh., Bull. Mosc., 1837, 98.
696. *spinolae* L. & G., Mon. iv., 1841, 129. N.S.W.
697. *straminea* Macl., Ent. Soc. N.S.W., 1862, 25. Q.
addenda Kerr., Ann. Soc. Ent. Belg., 1898, 149.
Johannae Théry, Mem. Soc. Ent. Belg., 1910, 55.
698. *subbifasciata* Saund., Jour. Linn. Soc., 1868, 479. N.S.W.
699. *subcostata* Kerr., Ann. Soc. Ent. Belg., 1900, 317. A.
700. *subpura* Blkb., Roy. Soc. S.A., 1903, 307. N.S.W.
701. *subversicolor* Cart., Linn. Soc. N.S.W., 1925, 231. . . . Tammin, W.A.
702. *tantilla* Obenb., Archiv. für Naturg., 1922, 116. Q.
703. *testacea* Saund., Ins. Saund., 1869, 14. V. & N.S.W.
704. *theryi* Cart., Linn. Soc. N.S.W., 1924, 534. N.S.W.
705. *thomsoni* Saund., Jour. Linn. Soc., 1868, 477. N.S.W. & V.
706. *tincticauda* Cart., Roy. Soc. S.A., 1916, 136. Yalgoo, W.A.
707. *titania* Cart., l.c., 134. Cooktown, Q.
708. *tricolor* Kirby, Trans. Linn. Soc., 1818, 455. N.S.W.
curla Saund., Jour. Linn. Soc., 1868, 467.
opima Kerr., Gen. Ins., 1902, 207.
709. *trifasciata* L. & G., Mon. ii., 1838, 38. W.A.
apicalis L. & G., l.c., 43.
710. *triguttata* Macl., Ent. Soc. N.S.W., 1862, 28. N.Q.
711. *trimaculata* Saund., Jour. Linn. Soc., 1868, 482. N.W.A.
712. *undulata* Don., Epit. Ins. N. Holl., 1805, pl. 7, fig. 5. . . . N.S.W., V.
Laportei Boh., Res. Eng., 1858, 61.
713. *uniformis* Kerr., Ann. Ent. Soc. Belg., 1898, 145. N.S.W., V.
? *graphisura* Thoms., Typ. Bup. App. 1a, 1879, 37.
714. *variopicta* Thoms., Typ. Bup., 1878, 54. N.S.W.
715. *vegeta* Hope, Tr. Ent. Soc. Lond., 1847, 283. N.S.W., V., S.A.
coeruleiventris Saund., Ins. Saund., 1869, 13.
haroldi Saund., Cat. Bup., 1861, 74.
viridiventris Saund., Ins. Saund., 1869, 20.
var. *cruentata* Kirby, Trans. Linn. Soc., 1818, 445.
neologa Thoms., Typ. Bup. App. 1a, 1879, 35.
? *coerulea* Kerr., Mem. Soc. Ent. Belg., 1892, 146.
coelestis Kerr., C.R. Soc. Ent. Belg., 1890, 48.
stillata Blkb., Roy. Soc. S.A., 1890, 148.
716. *venusta* Cart., Roy. Soc. S.A., 1916, 99. N.Q.
suavis Cart., Linn. Soc. N.S.W., 1913, 507.
modesta Obenb., Archiv. für Naturg., 1922, 122.
717. *versicolor* L. & G., Mon. ii., 1838, 42. W.A.
strandi Obenb. (*Archaeozodes*) Entom. Mitteil., 1920, 165.
718. *vicina* Saund., Tr. Ent. Soc. Lond., 1868, 43. N.S.W.
bicincta L. & G., Mon. ii., 1838, 31.
719. *victoriensis* Blkb., Roy. Soc. S.A., 1890, 152. V.
sensitiva Kerr., Ann. Soc. Ent. Belg., 1898, 148.
720. *vigilans* Kerr., l.c., 143. N.S.W.
721. *violacea* Macl., Ent. Soc. N.S.W., 1862, 23. N.S.W., Q., S.A.
cupreoflava Saund., Ins. Saund., 1869, 10.
equina Blkb., Roy. Soc. S.A., 1892, 48.
obliquefasciata Obenb., Archiv. für Naturg., 1922, 115.
722. *virginea* Erichs., Wieg. Arch., 1842, 135. T.
723. *viridiventris* Macl., Ent. Soc. N.S.W., 1862, 27. Q.
724. *vittata* Saund., Jour. Linn. Soc., 1868, 478. S.A., W.A.

725. *wilsoni* Saund., l.e., 476. N.S.W., V., T.
sigma Kerr., C.R. Soc. Ent. Belg., 1890, 43.
726. *xanthospilota* Hope, Tr. Ent. Soc. Lond., 1847, 238. N.S.W., V., S.A., W.A.
splendida Gehin., Bull. Soc. Moselle, 1855, 14.
parallela White, Proc. Zool. Soc. Lond., 1859, 119.
- Sub-family CHALCOPHORINAE.
 Tribe CHALCOPHORINI.
- CYRIA. Sol., Ann. Soc. Ent. Fr., 1833, 269.
727. *australis* Boisd., Voy. Austral., ii., 1832, 62. Q. & N.S.W.
gagates Hope, Bup., 1846, 1.
 var. *tridens* Blkb., Roy. Soc. S.A., 1892, 41.
728. *cincta* Cart., Linn. Soc. N.S.W., 1908, 416. N.Q.
729. *clateroides* Saund., Tr. Ent. Soc. Lond., 1872, 244. W.A.
730. *imperialis* Fab., Sys. Eleuth., 1801, 204. Q., N.S.W., V., T.
 var. *melaina* Cart.
731. *vittigera* L. & G., Mon. I., 1837, 21. W.A.
- CYRIOIDES. Cart., Linn. Soc. N.S.W., 1920, 222.
732. *sexspilota* Cart., l.e. Johnstone R., Q.
- DIADOXUS. Thoms., Typ. Bupr., 1878, 15.
733. *erythrusus* (Stigmodera) White, Stokes Voy., 1843, 507.
pistucina (Anthaxia) Hope, Bupr., 1840, 10. N.S.W., V., S.A.
734. *jungi* Blkb., Roy. Soc. S.A., 1899, 28. Yorke Pen., S.A.
735. *scalaris* L. & G., Mon. I., 1837, 141. N.S.W., V. & S.A.
erichsoni (Anthaxia) Hope, Bupr., 1840, 10.
 var. *blackburni* Obenb., Sborn. Ent. Mus. Praze, 1923, 72.
- CYPHAGASTRA. Deyr., Ann. Soc. Ent. Belg., 1864, 36.
736. *browni* Cart., Linn. Soc. N.S.W., 1921, 305. N.T.
737. *farinosa* F., Sys. Ent., 1774, 219. Java, Borneo.
 *s.s. *venerea* Thoms., Arch. Ent., 1857, 431. N.Q.
738. *macfarlani* Waterh., Ann. Mag. Nat. Hist., 1835, 382. N.T. & N.G.
739. *pistor* L. & G., Mon. I., 1835, 25. N.Q., N.T. & N.W.A.
saundersi (Chrysodema) Macl., Linn. Soc. N.S.W., 1888, 1227.
740. *quadrivittata* Cart., Roy. Soc. S.A., 1916, 143. W.A.
741. *vulnerata* Théry, Ann. Soc. Ent. Belg., 1908, 80. N.T.
742. *woodlarkiana* Montr., Ann. Soc. Agr. Lyon., 1855, 10. Woodlark Is.
- *See also Ann. & Bull. Soc. Ent. Belg., 1926, 69, etc., for Théry's views on these spp.
- CHRYSODEMA. L. & G., Mon. i., 1835, 1.
- Pseudochrysodema* Saund., Cist. Ent., i., 1874, 223.
743. *aurofoveata* Guér., Voy. Coq., 1831, 64. Banks Is., C. York.
744. *subfasciata* Cart., Roy. Soc. S.A., 1916, 139. N.T. & N.W.A.
- PSEUDOTAENIA. Kerr., Gen. Ins., 1902, 81.
745. *ajax* Saund., Tr. Ent. Soc. Lond., 1872, 245. Q.
telamon Fairm., Jour. Mus. Godeff., 1879, 96.
746. *frenchi* Blkb., Roy. Soc. S.A., 1891, 136. N.Q.
747. *gigas* Hope, Tr. Ent. Soc. Lond., 1846, 208.
748. *quadrisignata* Saund., l.e., 1872, 245. Q.
749. *salamandra* Thoms., Bull. Soc. Ent. Fr., 1879, 158. Q.
 var. *vittata* Waterh., Ann. Mag. Nat. Hist., 1881, 462.
750. *spilota* Cart., Roy. Soc. S.A., 1916, 141. W.A.
751. *superba* Saund., Tr. Ent. Soc. Lond., 1872, 246. W.A.

752. *waterhousei* V. de Poll., Not. Leyd. Mus., 1886, 222. Q.
laeta Waterh., Ann. Mag. Nat. Hist., 1886, 371.
gigantea Nonfried., Berl. Ent. Zeit., 1891, 374.
- PARACUPTA.** Deyr., Ann. Soc. Ent. Belg., 1864, 33.
753. *aurofoveata* Saund., Jour. Linn. Soc. Lond., 1869, 334. Q., N.W.A.
754. *wallisii* Montr., Ann. Soc. Linn. Lyon., 1855, 11. Woodlark Is.
- CHALCOTAENIA.** Deyr., Ann. Soc. Ent. Belg., 1864, 12.
755. *australasiae* Saund., Tr. Ent. Soc. Lond., 1872, 248. W.A.
occidentalis Waterh., l.c., 1875, 205.
angulipennis Blkb., Horn. Exp., 1896, 269.
756. *beltanae* Blkb. (Chalcophora) Linn. Soc. N.S.W., 1894, 100. C.A.
757. *castanea* Cart., Roy. Soc. S.A., 1916, 141. Cue, W.A.
758. *cerata* Kerr., Ann. Soc. Ent. Belg., 1891, 151. S.A.
759. *cuprasceus* Waterh., Tr. Ent. Soc. Lond., 1875, 203. Q.
australis Fairm., Pet. Nouv. Ent., 1877, 166.
760. *elongata* Waterh., l.c., 203. Bowen, Q.
761. *exilis* Blkb. (Chalcophora) Linn. Soc. N.S.W., 1894, 98. C.A.
762. *laeta* Waterh., Ann. Mag. Nat. Hist., 1881, 463. Q.
763. *lamberti* L. & G., Mon. i., 1835, 4. N.S.W.
764. *martini* Saund., Tr. Ent. Soc. Lond., 1872, 247. W.A.
biimpressa Cart., Linn. Soc. N.S.W., 1913, 480.
765. *notata* Obenb., Col. Rundsch., 1917, 99. A.
766. *pedifera* Blkb. (Chalcophora) Linn. Soc. N.S.W., 1890, 307. Q.
767. *quadriimpressa* Waterh., Tr. Ent. Soc. Lond., 1875, 204. N.A.
sulciventris Blkb., Horn. Exp., 1896, 270.
boucardi Théry, Ann. Soc. Ent. Belg., 1922, 225.
768. *sphinx* Obenb., Col. Rundsch., 1917, 141. W.A.
769. *violacea* Cart., Linn. Soc. N.S.W., 1915, 76. Cue, W.A.
- IRIDOTAENIA.** Deyr., Ann. Soc. Ent. Belg., 1864, 25.
770. *albivittis* Hope, Tr. Ent. Soc. Lond., 1845, 214. N.S.W., V., T.
pyritosa Boh., Eng. Reis. Zool., 1858, 58.
771. *bellicosa* Blkb. (Paracupta) Roy. Soc. S.A., 1903, 181. Kuranda, Q.
terraereginae Obenb. (Iridotaenia) Arch. für Naturg., 1924, 36.
Species incertae sedis.
772. *Amorphosoma tasmanicum* Germ., Linn. Ent., iii, 179.

Unknown in Australian collections; probably a *Hypocisseis* and possibly identical with *H. ornata* Cart., but until the type can be examined it cannot be determined.



Theryaxia suttoni.

773. *Discoderes torridus* Blkb., Roy. Soc. S.A., 1891, 301. N.Q.
Belongs to a genus—probably new—near *Hypocis*. Type in National
Museum, Melbourne.

APPENDIX.

Dr. Obenberger's paper "Opuscula Buprestologica" I. (Archiv. für Naturg., 1928) has been received too late for its due consideration. His 39 new names for Australian BUPRESTIDÆ are as follows. I have had time only to study his *Stigmodera* species, which include, I think, several synonyms.

- BUBASTES *Van Rooi* Obenb., W.A., p. 199.
germari Obenb., W.A., p. 200.
kirbyi Obenb., A., p. 200.
thomsoni Obenb., N.Q., p. 201.
Odewahni Obenb., Q., p. 201.
saundersi Obenb., W.A., p. 201.
borealis Obenb., Yorktown, Queensland (sic), p. 202.
- EURYSPILUS (*n. gen.*) *nickerli* Obenb., W.A., pp. 202-204.
- EURYSPILUS *strandi* Obenb., A., pp. 203-204.
- ASTRAEUS *strandi* Obenb., N.S.W., p. 205.
- NEOTORRESITA *microphaenopes* Obenb., Q., p. 205.
kerremansi Obenb., A., p. 206.
- ANTHAXIA *Novae-Hollandiae* Obenb., Vic., p. 235.
- ANILARA *Balthasari* Obenb., Vic., p. 272.
Mephisto Obenb., Belmore, A., p. 273.
Blackburni Obenb., Vic., p. 273.
strandi Obenb., Barwon R., N.S.W., p. 274.
quieta Obenb., Vic., p. 275.
chalcea Obenb., Vic., Queensland, p. 275.
tibialis Obenb., A., p. 276.
victoriae Obenb., Vic., pp. 276-277.
- CHRYSOBOLRIS *Odewahni* Obenb., W.A., p. 310.
macleayi Obenb., W.A., p. 311.
- STIGMODERA (Themognatha) *Mrazi* Obenb., Q., p. 325, t. vii, fig. 1 = *donovani* Saund.
(Themognatha) *jakavlevi* Obenb., Q., p. 326, t. vii, fig. 2 = *sanguineocincta* Saund.
(Castiarina) *jakobsoni* Obenb., Q., p. 327, t. vii, fig. 14.
(Castiarina) *Tasmani* Obenb., Tas., p. 328, t. vii, fig. 8 = *jubata* Blkb.
(Castiarina) *bicolorella* Obenb., W. A., p. 329, t. vii, fig. 11.
(Castiarina) *fossithorax* Obenb., N.A., p. 329, t. vii, fig. 9.
(Castiarina) *Semenovi* Obenb., Rockhampton, Q., p. 329, t. vii, fig. 18 = *moribunda* Saund., var. *dispar* Blkb.
(Castiarina) *Balthasari* Obenb., Q., p. 330, t. vii, fig. 24.
(Castiarina) *Odewahni* Obenb., W.A., p. 330, t. vii, fig. 19 = *hopei* Saund.
(Castiarina) *Cicerini* Obenb., Tas., p. 331, t. vii, fig. 13 = *erythromelas* Boisd.
(Castiarina) *Gebhardti* Obenb., Yorktown, p. 332, t. vii, fig. 12 = *sagittaria* L. & G.
(Castiarina) *protensa* Obenb., Yllgarn (sic) W.A., p. 332, t. vii, fig. 22.
(Castiarina) *acutangula* Obenb., Q., p. 333, t. vii, fig. 20 = *cupreoflava* Saund., var. *equina* Blkb.

(Castiarina) *yilgarni* Obenb., W.A., p. 333, t. vii., fig. 23.

(Castiarina) *stigmaticollis* Obenb., Rockhampton, Q., p. 334, t. vii., fig.

10 = *octospilota* L. & G., var. *rufipes* Macl.

(Castiarina) *yorkensis* Obenb., Yorktown, p. 335, t. vii., fig. 21.

Yorktown is probably meant for York, W.A., though in the case of *Bubastes borealis* it is given as Yorktown, Queensland, which is non-existent.

H. J. C.

EXPLANATION OF BUPRESTIDAE PLATES.

PLATE NO. 1.

- Fig. 1. *Prospheres aurantiopictus*, L. & G.
 2. *Melobasis dives*, Carter.
 3. *Cyria australis*, Boisd., var. *tridens*, Blackb.
 4. *Bubastes formosa*, Carter.
 5. *Cyrioides sexspilota*, Carter.
 6. *Cyphogastra pistora*, L. & G.
 7. *Chrysodema subfasciata*, Carter.
 8. *Cisseis fulgidicollis*, Macl.
 9. *Chalcotaenia australasiae*, Saund.
 10. *Paracephala cyaneipennis*, Blackb.
 11. *Stigmodera rectipennis*, Blackb.
 12. *Neocuris ornata*, Carter.
 13. *Calodema regalis*, L. & G.
 14. *Aleinous nodosus*, Kerr.
 15. *Pseudotaenia laeta*, Waterh.
 16. *Hypocisseis latipennis*, Macl.
 17. *Cyria vittigera*, L. & G.
 18. *Castalia bimaiculata*, Linn.
 19. *Metaxymorpha hauseri*, Théry.
 20. *Curis caloptera*, Boisd.

PLATE NO. 2.

21. *Stigmodera castelnaudi*, Saund.
 22. *Stigmodera oleata*, Blackb.
 23. *Stigmodera pertyi*, L. & G.
 24. *Stigmodera limbata*, Donovan.
 25. *Stigmodera cupricollis*, Saund.
 26. *Stigmodera sexplagiata*, L. & G.
 27. *Stigmodera duboulayi*, Saund.
 28. *Stigmodera miranda*, Carter.
 29. *Stigmodera roei*, Saund.
 30. *Stigmodera alternata*, Lumk.
 31. *Stigmodera coccinata*, Hope.
 32. *Melobasis nobilitata* Thoms.
 33. Diagram of head of *Agrilus*.
 34. *Iridotaenia bellicosa*, Blackb.
 35. *Stigmodera mustelamajor*, Thoms.
 36. *Stigmodera erubescens*, Blackb.
 37. Explanation of 38.
 38. Diagram of *Stigmodera octospilota* (ventral).
 39. Dentate segments of antennae.
 (1) *Merimna atrata*, Hope.
 (2) *Cyphogastra pistora*, L. & G.

- (3) *Cyrioides sexspilota*, Carter.
 (4) *Cyria vittigera*, L. & G.
 40. *Stigmodera insignis*, Blackb.

PLATE No. 3.

41. *Habroloma australis*, Macl.
 42. *Agrilus bispinosus*, Carter.
 43. *Astraeus splendens*, V. de Poll.
 44. *Nascioides tillyardi*, Carter.
 45. *Xyrosceles erocata*, C. & G.
 46. *Aphanisticus endeloides*, Carter.
 47. *Torresita cuprifera*, Kirby.
 48. *Buprestodes corruscans*, Carter.
 49. *Melobasis nervosa*, Boisd.
 50. *Neobubastes aureocincta*, Blackb.
 51. *Ethon corpulentum*, Boh.
 52. *Chrysobothris incana*, Macl.
 53. *Nascioides costata*, Carter.
 54. *Merimna atrata*, Hope.
 55. *Microcastalia globithorax*, Thoms.
 56. *Neobuprestis marmorata*, Blackb.
 57. Wing of *Stig. octospilota*.
 58. *Synechocera longior*, Carter.
 59. Tarsal claws of *Stigmodera*.
 (a) *S. (Thermognatha) variabilis*, Don.
 (b) *S. (Castiarina) thomsoni*, Saund.
 60. *Anilara viridula*, Kerr.

DIAGRAM OF *S. OCTOSPILOTA*.

- Fig. 1. antenna.
 2. eye.
 3. head.
 4. gula.
 5. inflexed side of pronotum.
 6. prosternum.
 7. prosternal "process."
 8. sternal "cavity."
 9. anterior coxa.
 10. anterior acetabulum or coxal cavity.
 11. intermediate coxa.
 12. intermediate coxal cavity.
 13. epipleuron, or inflexed margin of elytron.
 14. mesosternum.
 15. mesosternal episternum.
 16. metasternum.
 17. metasternal episternum.
 18. metasternal epimeron.
 19. antecoxal piece.
 20. posterior coxae.
 21. femora.
 22. tibiae.
 23. tarsi.
 24. plates of ventral abdominal segments.

THE LORICATES OF THE NEOZELANIC REGION.

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(By Permission of the Trustees.)

INTRODUCTION.

At the special request of several New Zealand Malacologists we have undertaken the congenial task of compiling a companion to our Monograph of the Australian Loricates, dealing with the Neozelanic forms.

One or other of us has collected on Lord Howe, Norfolk, and the Kermadec Islands, and published the results of our researches, which led us to regard the marine fauna of these Islands as distinctly Neozelanic. We therefore include them in the Region, together with the Chatham, Subantarctic, and Macquarie Islands for reasons hereinafter more fully set out.

One of us also collected extensively in New Zealand, and our united collections embrace all but a few of the recently nominated forms, as well as several hitherto undescribed species. In addition to this mass of material, Miss Marjorie K. Mestayer, Drs. C. E. R. Bucknill and H. J. Finlay, Messrs. A. E. Brookes, W. R. B. Oliver, and A. W. B. Powell have generously placed their notes and material at our disposal for the purposes of further examination and illustration.

This essay must be construed as a more or less preliminary account of the Neozelanic Loricates, and its publication will, it is confidently anticipated, stimulate research and lead to the discovery of many new forms in this extremely interesting Region.

In view of the difficulty of access to some of the publications containing original descriptions, we have incorporated these throughout so that comparison can be made easily by Neozelanic students. Through this method errors of determination may be detected, as in the case hereafter noted of *Chiton circumvallatus* Reeve.

SYSTEMATICS AND STRUCTURE.

The shell-forming animals comprised in the Phylum MOLLUSCA are divided into three groups generally described as univalves, bivalves, and multivalves. The Loricates, consisting of eight overlapping valves connected by a leathery mantle or girdle, are comprised in the third group. The popular name given to the group was CHITON, from the Linnean name of the first recognised genus. Burrow (1815) wrote: "The name of the genus, CHITON, is derived from the Greek word χιτών signifying a coat of mail; and aptly expresses the loricated appearance of the shell, arising from the position of the valves." Schumacher (1817) in his "Essai d'un Nouveau Système des Habitations des Vers Testacés" was the first systematist to establish the multivalves as a separate division under the ordinal name LORICATA, with the vernacular name of "Les Armurés." We suggested* "Loricata" as a popular or vernacular name for the group, as more acceptable than Chiton, which is now the name of a very restricted genus of the group. The name LORICATA is derived from the Latin *Loricata*, which means equally a coat of mail or cuirass. Previous writers have generally adopted the

* Australian Zoologist, iii., 1923, 186.

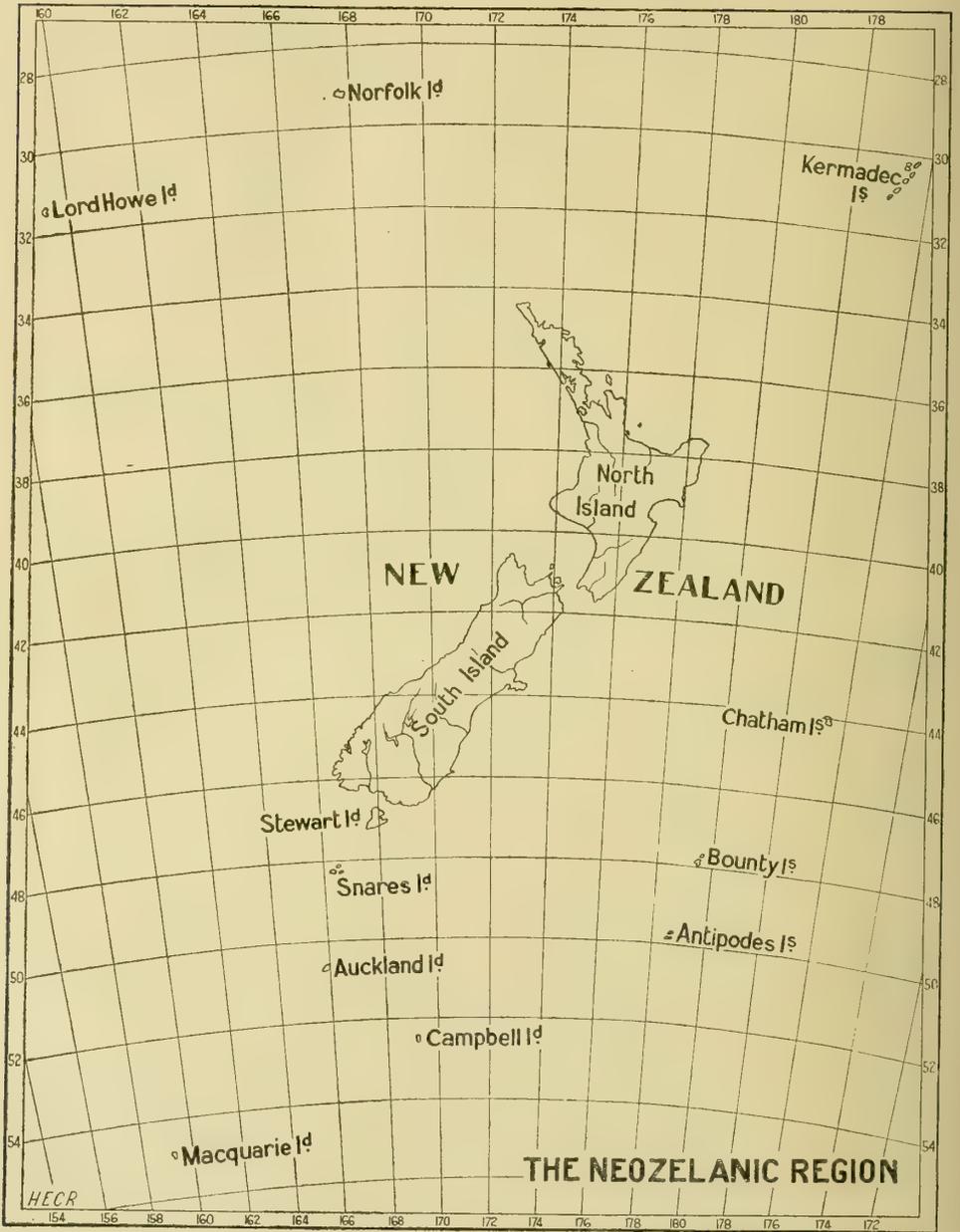


Fig. 1. MAP OF THE NEOZELANIC REGION, ON GLOBULAR PROJECTION.

ordinal name POLYPLACOPHORA, proposed by Gray (1821), and some have been at great pains to show that this name was adopted on the recognised grounds of priority, but, as they evidently overlooked Schumacher's name we, also on the ground of priority, adopted it, and our action has been approved by the leading scientific authorities.

These shells are popularly known, more in a dismembered state than as entire shells, by various names, amongst which may be mentioned "Coat of Mail Shells," "Butterfly Shells," "Sea Butterflies," and "Sunset Shells."

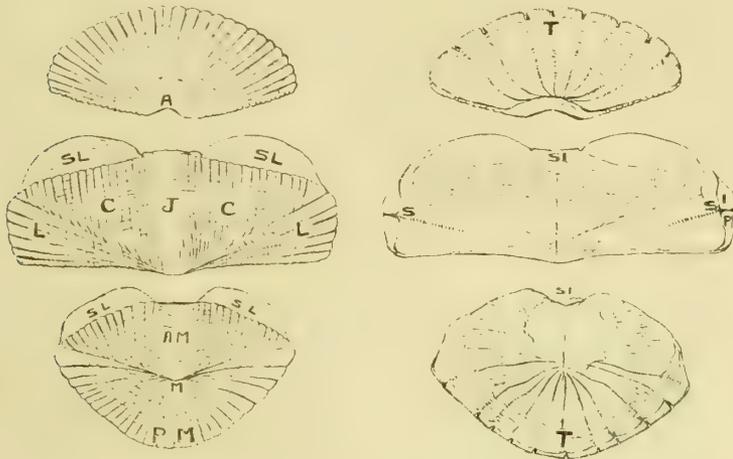


Fig. 2 (1). Exterior (tegmen) of *Rhyssoplax canaliculata* anterior, one median, and posterior valves. A.—Apex, S.L.—Sutural laminae, C.—Central areas, L.—Lateral areas, J.—Jugum, M.—Mucro, A.M.—Ante-mucronal area, P.M.—Post-mucronal area.

(2).—Interior (articulamentum) of same. T.—Teeth, I.P.—Insertion plates, S.—Slits, Si.—Sinus.

The Shell.—The shell of a Loricata consists of eight pieces, called *valves*, held together by a leathery *girdle*. These valves, which are composed of a chitinous foundation, reinforced by carbonate of lime, may be separated from the girdle by soaking the shell in water for a few hours, or in the case of dried specimens, by boiling in a 5 per cent. solution of caustic soda. They are of three forms; the head or *anterior* valve; six central or *median* valves, all of the same shape but differing slightly in dimensions; and the tail or *posterior* valve. They are sometimes referred to by consecutive numbers, 1 to 8, commencing with the anterior valve, which overlaps the first median valve, which in turn overlaps the second, and so on, the seventh (or sixth median) valve overlapping the anterior edge of the posterior valve. Each valve is composed of two or more layers, the outer or surface being called the *tegmen*, and the inner called the *articulamentum*. The tegmen in nearly all Loricates is divided into more or less clearly defined *areas*, which are adorned with the *sculpture*, or the *colour-pattern* which forms the basis of specific variation. The median valves are divided into two *lateral areas*, and two *central areas* connected by a *dorsal area*, or *jugum*, extending along the ridge of the valve, the posterior extremity of which, if projecting, is called the

beak. The line of demarcation between each lateral and central area is called the *diagonal*. As a rule the anterior valve forms a complete area as regards sculpture, which generally resembles that of the lateral areas of the median valves; occasionally the *apex* is differentiated. The posterior valve is divided into two areas by a *muero* or projection, more or less central. The area in front of the muero is styled the *antemuero*nal, and the area behind is styled the *post-muero*nal area; the former is sculptured similarly to the central areas of the median valves, and the latter is sculptured similarly to the anterior valve. In some genera the muero is so far behind the centre that the post-mueroal area is reduced to an inconspicuous tract, or is altogether absent.

The articulation is larger than the tegmentum, projecting in front, as regards valves 2 to 8, in two *sutural laminae*, which are separated by a bay called the *sinus*. At the sides of the median valves and round the edge of the end valves, most Loricates have projecting *insertion plates*, to which the girdle is attached. These insertion plates are generally cut into by *slits*. From the slits to the apex of each valve run more or less distinct *slit-rays*. The edges of the insertion plates between the slits are called *teeth*, which are in some genera finely cut into combs or *pectinated*; in some thickened outside or *propped*, and in some cut quite square.

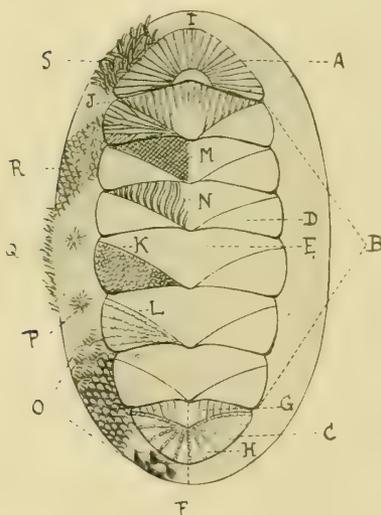


Fig. 3.—Composite diagram of a Loricata, showing the parts of the shell (A. to H.); the variations of sculpture more frequently occurring (I. to N.), and the principal varieties of girdle-covering (O. to S.).

A.—Anterior valve, B.—Median valves, C.—Posterior valve, D.—Lateral area, E. Central area, F.—Muero, G.—Ante-mueroal area, H.—Post-mueroal area.

I.—Radially ribbed, J.—Divaricating radially, K.—Nodulose, L.—Radially nodulose, M.—Graduated in quincunx, N.—Sulcate.

O.—Scales (mueroal, smooth, and striate), P.—Spiculose bunches, Q.—Spicules, R.—Scales and spiculose tufts, S.—Calcareous spines.

The Girdle.—The valves of the shell are linked together by means of a flexible integument, composed of muscular tissues, in which the insertion plates or edges of the valves are embedded. This is called the *girdle*, and its surface is variously clothed with *scales* (which may be smooth and rounded, polished, striated, flat, regular, or irregular), *corneous* or *hairy processes*, *spicules*, or a combination of two of such coverings. In some forms the girdle encroaches upon, and even wholly covers the valves. In those genera which have a posterior sinus in the tail valve, the girdle has a corresponding sinus or slit. The slitting of the insertion plates, and the covering of the girdle, form the principal characters upon which the genera are founded.

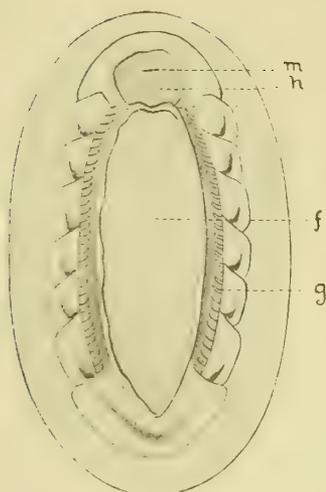


Fig. 4.—Loricated animal, as dried in shell. (When alive the foot is generally more expanded, hiding the gills). H.—Head, M.—Mouth, F.—Foot (ventral surface), G.—Gills.

The Animal.—The ventral surface of the Loricates consists of a fleshy foot, similar to that of the *Gastropoda*. Anterior to the foot is the head, with the mouth in the centre. The gills extend along and behind the edges of the foot from one-fourth to the entire length of the foot; commencing at the posterior end. The distinguishing feature of the Order is the symmetrical arrangement of the internal anatomy, all other *Gastropods* being asymmetrical in this respect. While there are no tentacles or eyes in the adult, many species have visible *ocelli* in the tegmentum, which are connected with the nerve-centre and are functional in conveying to the animal the sensation of light or darkness. Even where these *ocelli* are not visible, the animal is sensitive to light, and endeavours to escape from it.

The *radula*, the organ by means of which Loricates obtain their food, consists of a long siliceous ribbon bearing numerous rows of hooklets, and as this is the only hard part of the internal anatomy of most mollusks it has been largely used in grouping. In the Loricates the radula, odontophore, or lingual ribbon, as the organ is variously called, is of a complex type and can only be used by a specialist familiar with microscopic work, requiring long and careful study. As it is easily seen with the naked eye near the head when Loricates are being cleaned out, we may note the general features as follows:—Viewed with a lens it presents a spiny surface, the spines arranged in rows of about 16, two near the middle being much larger and more strongly hooked than the others. The total length of the radula may, in the larger Loricates of the Region, measure 10 mm., with a breadth of 1 mm. It is used to tear away the algal or fleshy food by a forward thrust, the small particles of food being conveyed to the stomach by retracting the ribbon.

Reproduction.—Dall (Scientific Results of the Exploration of Alaska, 1878) states that these animals are of two sexes, the histological characters of the male and female gland resembling those of the Limpets. Clark (Annals and Magazine of Natural History, 1855) observed an individual of *Chiton marginatus*, placed in a vessel of sea water, which “poured out, for several minutes a continuous stream of flaky-white viscous matter, like a fleecy cloud, and then discharged ova—not in volleys, but one or two at every second for at least fifteen minutes, forming a batch of from 1,300 to 1,500.” Lovén (Transactions of the Royal Academy of

Sciences, Stockholm, 1855) says that "some individuals kept in confinement laid their eggs, loosely united in clusters of from 7 to 16, upon small stones." One of us took specimens of *Heterozona subviridis* at King Island, Bass Strait, in December, 1922, and of *Sypharochiton mayi* and *Ischnochiton atkinsoni* in January, 1929, at Port Esperance, Tasmania, with clusters of eggs disposed between the margin of the foot and the gill rows. Dall (*loc. cit.*) summarises Lovén's observations in the following terms:—"The Chitons differ from most Mollusks in that the shell does not appear on the embryo until some time after they are hatched. The embryo of *Chiton cinereus* is oval, with no trace of shelly valves or depressions for them, and is divided into two nearly equal parts by a transverse depression, the margins of which are ciliated. On the middle of the upper part is a tuft of filaments which move slightly. At each end of the depression are two dark points, representing the eyes. The young when hatched become more elongated, the front part is finely ciliated, and the tuft occasionally vibrates. The hinder part extends more rapidly and becomes conic. The back is marked by seven furrows; between these the first rudiments of shelly valves make their appearance in the form of fine granulations. Soon after this, the animal can crawl as well as swim, and the mantle becomes separated from the foot by an indentation. The eyes are placed on the ventral side, and hardly visible from above. The upper anterior part of the animal is marked with acute tubercles. The mouth is not yet visible. The valves first appear in the form of seven narrow bands with irregular margins; the tuft disappears. The head and mouth then develop. The eyes are on distinct lateral protuberances. No gills have appeared. The mantle and front valve advance over the head and eyes; the tuberculated area in front of the valves is gradually diminished, and the tail-plate appears behind the seventh. The valves are at first irregular, but increase from below, and deep notches, persistent in the adult, are formed on the front edges, one on each side. It will be seen that the valves are formed each in one piece, and not by the coalescence of parts corresponding to the various areas of the adult valve."

Food.—So far as is known at present, the majority of Loricates are vegetable feeders, but there have been records of carnivorous habits in respect of certain individual species. We have seen *Sypharochiton maugeanus* holding a small crab under its head valve, crushed and ready for consumption. Further investigation and observation in aquaria is necessary to determine whether the known carnivores are habitually or only occasionally addicted to an animal diet.

Ecology.—This term is here applied to the position or *station* on the littoral or sea floor frequented by the various genera, and the interrelation of the animals with surrounding conditions. Generally speaking, the Loricates are of littoral habit, the range extending from mean high water mark to a few feet below low water mark. A small percentage of recorded species is found at greater depths below low water, those from the greatest depths being more or less degenerate forms. The station of the various genera differs, some being restricted to the upper side of the rocks; a much larger proportion being found on the under side of stones below median tide mark; while others are found amongst the roots of kelp. Those genera which are emerging and gradually becoming established in stations where they are exposed to the sun and air for the greater part of each day are generally covered with parasitic growths, or the tegmentum is so eroded as to obliterate the sculpture. These forms appear to be sedentary. The occupants of the next lower zone are more nomadic, moving freely and changing their station in accordance with the seasons and the varying surface temperatures of the water.

Coloration of Shell.—The coloration of the tegmentum may be divided into three categories, viz:—(1) Specific, (2) Individual, and (3) Environmental.

1. *Specific*.—Many species have a fixed colour pattern, which may extend over the whole tegumentum, or be restricted to certain definite parts, the remainder of the shell being variable in coloration, which is therefore individual. The specific colouration is always present and, within its extent, unvarying.

2. *Individual*.—Some species show no specific coloration but present a fascinating variety of colours, which may be either uniform for the whole shell, or picked out in contrasting colours and shades, the whole forming a beautifully symmetrical pattern, the markings extending over each valve in exactly the same manner on each side of the dorsal area.

3. *Environmental*.—Colour which has been absorbed or assumed as the result of some strong local influence, such as the presence of rusty iron in the pool, which imparts a reddish or brownish tinge to the shell; or the character of the rock which, if basalt or ironstone influences the shell to assume dark colours, and if sandstone or limestone causes lighter and brighter shell coloration. Evidence of protective coloration may be found in some species, but it is evanescent, dying out as the shell dries. The more brilliant shells of individual coloration are sometimes found in environments that suggest protective mimicry, but the fact that the animals are nomadic, and are just as frequently found in positions where their colour contrasts violently with their surroundings effectually disposes of the assumption that the colours are adopted for the purpose of protection.

Teratology.—Abnormal Loricates, having less or more than eight valves, are occasionally met with. We have collected specimens of several different species with five, six, seven, or nine valves. Though some of these abnormalities are due to fracture and subsequent fusion in repair, quite a number are clearly of congenital origin. A specimen having only three valves is preserved in the British Museum, the six median valves having become fused into one. So far, the only aberrants recorded from the Neozelanic Region are 5, 6, or 7-valved examples, but more intensive search will doubtless reveal others.

Region.—The Neozelanic Region, for the purposes of this Monograph, embraces the area lying between the 29th and 55th parallels of South latitude, and between the 158th meridian of East and the 175th meridian of West longitude. It includes Lord Howe, Norfolk, the Kermadec, Chatham, Bounty, Antipodes, Auckland, Stewart, and Macquarie Islands, as well as the North and South Islands of New Zealand. As it embraces subtropical, temperate, and cold waters there is a possibility of a different faunula at each extremity, some 2,000 miles apart, but curiously enough such is not well defined nor easily noticeable. While *Plaxiphora*, accompanied by *Hemiarthrum* are the most noticeable forms at the extreme South. *Maorichiton* and *Eudoxochiton*, both peculiar Neozelanic forms, exist at the Northern extremity.

Finlay has published (Gedenboek Verbeek, p. 168, 1925: Trans. New Zeal. Inst., Vol. 57, p. 328, 1926) a scheme proposed by Iredale for the subdivision of the Maorian Sub-Region into five provinces, thus:—

Kermadec Province	Kermadec Islands.
Cookian Province	North Island of New Zealand.
Forsterian Province	South Island of New Zealand and Stewart Island.
Moriorian Province	Chatham Islands.
Rossian Province	Subantarctic Islands, including Macquarie Island.

To which we here add the

Phillipian Province	Lord Howe and Norfolk Islands.
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Hull proposed this name many years ago. (*Emu*, xi., 1911, 60).

In order to attain a measure of completeness we have included the Lord Howe and Norfolk Island species. These were not included in the Australian Monograph, as, although they showed a little relationship, the remainder of the

fauna failed to support any claim to close alliance between these groups and Australia. They have commonly been associated with the Kermadecs, and as there is little discordance (the only notable exotic being *Cryptoplax*, a Neocaledonian relation) we are treating them here. It may be pointed out that *Placostylus* allies New Caledonia, Lord Howe Island and New Zealand, and the parrot genus *Nestor* undoubtedly associates Norfolk Island with New Zealand. While not otherwise advising the inclusion of these Islands in the Neozelanic Region, we think that the Loricates can be here most profitably dealt with. The New Caledonian Loricates will later be fully described and illustrated by Hull and Risbec.

Collection and Preservation of Loricates.—A considerable number of species may be collected at low tide without even wetting one's boots, but to obtain the occupants of the lower zones it is necessary to wade into water to a depth of three feet at low tide. It is advisable, therefore, to take a change of clothing and a strong pair of boots to protect the feet from oyster shells and sharp stones. Rock eels and octopods are frequently met with in the pools, and some protection from the bite of the former and the tentacles of the latter is desirable. A short crowbar or a curved iron "erook" to lift heavy stones should be carried. To remove the Loricates from the stones to which they adhere a penknife is required, while a pin may be used for the smaller specimens. Slips of wood, one to two inches in width and eight inches in length, or of glass one by four inches, with tape or string to bind the shells thereon are necessary if "cabinet" specimens are required. Immediately upon removing the shell it should be placed on the wetted slip and gently pressed down until it assumes a natural position with the girdle well expanded. A few turns of the tape should be taken round the shell and the end left loose for the next specimen. With most shells the tape can be drawn quite tightly, but some of the more fragile shells, such as *Terenochiton* and the smaller *Ischnochitons*, require a certain amount of care as the valves are liable to become crushed. Both sides of the slips can be filled if the shells are plentiful. If it is desired to retain the animal for examination of the radula, etc., it may be allowed to remain and dry on the slip, or the slip when filled placed in alcohol. Formalin should never be used as a preservative. To make cabinet specimens of vermiform Loricates, such as *Cryptoplax*, the animal should be removed, and a boat-shaped piece of wood cut to the required length, with both ends pointed. This should be fitted into the shell, the flexible girdle adjusted, and the tape wound tightly round the whole.

If specimens are plentiful and time short, they can be rapidly transferred from the stones to the slips, and placed in a can of fresh water, in which they will drown, in most cases relaxing in dying. On reaching home the collector can remove the animals and tie the shells down at leisure. The animal should be removed by running a knife round the body, cutting from the tail forward, so as not to bring the edge of the knife into opposition to the sutural laminae. Shells having spongy girdles, such as *Onithochiton*, *Eudoxochiton* and *Plaxiphora*, should be manipulated by pressing the girdle outwards between the forefinger and thumb, both at the time of tying down and once or twice during the process of drying, or a "sausage" of cotton wool may be packed round the shell over the girdle, and the whole tied down with tape. The interior of the shell should be wiped dry after removing the animal and before tying the shell down.

When it is desired to make particularly fine cabinet specimens, too much care cannot be bestowed on the arrangement of the girdle and the disposition of the shell in as natural a manner as possible. Each specimen should be washed in clean fresh water to remove the salt, which crystallises and dulls the surface coloration. It is not advisable, however, to use any artificial varnish, vaseline or oil, for, although such media may tend to restore the brilliancy of the colouring

they invariably impart an unnatural appearance to the shell, or collect dust and hairs.

For the cabinet or display in a museum the shells may be mounted most effectively on neutral tinted cards, a very small quantity of gum tragacanth being used to attach the two ends to the card. This gum leaves no shiny trace on the card, and while holding the specimen firmly in place allows of its removal without damage. In every instance the locality where the shell was taken should be noted on the card, and in this respect the collector cannot be too precise. Such localities as "New Zealand" are too vague—the exact bay or headland should be specified, and the date of taking added, together with the name of the collector.

Classification.—Nearly every student has proposed an improved system in this group. Thus Dall improved upon the Carpenterian M.S., and Pilsbry put the group into good working order, so that only in detail did emendation seem possible. However Thiele, by means of intensive study of the radula, was able to indicate some amendments in Pilsbry's scheme which showed progress, and we have utilised Thiele's basis for the purpose of our reconstruction. Iredale has already suggested (Proc. Mal. Soc., xi, 1914, 27) the rejection of Thiele's *Lepidopleurina* as a primary division, and we here omit all subordinal distinction, classing the Loricates in several families without intermediate higher groupings. Ashby* has recently essayed a phylogenetic classification of the Neozelanic Loricates, which is scarcely worthy of consideration, as his basis has involved many incompatible factors. This will be more fully discussed when we have completed the systematic description of the Loricates.

We have already shown** that the *Ischnochitonidae* represent the most primitive stock and that the *Lepidopleuridae* are probably degenerates, a possibility Pilsbry was also inclined to accept when he placed the *Lepidopleuridae* as the most primitive forms. *Lepidochitonidae* and *Loricidae* are developed Ischnochitons, while the *Cryptoconchidae* and *Cryptoplacidae* may have evolved from an Ischnochitonid ancestor, with another branch developing into the *Plaxiphoridae*, and another into the *Chitonidae*. Thus the primitive Loricite might have had the quincuncial punctation of the juvenile Ischnochitonids or Lepidopleurids, and the scaly girdle as seen in these. No Ischnochitonid in this region has developed a hairy or spinose girdle, but *Chaetopleura* (South America) is of that form. Complex sculpture has been produced, but the insertion plates are always of simple design. The Lepidopleurids have degenerated, losing the insertion plates, while retaining primitive sculptural design. The Lepidochitonids have modified the sculpture a little, but have developed the scaling so that in some species corneous processes are seen. It should be noted that a Lepidopleurid with a hairy girdle has been found, while a series of Lepidopleurids has developed the scales into spicules. The insertion plates of the Lepidochitonids have also become modified, the teeth being coarse, irregular and brittle, but so far no loss of insertion plate is known. The *Cryptoconchidae* form a well-developed group in which the sculpture is mostly nodulose, a few developing linear sculpture as a result of the fusion of the nodules. The girdle is always spiculate, but in some cases there is almost a scale-like subordinate covering, while the insertion plates have become for the first time reducible to definite formula, the anterior valve being five-slit, the median valves one-slit, and the posterior valve with two side slits, more or less inter-slit. A further modification has produced the *Cryptoplacidae*, wherein an elongated worm-like body has been formed, the valves being diminished in size, the girdle proportionately very large, always covered with spicules, and the insertion plates long, in the anterior valve only three-slit, long in the median valves

* Trans. N.Z. Inst., 1928.

** Aust. Zool., iii., 1923, 193.

but unslit, and tending to reduction in the tail valve. Then the *Plaxiphoridae* have developed a formula of insertion plate slitting in which the anterior valve has eight slits, the median valves one-slit, and posterior valve only a callus; the girdle bearing hairy processes only.

The *Chitonidae*, as at present recognised, include a series of Loricates with the highest development, having varied sculpture, varied insertion-plate slitting, and varied girdle covering, with the two additional features of pectination of the insertion plates and visible ocelli in the tegmentum.

Key to the Families.

The differential features of the Families may be epitomised as follows:—

Girdle-covering scales only; insertion plates in all valves; more than eight slits in the head valve, all teeth smooth, and no scalloping present. . . . *Ischnochitonidae*.
 Girdle-covering scales, calcareous spicules, or corneous processes; insertion plates wanting, or if present, obsolete and unslit. *Lepidopleuridae*.
 Girdle-covering of slender scales latitudinally very closely packed, sometimes with corneous processes present; insertion plates in all valves, teeth coarsely denticulate. *Lepidochitonidae*.
 Girdle-covering scales and spicules or corneous processes of complex growth; insertion plates in all valves save posterior valve. *Loricidae*.
 Girdle-covering of calcareous spicules with prominent bunches; anterior valve with five slits. *Cryptoconchidae*.
 Girdle-covering of closely-packed calcareous spicules, bunches not very prominent; anterior valve with three slits; shape very elongate. *Cryptoplacidae*.
 Girdle-covering of corneous processes of simple growth; anterior valve with eight slits. *Plaxiphoridae*.
 Girdle-covering of scales or calcareous spines, never of corneous processes; teeth of insertion plates finely pectinate. *Chitonidae*.

These differential features apply more particularly to Australian and Neozelanic forms. It will be seen that all the Australian families are represented in the Neozelanic Region except one, the *Callistochitonidae*. As it is quite possible that members of this Family will yet be discovered in the Region, we here give its differential features:—

Girdle-covering scales only; insertion plates in all valves; teeth peculiarly scalloped. *Callistochitonidae*.

I. Family ISCHNOCHITONIDAE.

The Family ISCHNOCHITONIDAE includes a series of generalized Loricates with simple scaly girdles and simple insertion plates; and appears to represent the most primitive form. Although the family is widely distributed and well represented, both in species and genera, particularly in the Australian region, very few species have been recognized in New Zealand, though individuals are numerous. They live between tide marks, under stones, and in the only case reported from New Zealand of two species living together, they occupy slightly different stations, differing also in their movements. The animals are the most active of the whole Order, and when a stone is turned over they quickly move to the underside, being actively responsive to light conditions or phototropic. No ecologic studies have been carried out in connection with the New Zealand species, but in Australia they have been found to move up and down as the tide varies, and also to be very liable to wander through stress of sand movement on their stations.

Though as above noted many genera have been recognised in connection with Australian species, only two are admitted in the Neozelanic series, and only one on the mainland proper. Consequently there is little difficulty in this connection

and the generic diagnosis will cover the species (save the only one not congeneric, viz., *Subterenochiton*).

i. Genus ISCHNOCHITON.

1847. *Ischnochiton* Gray, Proc. Zool. Soc. (Lond.), 1847, 126. Type by subsequent designation (*id.*, *ib.*, 168), *Chiton textilis* Gray.

Shells of medium size for the family, the largest New Zealand form less than 50 mm. in length, coloration very variable, sculpture weak and ill-defined, consisting of minute pustules, arranged quincuncially, forming on the end valves, and lateral areas through more developed design, into radials, which rarely occur on the pleural areas. Girdle scales minute, generally striate. Insertion plates sharp and clean cut, not pectinated: many slits in end valves, one slit medially on each side: sutural laminae large, widely separated.

1. ISCHNOCHITON MAORIANUS.

Plate xxxiv., figs. 1-6.

1914. *Ischnochiton maorianus* Iredale, Proc. Mal. Soc., xi. (March), 36. Otago Peninsula, New Zealand: new name for *Ischnochiton longicymba* auct.
1835. *Chiton longicymba* Quoy and Gaimard, Voy. de l'Astrol. Zool., vol. iii., 390, pl. 75, figs. 1-6. New Zealand (part). Not *Chiton longicymba* Blainville, 1825 (a *Stenochiton* q.v.).
1843. *Acanthopleura longicymba* Gray, Travels in New Zealand (Dieffenbach), ii., 245.
1871. *Chiton longicymbus* Hutton, Trans. N.Z. Inst., iv., 1870, 178.
1873. *Chiton longicymbus* Hutton, Cat. Marine Moll. N.Z., 47.
1880. *Lepidopleurus longicymbus* Hutton, Man. N.Z. Moll., 113.
1885. *Lepidopleurus longicymbus* Filhol., Miss. l'île Campbell, iii. (2), 531.
1892. *Ischnochiton longicymba* Pilsbry, Man. Conch., xiv., 87, pl. xxii., figs. 58-66.
1897. *Ischnochiton longicymba* Suter, Proc. Mal. Soc., ii., 186 (July).
1904. *Ischnochiton longicymba* Hutton, Index Faunae N.Z., 87.
1904. *Ischnochiton fruticosus* Wissel, Zool. Jahrb. Abth. Syst., 20, 594.
1905. *Ischnochiton longicymba* Hamilton, Col. Mus. Bull., i., 36.
1909. *Ischnochiton longicymba* Suter, Nach. Blätt. Malak. Gesell., 2, 73. (Correction of Wissel's error).
1913. *Ischnochiton longicymba* Suter, Man. N.Z. Moll., 9: Atlas, pl. 2, fig. 2, pl. 3, fig. 3 a, b.
1915. *Ischnochiton maorianus* Iredale, Trans. N.Z. Inst., xlvii., 1914, 420, 425.
1924. *Ischnochiton maorianus* Odhner, Vedensk. Medd. Dansk. Nat. Foren., Bd. 77, (N.Z. Moll.), 5 (includes Auckland Is.).

Iredale's introduction reads: "For this species, which is well described and figured in Pilsbry's Monograph (Man. Conch., vol. xiv., p. 87, pl. xxii., figs. 58-66, 1892), I propose the name *Ischnochiton maorianus* n.sp. This species differs from *I. crispus* (Reeve) in its larger size, more rounded back, less distinctly striated girdle-scales, and the short posterior tooth of the insertion-plates of the median valves. *Hab.*: Throughout New Zealand. Type from Otago Peninsula."

Pilsbry's description was as follows: "Shell oblong, rather highly and broadly arched, not in the least carinated. Surface to the naked eye apparently smooth on the central, radiately lirate on the lateral areas and end valves. Color extremely variable, usually pale olive, mottled with darker olive or purple-black, or having a broad light band along the back. Lateral areas distinctly raised, sculptured with 8-12 radiating riblets, often bifurcating, the intervals densely granulated; the riblets are interrupted by irregular impressed concentric growth-lines. Central areas very closely and finely granulated in quincuncial pattern; the granu-

lation is nearly even on the jugum, although the anteriorly divergent rows of granules are sometimes slightly more prominent: on the slope between central and lateral areas, and on the extreme sides of the latter the granules are arranged to form more or less distinct longitudinal rows. The end valves are very minutely granulated and radially lirate. Umbo of posterior valve rather low, obtuse; posterior slope visibly concave. Interior green or blue, sometimes varied with red or corneous. Anterior valve with 9-12, central 1, posterior valve 11 slits; teeth thin, sharp and smooth; posterior tooth of the side insertion plates short, and terminating abruptly before attaining the posterior margin of the valve; eaves solid. Girdle closely covered with solid, convex, but somewhat flattened imbricating scales, most of which are rather weakly striated, but among which non-striated scales are mingled. Length 33, breadth 16 mill."

There is very little improvement possible on this description, but it should be noted that carinated specimens are sometimes found, and it is possible that in the Subantarctic Islands a carinate subspecies is present, but sufficient material is not available to definitely determine the exact status of the southern shells.

The coloration may be amplified as follows:—

(a) Olive-green, buff, or rose-lilac, with or without vertical lines in a darker shade, (b) wholly blackish or dark-grey, (c) black or bronze-green, with white dorsal stripe, or (d) with dorsal band of width varying on each valve, narrowest on valve iv. and widest on valve vi., (e) black or deep olive-green, with rose-lilac or other light-coloured blotches on either side of the jugum, (f) buff or other light colour, with dark dorsal stripe and anterior valve.

Dimensions: 45 x 22 mm. (Largest example measured).

Station: Under stones between median and lowest spring tide marks.

Habitat: Throughout New Zealand.

Remarks: For many years this common shell was known by the name of *Ischnochiton longicymba*, but Blainville had described his *Chiton longicymba* from King Island, Bass Strait, Australia. It was commonly accepted that the Australian (*I. elongatus crispus*) and New Zealand shells were identical, but when Pilsbry separated the two he allotted Blainville's name to the New Zealand species, whereas it obviously should have been restricted to the Australian species. Upon investigation Iredale found that Blainville had not described this species or kind of shell at all, so had no hesitation in describing the New Zealand shell as a new species, giving it the good name of *maorianus*. Later Iredale was able to show that Blainville had described a species of the genus *Stenochiton*, a very different style of Loricata, as his *Chiton longicymba* and thus definitely disposed of the confused name.

2. ISCHNOCHITON CIRCUMVALLATUS.

Plate xxxiv., figs. 7-9.

1847. *Chiton circumvallatus* Reeve, Conch. Icon., iv., pl. xxvii., sp. and fig. 168 (bis), Oct: New Zealand: we select Auckland Is.
1873. *Chiton circumvallatus* Hutton, Cat. Marine Moll., N.Z., 47.
1880. *Lepidopleurus circumvallatus* Hutton, Man. N.Z. Moll., 113. Campbell Island.
1880. *Lepidopleurus campbelli* Filhol, Comptes Rendus. Acad. Sci. Paris, xci., 1095. Campbell Island.
1884. *Lepidopleurus melantherus* Rochebrune, Bull. Soc. Philom. Paris, 1883-1884, 37. Campbell Island.
1885. *Lepidopleurus circumvallatus* Filhol, Miss. Pile Campbell, iii., (2), 531.
1885. *Lepidopleurus campbelli* Filhol, Miss. Pile Campbell, iii., (2), 533.
1892. *Chiton circumvallatus* Pilsbry, Man. Conch., xiv., 69. placed as a synonym of *I. (T.) cinereus*.

1893. *Lepidopleurus melanterus* Pilsbry, Man. Conch., xv., 107, description translated.
1893. *Lepidopleurus campbelli* Pilsbry, Man. Conch., xv., 107, description translated.
1897. *Ischnochiton parkeri* Suter, Proc. Mal. Soc., ii., 186, figs. 1-6, in text. Auckland Island and Campbell Island.
1904. *Ischnochiton parkeri* Hutton, Index Faunae New Zeal., 87.
1905. *Ischnochiton parkeri* Hamilton, Col. Mus. Bull. No. 1, 36.
1905. *Ischnochiton fulvus* Suter, Journ. Malae., xii., 66, pl. ix., figs. 5-10. Te Oneroa, Preservation Inlet and Brighton, Otago.
1908. *Ischnochiton fulvus* Iredale, Trans. N.Z. Inst., xi., 1907, 373.
1909. *Ischnochiton melanterus* Thiele, Revision Chitonen, pt. ii. (Chun's Zoologica, heft. 56), 111.
1909. *Ischnochiton fulvus* Thiele, Revision Chitonen, pt. ii. (Chun's Zoologica, heft. 56), 111.
1910. *Ischnochiton gryei* Iredale, Proc. Mal. Soc., ix., 91, June. (Incorrect).
1913. *Ischnochiton fulvus* Suter, Man. N.Z. Moll., 9. Atlas, pl. 3, fig. 2a-d.
1913. *Ischnochiton parkeri* Suter, Man. N.Z. Moll., 11, 1076: Atlas, pl. 3, fig. 5a-d.
1915. *Ischnochiton campbelli* Iredale, Trans. N.Z. Inst., xlvii., 1914, 419, 425.
1917. *Ischnochiton campbelli* Dupuis, Bull. Mus. Hist. Nat. Paris, No. 7, 534.
1918. *Ischnochiton campbelli* Dupuis, Bull. Mus. Hist. Nat. Paris, No. 7, 525.
1922. *Ischnochiton campbelli* Ashby, Trans. Roy. Soc. S.A., xlv., 574 (type exam. ?).
1922. *Ischnochiton melanterus* Ashby, Trans. Roy. Soc. S.A., xlv., 574 (type exam. ?).
1924. *Ischnochiton campbelli* Odhner, Vidensk. Medd. Dansk. Nat. Foren., Bd. 77 (N.Z. Moll.), 6.

Reeve described his *Chiton circumvallatus* thus: "Shell oblong-ovate, terminal valves and lateral areas of the rest sculptured with concentric ridges, central areas very minutely reticulated, posterior terminal valve umbonated; blackish-red, spotted with black, ligament arenaceous tessellated. *Hab.*: New Zealand. Approaching *C. longicymba*, but distinguished from that species by the conspicuous concentric ridges with which it is encircled."

Pilsbry included this species in the synonymy of *Ischnochiton (Trachydermon) cinereus* observing: "Carpenter, having examined the type of *C. circumvallatus* Reeve, writes that he is satisfied that it is merely a *cinereus*. The locality given by Reeve is no doubt wrong."

Apparently in this case a locality label had become misplaced, and Carpenter had not checked the specimen back with the description, as this does not apply at all to the British shell (which Iredale has collected), while the description and figure excellently depict the New Zealand species. Furthermore, Iredale examined in the British Museum a tablet agreeing with Reeve's figure, and to which Carpenter had allotted a new name. The specimens had probably been collected by some member of Ross's Voyage, which called at the Auckland Island, so we have designated that as the type locality. When Hutton wrote his 1880 Manual he included Reeve's species and gave as a locality "Campbell Island"; probably these specimens had been given by Filhol, as it is recorded that Filhol left botanical specimens in New Zealand, and Filhol used Hutton's Manual and may have shown his shells to Hutton. Then Filhol shortly described a species from Campbell Island, of which Pilsbry's translation is here copied: "Length 17, width 8 mill. Color clear yellow, last valve larger than the first, covered with concentric lines, granulated. Lateral areas marked with concentric lines, having a concavity above."

Dupuis has recently recovered a shell 12 mm. long and recorded it as type, and has been followed by Ashby, who has written: "The type is a half-grown specimen," whereas the measurements given indicate a full sized mature shell.

At the same time Filhol described a *Tonicia gryei*, and Iredale blundered badly in associating it with this species, as he was ignorant of the fact that a full complete description had been later correctly published by Filhol, making its identity certain. However, to continue, the irresponsible Rochebrune interfered with all the Loricates in the Paris Museum and, changing labels, localities, etc., introduced an almost ineradicable confusion into this group. Thus he apparently secured a lot of Filhol's specimens, and thereupon described them as a new species, as follows (again using Pilsbry's translation): "Shell ovoid, rotund; chestnut painted, with black spots. Anterior valve, posterior part of posterior valve, and lateral areas concentrically lyrate, the lyrae wide and flattened. Central areas most minutely tessellated. Marginal ligament narrow, dull rufous. Length 20, width 6 mill. Campbell Island (Filhol)."

Please note the measurements given by Rochebrune, as recently the identity of *C. longicymba* has been questioned on account of a discrepancy in Rochebrune's figures. Iredale has examined these shells and the figures given by Filhol, 17 x 8, are nearer.

The species was quite unknown to Pilsbry autoptically, so that Suter described it anew, as follows: "*Ischnochiton parkeri*. Shell oblong, highly and angularly arched. Colour very variable, from horny-yellow to chestnut-brown, mostly darker on the posterior margin of the valves, with more or less predominant black longitudinal stripes, assuming often a triangular shape, closer together or coalescing towards the girdle: the jugum with only a few or without black markings. Lateral areas distinct, raised, minutely granulated, and with three or four concentric, flat, impressed ridges, which are sometimes crossed by faint radiating riblets, their number being from 8-10. Central areas closely and finely quincuncially granulate, the anteriorly divergent rows predominating. End valves minutely decussate, with two concentric ridges, which are rendered granulose by numerous radiate riblets. Mucro of tail valve central, low, and obtuse, posterior slope slightly concave. Girdle of the same colour as the jugum, covered densely with small imbricating scales, all of about the same size; they are flatly convex and deeply grooved, 3-4 grooves on each. The margin of girdle beset with a fringe of minute spicules. Interior blue. Anterior valve with 11-13, central 1, posterior 12-13 slits: the teeth are sharp and smooth. The posterior margin of intermediate valves slightly beaked and denticulate; posterior tooth short, as in *Ischnochiton longicymba*. Eaves solid. Sinus broad, flat, smooth, channelled on each side on the inner surface of the sutural plates. Length 21, breadth 12 mm., divergence 120°. *Hab.*: Auckland Islands: Campbell Island. Specimens from Campbell Island, also in the Otago Museum, are of a light-brown colour, and were mistaken for *C. circumvallatus* Reeve. This species may be *Lepidopleurus melanterus* Rocheb., one of the many insufficiently described species."

It will be noted that Suter did not mention Filhol's *L. campbelli*, nor did he know of the long complete description given of that shell. Some years later Suter, meeting with a similar shell on the N.Z. mainland, described it as new as *Ischnochiton fulvus* thus: "Shell small, elongated oval, with the sides subparallel, obtusely angled, slopes flatly convex, fulvous. In size, outline and colour very much like *Lepidopleurus inquinatus* Reeve. Anterior valve with a few concentric ridges, minutely quincuncially punctate; the anterior margin white, the remainder uniformly fulvous. There is a slight posterior median notch. Intermediate valves. The whole surface minutely punctate like the anterior valve, with a few concentric ridges, which are more strongly developed on the lateral areas. The latter are distinctly separated from the central area by a broadly rounded edge,

and there is no indication of radiate riblets. Posterior valve concentrically ridged and quincuncially punctate like the other valves; micro subcentral, posterior slope slightly concave. Girdle covered with very small imbricating scales of somewhat unequal size. Under the microscope they are seen to be flatly convex and deeply grooved, usually four grooves on a scale. The girdle is mostly concentrically banded with white and fulvous, two rows of scales to each band. Colour varies from light to dark fulvous, the dorsal and anterior area being always lighter coloured. The anterior margin of the head valve, the anterior and lateral margins of the intermediate valves, and the entire margin of the tail valve have a narrow white border. Interior dirty white: sinus broad and deep, smooth. Anterior valve with 12 slits at unequal distances: intermediate valves with 1 slit on each side, posterior tooth small; posterior valve with 12 slits, the teeth unequal in breadth. All teeth are sharp and slightly grooved on the outer side. Length 12, breadth 7 millim.; divergence 100°. *Hab.*: Te Oneroa, Preservation Inlet and Brighton, Otago, South Island of New Zealand. The only New Zealand *Chiton* which bears a close resemblance with this species is, as already pointed out, *L. inquinatus*, which, however, may at once be distinguished by the longitudinal striated intermediate valves."

Iredale then added as regards *I. fulvus*. "It usually lives on clean smooth stones, unassociated with *I. longicymba* Q. & G. When the two occur on the same stone, *I. fulvus* Suter, is on the clean edge, whilst *I. longicymba* Q. & G. is on the muddy side underneath. *I. fulvus* Suter, is as variable as regards colour as almost any other *Chiton*, but is almost always unicoloured: it runs through all the shades from pure-white through pale-yellow to fulvous and red-brown. The most striking shell, however, is a deep-green, with a green-and-white girdle."

When Iredale worked through the collection at the British Museum in conjunction with those from the Paris Museum, he concluded that *I. fulvus* was conspecific with *I. parkeri*, which was the same as *I. melanterus* Rocheb. and *T. gryei* Filhol. Later correcting himself he determined *I. campbelli* as the correct name. Suter did not agree with the identity of *I. fulvus* and *I. campbelli*, but there does not appear to be specific separation from study of the descriptions alone, nor by the shells so far seen. The two descriptions given by Suter appear to cover every detail, the essential features being the lack of radial sculpture until senile, when deeply cut growth lines amply distinguish the species, and the few grooves on the girdle scales. We have figured an immature specimen of "*fulvus*" showing the sculpture, while the excellent figures of Reeve and Suter of the Subantarctic form will easily distinguish this.

[ISCHNOCHITON sp.]

1907. *Ischnochiton contractus* Suter, Proc. Mal. Soc., vii., 293, June. Auckland Islands.

Not *Chiton contractus* Reeve, Conch. Icon., iv., pl. xv., sp. and fig. 78, 1847 (March), which, though localized as from "New Zealand," is an Australian species.

1909. *Ischnochiton contractus* Suter, Subant. Islands, N.Z., I., 1. Same specimen.

1913. *Ischnochiton contractus* Suter, Man. N.Z. Moll., 8. Atlas, pl. 2, fig. 3.

1915. *Ischnochiton contractus* Iredale, Trans. N.Z. Inst., xlvii., 1914, 419, 425.

Suter wrote: "It is a young example, having a length of 9 mm. only, and most of the valves are broken. The colour is yellowish white, with three longitudinal rows of brown spots. The sculpture consists of the characteristic zigzag wrinkles, which are very delicate, as might be expected in such a young specimen."

This record can only be regarded as worthless until perfect shells are found].

3. ISCHNOCHITON GRANULIFER.

Plate xxxiv., figs. 16-17.

1909. *Ischnochiton granulifer* Thiele, Revision Chitonen., pt. ii. (Chun's Zoologica, heft. 56), 83, pl. viii., figs. 31-35. "1910": New Zealand, exact locality unknown.
1913. *Ischnochiton granulifer* Suter, Man. N.Z. Moll., 1078.

Suter has translated Thiele's description as follows: "In size and general appearance similar to *I. luteoroseus* Suter. One specimen is uniformly yellowish, the other whitish, indistinctly marbled, and with a few symmetrical reddish-brown spots near the lateral margin. The valves are rather strongly convex, angled at the middle, sides convex. The whole surface is covered with roundish granules, the lateral areas are hardly defined, the tail-valve has a central mucro with a concave posterior slope. Head valve with 13, tail valve with 8, slits. The minute scales of the girdle beset with numerous small globules fastened to a thin stalk. Marginal bodies symmetrically striated. Length 6 mm., breadth 3.5 mm. *Hab.*: The two specimens were collected in New Zealand by Dr. Thilenius, no exact locality being given."

We have copied Thiele's figures, and this constitutes all the knowledge we have of this species, which will not easily be recognised.

4. ISCHNOCHITON LUTEOROSEUS.

Plate xxxiv., figs. 18-23.

1907. *Ischnochiton* (*s. str.*) *luteoroseus* Suter, Proc. Mal. Soc., vii., 293, fig. 1, in text. Bounty Islands, N.Z.
1909. *Ischnochiton* (*s. str.*) *luteoroseus* Suter, Subant. Islands, N.Z. I., 2. Also from Dusky Sound, N.Z.
1913. *Ischnochiton* (*s. str.*) *luteoroseus* Suter, Man. N.Z. Moll., 10. Atlas, pl. 3, fig. 4.
1924. *Ischnochiton* (*s. str.*) *luteoroseus* Odhner, Vidensk. Medd. Dansk. Nat. Foren., Bd. 77 (N.Z. Moll.), 6. (Doubtful record).

Suter's description reads: "Shell very small, elongately oval, minutely granulate, uniformly pink or yellowish, with longitudinal pink bands. Anterior valve with a posterior rounded sinus, finely granulated in quincuncial pattern, as is the surface of all the other valves. Intermediate valves with the lateral areas hardly raised, and not well defined; slightly beaked, and the jugum sharply rounded. Posterior valve with a central mucro, a slight transverse impression below it, the posterior slope straight. Girdle scaly, scales roundish, imbricating, flatly convex, smooth, and of equal size. Colour pink, but mostly yellowish with concentric pink bands on the head valve, longitudinal, usually three on each side, on the intermediate valves, and mostly absent on the tail valve: these bands are slightly undulating or zigzagging. Interior bright pink, sinus broad and smooth, sutural laminae broadly rounded. Anterior valve with 11 slits on each side, posterior valve with 8 slits; corresponding with the slits there are radiate fine white lines in all valves. Length 5, breadth 3 mm., divergence 80°. *Hab.*: A few specimens and a number of valves in sand dredged, in 50 fathoms, near the Bounty Islands, by Captain J. Bollons. To judge from the valves gathered, the species will attain a slightly larger size, but most of my specimens are considerably smaller. The smallness, colour, and absence of radiating sculpture distinguish this species from the other New Zealand forms of the genus."

We have given original figures, prepared from paratype valves of this species: the coloration and habitat assist in determination, and it is possibly restricted to the type locality.

5. *ISCHNOCHITON INTERMEDIUS*.

Plate xxxiv., figs. 10-15.

1912. *Ischnochiton intermedius* Hedley and Hull, Proc. Linn. Soc. N.S.W., xxxvii., 274, pl. xi., figs. 3 a-b-c (December 13). Norfolk Island.

The original description reads: "Shell rather depressed. Colour variable, either a monochrome of olive, ochraceous, cream, pale or dark brown, or variegated with these tints, frequently with a dark or pale dorsal stripe. Anterior valve with numerous fine irregular, radiating riblets. Posterior valve; mucro elevated, central, with radiating riblets upon the posterior half, fewer and coarser than those of the anterior valve; anterior half similar to the central area of the median valves. Median valves: lateral areas with 4-6 faint irregular granular riblets; central areas not differentiated from the jugal tract, sculptured as in allied forms. Girdle densely clothed with minute scales. Interior, blue, sinus broad and shallow; anterior valve having 12, median 1-1, and posterior valve 12 slits. Dimensions: Length 19 mm., breadth 9 mm. Station: On the under surface of loose stones in shallow water, in sheltered pools. *Hab.*: Norfolk Island. Remarks: This shell is extremely common, and appears to occupy a position intermediate between *I. crispus* Reeve, of Australia, and *I. longicymba* Quoy, of New Zealand. Compared with *I. crispus*, the novelty is more elevated, has more definitely sculptured lateral areas, and is especially distinguishable from both *I. crispus* and *I. longicymba* by the extremely minute girdle scales." These scales are finely striated.

6. *ISCHNOCHITON KERMADECENSIS*.

Plate xxxiv., figs. 24-25.

1914. *Ischnochiton kermadecensis* Iredale, Proc. Mal. Soc., xi., 35, pl. 1, fig. 3 (March). Sunday Island, Kermadec Group.
1914. *Ischnochiton kermadecensis* var. *exquisitus* Iredale, Proc. Mal. Soc., xi., 36, pl. 1, fig. 2 (March). Sunday Island, Kermadec Group.
1915. *Ischnochiton kermadecensis* Oliver, Trans. New Zeal. Inst., xlviii., 1914, 557 (July 12, 1915).

Iredale's descriptions and comments are here reproduced, and though lengthy are worthy of consideration as still being suggestive: "Shell small, elongate, slightly elevated; valves faintly keeled; girdle scaly. Coloration varied; commonly olivaceous of various shades, sometimes splashed with lighter or darker; commonly brownish, with a brick wash fading to dirty yellow, sometimes splashed with lighter or darker markings, rarely with an uniform dorsal broad light stripe: frequently with lighter markings down the back extending on to some valves so as to recall the var. *picturatus* of *I. smaragdinus*; no specimens with the markings of the var. *decoratus* of *I. crispus* Reeve, though similar markings occur in the Neozelanic *I. longicymba* Quoy and Gaimard, not Blainville = *I. maorianus* n.sp. Other colorations and variations occur more rarely. Anterior valve faintly but closely radiately ribbed. Median valves with the lateral areas small, but similarly sculptured: pleural areas finely quincuncially punctate. Posterior valve with the posterior area sculptured as the anterior valve, the anterior area as the pleural areas of the median valves. Internal coloration generally greenish-blue, but varying somewhat according to the external coloration. Anterior valve has the smooth insertion-plate variously slit, apparently the number of slits varying with age; at least, I am unable to separate the shells specifically, though dissections give the following results: anterior 13 slits, posterior 12 slits; ant. 9, post. 8; ant. 12, post. 12; ant. 11, post. 10; ant. 12, post. 9; ant. 12, post. 11 slits. The shells with the largest number of slits are the smallest, whilst the shells with the fewest slits are the largest. This is exactly the opposite to my anticipations regarding insertion-

plate slitting. I am still engaged in the study of this variation in the slitting, and have made many dissections with no definite result as yet. Median valves have the sutural laminae short, broad, and placed far apart, the insertion-plate with one slit, the posterior tooth quite unlike either that of *I. crispus* (Reeve) or *I. maorianus* (= *I. longicymba* Auct.). In some cases it is longer than in others, but in all cases it is shorter than in the former, though longer than in the latter. Posterior valve with insertion-plate very short, and variously slit as above noted. Girdle covered with very minute regularly striated scales. Juvenile shells show a completely punctate surface, no radial ribbing being observed either on the anterior and posterior valves, or on the lateral areas of the median valves. As above noted, the slits in the anterior and posterior insertion-plates seem to be more numerous in this stage and decrease with age. Length of type 18, breadth 9 mm. *Hab.*: Sunday Island, Kermadec Group. *Station*: On the underside of clean smooth stones below low tide marks. *Remarks*: . . . the Norfolk Island shell to be more strongly sculptured, to be a longer, narrower, and higher shell, with the back rounded and no keeling present. The girdle is also broader, whilst the scales on the girdle of the Kermadec shell are even smaller than those on the Norfolk Island one. The posterior valve in *I. intermedius* has the mucro more central and more elevated, the posterior slope being therefore shorter and steeper. Upon dissection I find the posterior tooth of the insertion-plate of the median valves to be very short, at once recalling that of *I. maorianus* (= *I. longicymba* Auct.), and shorter, noticeably, than that of *I. kermadecensis*. *Ischnochiton gryei* Filhol (= *fulvus* Suter) is less elevated, has a less prominent posterior valve, and larger girdle scales."

The variety was added with the following comment: "After much consideration I have concluded to introduce this shell with varietal rank only. I collected a number of these shells and found them to be fairly constant, but here accept their identity with the common Kermadec species. This variation seems unique in Australasian *Ischnochiton*, as it does not occur in any other species to my knowledge, and I have seen nothing like it from Norfolk Island. The general coloration of the valves is cream, splashed longitudinally, but irregularly, with very pale orange, the girdle being uniformly black. The whole shell seems less elevated and less sculptured and the girdle-scales are smaller, but I have decided to disregard these points in view of the known variation of the common darker shells. The internal coloration is whitish, the insertion-plates seem shorter and more delicate, whilst the slits are twelve in the anterior valve and twelve or more in the posterior. The continual recurrence of this peculiarly coloured shell suggests that in time this 'sport' might become fixed. The peculiar coloration met with in many species of *Ischnochiton* and *Chiton* seems to support this theory. Length of type 14, breadth 8 mm. *Hab.*: Sunday Island, Kermadec Group. *Station*: With *I. kermadecensis*."

EXPLANATION OF PLATE XXXIV.

- Fig. 1. *Ischnochiton maorianus* Iredale, whole shell.
2. *Ischnochiton maorianus* Iredale, interior of anterior valve.
3. *Ischnochiton maorianus* Iredale, interior of median valve.
4. *Ischnochiton maorianus* Iredale, interior of posterior valve.
5. *Ischnochiton maorianus* Iredale, exterior of median valve.
6. *Ischnochiton maorianus* Iredale, girdle scales.
7. *Ischnochiton circumvallatus* Reeve, whole shell (immature "fulvus").
8. *Ischnochiton circumvallatus* Reeve, interior of median valve.
9. *Ischnochiton circumvallatus* Reeve, girdle scales.
10. *Ischnochiton intermedius* Hedley & Hull, whole shell.
11. *Ischnochiton intermedius* Hedley & Hull, exterior of anterior valve.
12. *Ischnochiton intermedius* Hedley & Hull, exterior of median valve.
13. *Ischnochiton intermedius* Hedley & Hull, interior of median valve.
14. *Ischnochiton intermedius* Hedley & Hull, exterior of posterior valve.
15. *Ischnochiton intermedius* Hedley & Hull, girdle scales.
16. *Ischnochiton granulifer* Thiele, posterior valve, copy of Thiele's figure.
17. *Ischnochiton granulifer* Thiele, median valve, copy of Thiele's figure.
18. *Ischnochiton luteoroseus* Suter, exterior of anterior valve.
19. *Ischnochiton luteoroseus* Suter, exterior of median valve.
20. *Ischnochiton luteoroseus* Suter, exterior of posterior valve.
21. *Ischnochiton luteoroseus* Suter, interior of anterior valve.
22. *Ischnochiton luteoroseus* Suter, interior of posterior valve.
23. *Ischnochiton luteoroseus* Suter, interior of median valve.
24. *Ischnochiton kermadecensis* Iredale, whole shell.
25. *Ischnochiton kermadecensis* Iredale, var. *exquisitus*, whole shell.

RE-DISCOVERY OF *CRINIA TASMANIENSIS*,

With Notes on this and other Tasmanian Frogs. (1).

By FRANK N. BLANCHARD.

Plate xxxv.

A suggestion made by the late Professor Launzelot Harrison that the writer, during his projected visit to Tasmania, make an effort to find again *Crinia tasmaniensis*, the frog that had not been seen since the original specimens were described in 1864, was followed, strangely enough, by discovery of that species, two days after arrival in Tasmania, under the first stone turned in search of frogs. Further collecting and study showed that very little had been published on Tasmanian frogs. Apparently the only original work based on field observations is that of Savage English, done in 1901-1903 (2). This is useful, but only a beginning. Definite locality records are needed for determination of the exact distribution of each species in the State, and many specimens must be collected to show the range of variation within each species. In particular, thorough study is needed of the habitat limitations and of breeding, feeding and living habits of each species. Since this work is not likely to be completed by any one individual, it is very desirable that all pertinent observations bearing on these problems be put on record. Following will be found the observations made toward this end by the writer in February and March, 1928.

Thanks are due to Mr. H. H. Scott, of the Victoria Museum at Launceston, for the opportunity to examine the five unlabelled specimens of frogs left in his care by Mr. English; to Dr. Charles Anderson and Mr. J. R. Kinghorn for assistance with facilities, literature and specimens in the Australian Museum; to Mr. H. W. Parker, of the British Museum, for identification of specimens; and to Mr. G. Weindorfer, of Cradle Valley, Tasmania, for assistance in field studies.

Specimens representing the species collected by the writer have been deposited in the Australian Museum at Sydney. All measurements and dissections have been made on specimens preserved in formalin.

Crinia tasmaniensis (Günther).—This species, described by Günther in 1864 from specimens collected in Tasmania, was found by the writer at Lake Fenton, in the National Park, on January 15, 1928. Further search revealed numerous examples in several other localities, and, while the greater number of individuals were found at an elevation of 3,000 to 3,500 feet, it is still uncertain whether this was because that habitat is more favourable or because the search was more persistent there.

The species seems to be strictly aquatic (as would be expected from the fringes on the hind toes), but limited to the shallowest water, and probably is not to be found at any considerable distance from a favourable breeding pool. Individuals were found only in wet places, such as under stones that rested loosely in shallow water along lake margins and creeks. They were particularly easy to find where very small streams had dried to series of shallow, sun-warmed pools. Persistent turning of stones in such places was sure to result in the collection of a fair number of specimens.

Many more sexually mature females were found than males. In three days collecting in Cradle Valley, March 12 to 15, the females outnumbered the males, three to one (60 females and 16 males). From the fact that all the males found had large fat bodies, it might be argued that the males were more or less in retirement because sufficiently fed for the winter hibernation period, then near at

(1) Contribution from the Zoological Laboratory of the University of Michigan.

(2) Proc. Zool. Soc. London, 1910, pp. 627-634, pl. 51.

hand, while the females had to keep actively feeding in order to produce the next season's eggs in addition to providing sufficient reserve for themselves. Perhaps the same reasoning explains the scarcity of sexually immature individuals. In addition to the 76 adults collected in Cradle Valley in three days, six immature specimens were obtained. Three were males measuring 15, 17 and 19 mm., and three were females measuring 17, 20 and 24 mm.

The males may be distinguished by their dusky throats and the general duski-ness and indistinctness of the markings on the lower surface, and by their smaller size. Twelve mature males varied in body length from 19 to 24 millimeters, and averaged 21 millimeters. Fifty-seven females varied from 23 to 30 millimeters, and averaged 27 millimeters. In addition to these differences, the hind legs of the males are relatively longer. Carried forward along the body, the heel reaches the angle of the mouth in adult males; in females it reaches nearly to the insertion of the front leg. For a time after egg-laying this difference would be less pronounced and possibly would disappear.

Tadpoles were found in abundance, in association with the tadpoles of *Hyla ewingii*, in the mountain pools or tarns, at Wombat Moor, in National Park, February 6 to 11. A rather long breeding season is indicated by the fact that all stages were numerous, from larvae with hind limb buds barely visible through metamorphic stages. At the same time newly transformed individuals were plentiful at the margins of the pools. A series of eight such individuals, that had just lost their tails, measured 9 and 10 millimeters in length. In like situations in Cradle Valley, three weeks later, no tadpoles that were certainly of this species were found and only one newly transformed young one was seen, although *Hyla ewingii* in tadpole and transforming stages was abundant here.

The observations and measurements above recorded indicate that sexual maturity is attained in this species at the end of the second season following meta-morphosis.

The number of eggs in a complement was indicated by dissection of two in-dividuals of maximum size (30 millimeters); in one case it was 46 (23 eggs in each ovary), and in the other 69 (36 in the left ovary and 33 in the right).

The colour above, as determined from fresh specimens, is dark brown, grey or olive, with elongate streaks of darker on each side of the mid-dorsal line and along the sides of the body. Between these dark streaks on each side is, charac-teristically, a light band, which may be light brown, orange or even reddish. Be-tween the eyes is a triangular, or v-shaped, dark spot, and obliquely backwards from each eye is a dark, wedge-shaped patch.

The anterior face of the upper arm is often orange or yellow, and an orange patch is sometimes present between the eyes in front of the dark patch. Oc-casional individuals have an irregular orange spot near the middle of the back. In some specimens the dorsal markings are almost entirely irregular.

The lower surfaces are generally white, sometimes cream-coloured, with irregular, scattered or anastomosing black marks. The posterior part of the belly and the hind legs are characteristically bright red between the black markings, but in many individuals the red is entirely lacking, and in some cases (males) the black nearly covers the lower surfaces.

This species was collected in the vicinity of Lake Fenton and the headwaters of the Broad River, in National Park, January 15 and February 5 to 13, and in Cradle Valley, March 9 to 15. One very small individual (11 mm. long) in which the adult markings and coloration were perfectly developed was taken in a wet marsh at Port Arthur, January 29, and two adult males were secured at Wilmot, March 16, among rushes in a wet field in a typical breeding habitat of *Crinia laevis*.

On checking the identity of this and other species at the Australian Museum

in Sydney it was discovered that two specimens of this species had been collected in 1909 at Mount Wellington and Hobart by Professor E. J. Goddard and correctly identified in the Museum records; and, furthermore, that another specimen had been taken at Mount Wellington by Charles Hedley two years later, and entered on the records as *C. signifera*. In addition to the above, Miss V. Irwin Smith collected two specimens near the Springs on Mount Wellington, February 22, 1928. After Professor Harrison's death a specimen of this species, and so labelled, was found in the University of Sydney collection in a bottle with a loose tag, bearing in Professor Harrison's handwriting the words "1 spec. Ulverstone, Tas. Fletcher coll." This specimen was not mentioned by Fletcher in his account of the "Batrachia of Tasmania," published in 1897 (3), so it was probably collected subsequently to that time.

To make finally certain of the correctness of the determination of this species a sample from the National Park, Tasmania, was sent to Mr. H. W. Parker for comparison with the co-types in the British Museum. He replied that the specimen submitted "agrees with the co-types in all respects." Thus it must now be granted that not only is *Crinia tasmaniensis* a valid Tasmanian species, but that it is common and of very general distribution in the island.

Hyla ewingii (Dumeril and Bibron).—This species was found about Lake Fenton and the moors at National Park in much the same habitats as *Crinia tasmaniensis*; and it was likewise abundant in Cradle Valley along tarns and streams and under logs at edges of myrtle woods. Its tadpoles and transforming young were seen in abundance at the former place during the period of observation, February 6 to 11, and at the latter from March 9 to 15. At Eaglehawk Neck, on January 27, the species was in full chorus in ponds on the "Neck," and fresh eggs in little masses were attached to grass stems all over the pond bottoms. Many pairs of frogs were seen, and many males were noted clasping dead females. Some of the latter may have been squeezed to death by the embrace. The species was taken also at Port Arthur on January 30, at Wilmot, March 7, and at Sheffield, March 17.

Limnodynastes dorsalis Gray.—This species was taken only at Eaglehawk Neck. Here in ponds on the "Neck" it was found in full chorus with *H. ewingii* on January 27. Many pairs and singing males were observed and numerous fresh, foamy egg masses were conspicuous about the pond. The egg masses rested at the surface of the water, often close against clumps of grasses or sedges.

The females differ from the males in having a wide flange, or fringe, on the inner side (and a lesser one on the outer side) of the second digit of the fore limb, and a narrow flange on the inner side of the third digit, particularly on the third phalanx from the tip. The lower surfaces of all the specimens collected are variegated with small, indefinite markings,—in some cases rather heavily, in others scarcely at all. The dorsal stripe is complete in seventeen specimens and incomplete in eleven. In the latter it occupies about half, or more, of the mid-dorsal line, beginning on the rostrum or between the eyes.

Crinia signifera Girard.—A single adult of this species was collected near Eaglehawk Neck, January 27, under a piece of wood, and several individuals were found in the Russell River Valley, at National Park, Tasmania, February 18 to 23. One was sitting in shallow water in a drainage ditch and about six others were found individually under wood, bark and leaves in various moist places at the edge of the park. A small one, just transformed, was found in a wet grassy meadow near the entrance to the Park. It was grey like most of the adults. One of the adults was brown above; the rest were dark grey.

Pseudophryne bibronii Günther.—One specimen of this species was found

(3) Fletcher, J. J., Batrachia of Tasmania. Proc. Linn. Soc. New South Wales, 1897, pp. 660-673.

under a chip in dry, open woods near the Blow Hole, at Eaglehawk Neck, on January 27, and two were collected near a marsh on high ground at Port Arthur, January 30. The lower surfaces were boldly marbled with black and pale blue. There is a bright orange spot on the thigh, behind, that is concealed when the hind legs are drawn up. There is no yellow spot on the snout, nor along the urostyle,—marks that, according to Harrison (4), are sometimes present in this species.

Crinia laevis Günther.—This species was first seen by the writer near the entrance to the National Park, along the flood plain of the Russell River. Here, on February 17, a female with unlaidd eggs was found under a board beside a lumber pile, several yards distant from wet ground. Others were found a few days later as a result of a most diligent search under logs and pieces of wood, in the wet meadow along the roadside close to the Park gate. Singing was proceeding from this meadow, and only males were found. Thus breeding was probably taking place or about to occur. That this is near the breeding season English showed (*loc. cit.*, p. 631) by the discovery of eggs on March 30, and confirmation of this was obtained by the writer on March 7 and 16, at Wilmot, in the north-western part of the island. Here, in a wet pasture grown thickly with grasses, sedges and bulrushes, the males were in full chorus, and egg masses varying in age from fresh ones to those containing large embryos were found in abundance. English found the eggs in smooth-sided underground chambers, but those found by the writer were a little above the ground and attached to the moist stems of grasses, sedges or bulrushes, where these were growing in thick clumps on wet ground. They were also abundant where masses of bulrushes had been trodden to the ground. The egg masses were very loosely attached to the stems, and the individual eggs were attached, but loosely to each other (Plate xxxv.). They were mostly placed a few inches above the ground, but some were actually on the wet earth. A few were over water, but most of those found were over damp ground only. Rains would, of course, flood all the eggs. A few masses were found spread along the sides of a concavity in the ground under a thick board that rested on muddy earth. The number of eggs was counted in one complete set, and proved to be 121. It would be most interesting to learn the history of this species through the tadpole stage and transformation.

The frogs were in continuous chorus, increasing in intensity as darkness approached and continuing during the night. The song is a short rasping note, repeated several times in a few seconds. Specimens were easily collected by parting the sedge or grass clumps where they grew thickest on wet ground and searching near the ground in the vicinity of the eggs. Most of the specimens so obtained were adult males, recognizable by the yellow throat, but a few females, also, were found in these places. Many females and a few males and immature individuals were found under stones and bricks imbedded in a muddy, open place and under dry sods thrown out from a drainage ditch along this field.

The males of this species are but little smaller than the females. Forty-four males varied in length from 22 to 31 millimeters, averaging 26, and ten females varied from 23 to 33, averaging 28 millimeters. At egg-laying time the females are much wider than the males. The males are at once distinguishable by their bright yellow throats. In preservative the yellow fades, but the males may still be distinguished by the skin of the throat which is loose and almost without sign of darker markings. The throat of the female is marked with the same reticulate or spotted pattern as the belly, and its skin is not loose.

The coloration in life is as follows. The belly region is marbled with a blackish brown and the parts between are suffused with pink posteriorly and a bluish tint anteriorly. The legs are marbled with black or brown and pink. The

(4) Harrison, Launcelot. On the breeding habits of some Australian frogs. *Australian Zool.*, vol. 3, pt. 1, 1922, pp. 17-34.

posterior angle of the body, where concealed by the thigh, is deep pink, outlined with black. The upper surfaces are slaty or brown in colour, punctulated irregularly with spots of black and red of varying size, the red spots more or less bordered by black.

Two immature males, each 17 millimeters long, are in length about half way between small adults and the probable length of the young at metamorphosis. This leads to the expectation that sexual maturity may be attained about two years after metamorphosis.

In addition to National Park and Wilmot, the species was collected at Sheffield, March 17, where it was in chorus in the dense, tall grasses and sedges lining a wet roadside drainage ditch. Eggs in early development were found here. Most unexpectedly an adult male was found in Cradle Valley, 3,000 feet elevation, March 12, under a stone in a shallow stream, a typical habitat of *C. tasmaniensis*.

For comparison with the type in the British Museum, a specimen was sent to Mr. H. W. Parker. He replied: "Your specimen (male) agrees with the type (female) in all respects, except that in yours the inner finger and toe are much shorter and that in the type the throat is marbled with brown instead of being yellow as in yours. Your specimen agrees in length of inner finger and toe with a female specimen (referred to *C. laevis* by Boulenger) from Victoria, which is the type of *C. froggatti* Fletcher, but in this specimen, too, the throat is brown spotted." The colour of the throat, as remarked above, is a secondary sex character. It appears, also, from the series of specimens at hand that the inner digits on fore and hind feet are shorter on the whole, in the males than in the females, but this seems to be too variable for much reliance. It may be well to point out here that *C. froggatti* need not be confused with *C. laevis*. The differences, although not well defined, are numerous. *C. froggatti* is a smaller and more slender species. The heel of the male, carried forward along the body, reaches nearly or quite to the posterior angle of the mouth, while in *C. laevis* it generally falls decidedly short of this point. Forty-four sexually mature males of *C. froggatti* (collected near Healesville, Victoria) varied from 18 to 24 millimeters in length, averaging 22, and five females varied from 24 to 26, averaging about 24. Thus, each sex averages four millimeters shorter than the corresponding sex in *C. laevis*. The ventral black markings are smaller and more numerous than in *C. laevis*, and the whole lower surface tends to be more dusky. The sexual differences in the throat are less marked. The song of *C. froggatti* is entirely distinct. It may be written as follows: Cr-r-rack, cr-r-rack, cr-r-rack, pip, pip, pip, pip-pip-pip-pip-pip-pip-pip. The first syllables are pitched low; the "pips" are high pitched and increase in frequency after the first few. The note of *C. laevis* lacks the "pip" entirely. It is perhaps not unreasonable to regard *C. laevis* as derived from *C. froggatti* by an increase in size, an increase in distinctness of markings and in sex differences, and a dropping of the high-pitched repetition of the "pip" syllable in the song.

NOTES ON SOME MAMMALS FROM BASS STRAIT ISLANDS,
INCLUDING A NEW SUBSPECIES OF PSEUDOCHIRUS.

By A. S. LE SOUEF, C.M.Z.S.

Plate xxxvi.

Many of the islands of Bass Strait are, or were, inhabited by typical native animals. With the exception of the Wombat, however (*Ph. ursinus*) which is now probably extinct, and the Rufous-bellied Wallaby (*Thylogale billardieri*), not much was known about them, nor do they appear to be represented in any Australian Museum. Settlement with the introduction of other animals, attendant bush fires, and slaughter for the fur market are rapidly depleting the fauna. Bennett's Red-necked, and the Rufous-bellied Wallabies are still hunted for their skins on Flinders and adjacent islands.

Governor Hunter obtained a Wombat from King Island in 1798, while both Bass and Flinders observed this animal in subsequent voyages. Mr. J. A. Kershaw, Curator of the National Museum, Melbourne, found two flat skins in a settler's hut on Flinders Island in 1908, and inquiries indicated that the animal was still to be found alive. My correspondents in 1928 did not mention it among the species they knew, so I presume that the last of them has gone. In 1845 the ship "Herald" procured a wallaby (*T. billardieri*) and a Phascogale from Hummock Island.

In order to have the animals that still exist on the islands identified and placed in the Australian Museum for reference purposes, I enlisted the help of Mr. Russell Holloway and Mr. R. V. Blyth to procure specimens from Flinders and West Sisters Islands; Mr. Cecil Ryan, of Pioneer, Tasmania, was kind enough to obtain and send me some marsupial mice from Clarke Island. In all eleven species were procured in 1928.

From Flinders Island were secured Water Rat, Bennett's Red-necked, and Rufous-bellied Wallabies, Dark Rat-Kangaroo, Long-eared Grey Opossum, a new subspecies of Ring-tailed Opossum, and the Hairy Echidna. From West Sisters Island Rufous-bellied Wallaby, Short-nosed Bandicoot, Yellow-footed Phascogale. From Clarke Island Little Phascogale and the White-footed Pouched Mouse. In addition another species of Rat-Kangaroo, probably *Bettongia cuniculus*, a Native Cat (*Dasyurus viverrinus*), and an Opossum Mouse (*Dromicia*) are reported as still being seen occasionally on Flinders and Barren Islands. Rats and mice are said to be common, but none have been obtained.

It is interesting to note that Bennett's and the Rufous-bellied Wallabies, Little Phascogale, and the Echidna are Tasmanian in character. The Long-eared Grey Opossum and Yellow-footed Phascogale are typical of those on the mainland. The Water Rat, Rat-Kangaroo, Bandicoot and the White-footed Pouched Mouse are common to Australia and Tasmania, while the Ring-tailed Opossum is a new subspecies of the Tasmanian *Ps. cooki*.

Bennett's Wallaby, *Wallabia ruficollis bennettii* Waterhouse.

Three specimens obtained from Flinders Island show the brownish-grey coloration typical of the Tasmania subspecies. Dimensions from filled out skins:—

Measurements (Austr. Mus., No. M.4325). (A).—Head and body, 1080; tail, 750; hind foot, 215 mm.

Measurements (Austr. Mus., No. M.4444). (B).—Head and body, 870; tail, 675; hind foot, 180 mm.

Measurements: Skull (A).—Basal length, 123; breadth, 77; nasals length, 56; nasals greatest breadth, 17; central breadth, 14; constriction, 17; palate length, 70; breadth outside m², 40; inside m², 23; diastema, 38; basi-cranial axis, 40.5; basi facial axis, 90.5.

Rufous-bellied Wallaby, *Thylogale billardieri* Desmarest.

Several specimens from Flinders Island are very even in characters. They agree with those from Tasmania, but have the under parts buff, and the posterior part of the ear is of similar colour. The general colour above is blackish olive grey, with a yellowish hip stripe generally present, and a cinnamon wash on the inguinal region sometimes in evidence. The upper lip may show a lighter coloration. The skull and teeth are typical of the normal form.

Two were obtained from the West Sisters Island, north east of Flinders, one of which, a large male, shows marked variation from the ordinary type. In place of the usual woolly fur on the neck and fore quarters, it has short, spinous, adpressed hair, with definite colour markings over the shoulders and back of the neck. The hair on the throat, moreover, is directed forwards, and a marked whorl is present. The second specimen shows the stiff hair on the sides of the neck and throat only, and has no special markings. On comparing the former specimen with several obtained from Tasmania by Kendal Broadbent, two males show the special characters mentioned. In one of these the hair is longer. These were apparently collected with others of both sexes, which are of the normal type. The skull and teeth of these short-haired forms do not show any marked differences from *billardieri*. It would thus seem that old males of this species show a hitherto unrecorded variation, as shown in the plate and following detailed description (Plate xxxvi.) :—Hair a little coarser than normal condition, being short and spinous on the shoulders, chest, neck and throat. There is a marked ridge on the centre of the chest, from which the hair radiates forward to chin, but twisting to form a whorl on throat. General colour above dark brownish-grey, being a little darker on the dorsal region and slightly lighter on flanks. A marked slightly raised dark line runs from the crown to merge into the colour of the back, and extending round the back of the arms. Sides of the neck dark fawn (Brussels brown), and this colour is conspicuous on each side of the nuchal line. Head evenly coloured dark grey, with the exception of the line on crown. Ears same as head, margined posteriorly and basally with buff. Limbs like back, a yellow hip stripe present. Tail above evenly coloured like back, under surface covered with stiff light grey hairs. Chest and belly light buff (cartridge buff), throat cream-buff. Head and body 770, tail 450, hind foot 134, ear 49 mm. (filled out skin, No. M.4443) male.

A similar specimen from Tasmania, male No. A.5340, measures:—Head and body, 654; tail, 340; hind foot, 122 mm. (filled out skin).

Skull, No. M.4443, measurements:—Basal length, 103; breadth, 58; nasals length, 40; greatest breadth, 16; least breadth, 9; constriction, 15; palate length, 50; breadth outside m^2 , 29; inside m^2 , 20.5; diastema, 23; basi cranial, 35.5; basi facial, 68. This animal is aged.

Dark Rat-Kangaroo, *Potorous tridactylus* Kerr.

A specimen obtained from Flinders Island seems to be typical of the species occurring on the mainland and in Tasmania.

Head and body, 335; tail, 182; hind foot, 70; muzzle to eye, 47; ear, 35 mm. (filled out skin).

Ring-tailed Opossum, *Pseudochirus cooki bassianus* subsp. nov.

Two males and a female Ring-tailed Opossum from Flinders Island show a difference in coloration from the Tasmanian form of *Ps. cooki* which, though not supported by any marked cranial features, appears to warrant subspecific distinction.

General colour of back a shade of Brussels brown (Ridgway) with shining pale golden-brown hairs and longer brownish-black ones intermingled along the

centre of the back. One male has a greyish tone throughout the back, but not so marked or universal as in the typical form. Limbs and base of tail much lighter than in typical *cooki*, the limbs being cinnamon or light sayal brown above, and the tail cinnamon brown basally, as opposed to the much darker greyish to blackish brown of the Tasmanian form; the hands and feet are also of a lighter brown.

Variation.—One adult male has no trace of the normal cream-coloured fringe around the inner base of the ear present in the other specimens of both forms. The whitish ear mark is not bordered with blackish-brown above in the specimens of *bassianus* as in typical *cooki*.

The extent of the white tail-tip is very variable, in the Tasmanian specimens, ranging from $3\frac{1}{4}$ to $7\frac{1}{2}$ inches, having the dark part from about one-half to three-quarters of the total length of the tail; in Flinders Island specimens the white tip measures from $3\frac{1}{4}$ to $5\frac{3}{4}$ inches, the dark part being from half to two-thirds the length.

Skull.—Generally as in the typical form, a series of comparative measurements showing the dimensions of Flinders Island specimens to intergrade with the large specimen listed by Thomas and an Australian Museum specimen from Railton, Tasmania. The facial index appears to be consistent in being relatively somewhat longer in the Flinders Island form, ranging from 187.7 to 197, as opposed to 175-179.5 in the Tasmanian form.

Dimensions of the filled out skin of a male, holotype, Austr. Mus., No. M.4450:—Head and body, 355; tail, 305; hind foot, 53 mm.

Skull dimensions of allotype, female, Austr. Mus., No. M.4449:—Basal length, 58.3; greatest breadth, 35.4; nasals, length, 27; greatest breadth, 11.5; constriction breadth, 7; palate length, 35.7; ms^{1-3} , 12 mm.

Long-eared Grey Opossum, *Trichosurus vulpecula* Kerr.

A specimen from Flinders Island represents a variation known as the "Red Brush," as distinguished from the silver-grey variety also said to exist there.

The neck, withers, and flanks are a foxy-rufous; the dorsal region is grey with a blackish wash; arms rufous, shading into grey on the paws; chest and belly with a bright yellowish wash.

This form is similar to, but rather brighter in colour than, old males from Victoria, differing materially from the Tasmanian form.

Short-nosed Bandicoot, *Isodon obesulus* Shaw.

Two skins with skulls, obtained from West Sisters Islands, do not differ materially from typical specimens from the mainland or Tasmania. Measurements:—

Filled out skins, Austr. Mus., Nos. M.4451-4452.

(A).—Head and body, 330; tail, 109; hind foot, 54 mm.

(B).—Head and body, 404; tail, 123; hind foot, 52 mm.

Skull (B).—Length, 64; breadth, 31; nasals length, 29; nasals greatest breadth, 6; intertemporal breadth, 12; palate length, 41; breadth between outside corners, m^3 , 18; between inside corners, m^2 , 11; basi-cranial axis, 20.5; basi-facial axis, 44 mm.

Yellow-footed Phaseogale, *Phascogale flavipes flavipes* Waterhouse.

One male obtained from West Sisters Island has the hair soft, fine and adpressed; above evenly coloured brownish-grey, feet and under surface whitish. Head and body, 123; tail, 83; hind foot, 16.5; ear, 13 mm. Austr. Mus., No. M.4459.

The premolar teeth of this specimen do not show the marked disparity in size typical of the mainland form.

Little Pouched Mouse, *Phascogale minima* Geoffroy.

From Clarke Island, external characters quite typical of the species. Head and body, 124; tail, 76; hind foot, 18; ear, 12 mm. Austr. Mus., No. M.4342.

White-footed Pouched Mouse, *Sminthopsis leucopus* Gray.

One spirit specimen from Clarke Island while agreeing in colour and measurements with mainland type has the hair very long, dense and comparatively coarse. This variation is probably due to the colder climate. Head and body, 79; tail, 79; hind foot, 18; ear, 13 mm. Austr. Mus., No. M.4343.

Echidna, *Tachyglossus setosus* Geoffroy.

Four specimens from Flinders Island are the same as the Tasmanian form, except that the hair covering the body is more profuse, and the quills proportionately less visible. Second and third claw of the hind foot almost equal in length. Total length, including bill, 430; bill, 31; tip of muzzle to eye, 43.5.

Although the Tasmanian Echidna has hitherto been treated as a subspecies of the mainland form, *T. aculeatus*, its external characters are so different and so uniform that it is well worthy of specific rank. The furry covering of the mid back and the equal length of the second and third hind claw at once serve to distinguish. Total length, including bill, 430; bill, 31; tip of muzzle to eye, 43.5 mm.

 THE LIFE OF A NATIVE BEAR (KOALA) IN CAPTIVITY.

Readers of this journal (Vol. 3, p. 112) will no doubt remember a very interesting article by Mr. A. S. Faulkner, of Albany, Western Australia, relating the history of a Native Bear, which he had had in captivity for 8½ years. "Teddy" was a female cub, about three months old, taken in August, 1914, on the Proserpine River, North Queensland. After about a month's training in the ways of civilisation, she was transported by easy stages to Geraldton, Western Australia, a distance of nearly 4,000 miles. After three years at Geraldton, she was taken to Adelaide, and six months later to Albany, Western Australia, where I had the pleasure of making her acquaintance in 1921.

Mr. Faulkner writes under date 5th August last:—"Teddy has been taken from us, and we miss her sadly, particularly my wife, who adored her little pet. She came with us from Albany to Adelaide, carefully transported, as usual, but unfortunately during a particularly bad winter she contracted a severe chill, and although we did all that was possible she died of pneumonia in September, 1926, having lived in captivity in complete contentment for twelve years. We took her down to Mr. Minehin, at the Zoological Gardens, and asked his advice as to treatment, but he could do nothing to aid, although he was very sympathetic. Before leaving Albany, I had noticed that her teeth were very long and jagged, so I filed them down a little. Further, her coat had lost its lustre, and there was every indication of age. I think the change so late in life hastened her end."

This is a very good record, and shows that the Koala can be kept in captivity even under conditions involving extensive travelling, changes of climate, and diet. There is little doubt, however, that the personal element entered largely into the successful keeping of "Teddy." In Zoological Gardens, and places where individual care and daily attention are wanting, the Koala does not thrive in captivity.

A. F. BASSET HULL.

FURTHER ADDITIONAL FAUNA OF THE COMBOYNE PLATEAU,
 1926-1928.

By E. C. CRISHOLM, M.B., CH.M., R.A.O.U.

In my two previous papers I dealt with the fauna of the Comboyne Plateau, (Vol. iv., Part ii., and Vol. iv., Part v.), from 1923-26. In this paper I continue my observations to 1928. I have made a fairly comprehensive survey of the district, which is fast losing its former beauty, being nearly all cleared for farming. The opportunity to record its original fauna will never recur.

INVERTEBRATA.

INSECTA—ODONATA.

Austroplebia costalis. This handsome dragon-fly was only seen once.

ORTHOPTERA.

Archimantis latistylus. Not very common.

Caedicia olivacea. Very plentiful, especially seen about garden plants.

Extatosoma tiaratum. Rare.

Acrophylla (Vetilia) titan. Rare.

Anostostoma erinaceus. Found about decaying wood, but not often seen.

HEMIPTERA.

Scutiphora pedicellata. Not common.

Eurymeloides pulchra. Common on eucalypt saplings, attended by a small black ant, attracted by a sweet secretion produced by the insect.

COLEOPTERA.

Ceratoferonia phylarchus. Plentiful and found under decaying logs on the ground.

Hyperion schroetteri. Found under logs and occasionally flying into the house at night, attracted by light.

Rhantus punctatus. Only seen once.

Macrogyrus oblongus. One of the common water beetles, and seen in colonies on the creeks.

Aulonogyrus strigosus. Not so plentiful as the last and about half its size, measuring only about $\frac{1}{2}$ inch in length.

Leis conformis. Not very plentiful here, and of great value on account of its feeding on aphid; cleaning up the woolly aphid on the apple trees here.

Coccinella repanda. A much commoner form than the last.

Verania frenata. Only occasionally seen. Two other unidentified forms I have noticed attacking the rose aphid—one of a canary yellow with two broad wavy transverse black bands across the elytra, and a central black spot at the tail end. The other is biscuit coloured, with black bordered elytra and a transverse row of three black spots on each elytron, making a continuous line of spots about the centre. The larvae, as well as the adults, feed on the aphid, and clear up an infested plant very quickly.

Ophidius histrio. Occasionally seen on flowers in the garden.

Diphucephala aurulenta. Found occasionally on flowers.

Phyllotocus macleayi. Found in swarms on flowers in early summer and doing an immense amount of damage.

Phyllotocus marginipennis. Appears in swarms and is very destructive to garden flowers.

Eupoecila australasiae. Found several times on garden flowers.

Diaphonia dorsalis. Very active and seen frequently flying around and alighting on a flower.

Rhoptera marginicornis. In the early summer evenings appears here in loud humming swarms, and attacks flowers and foliage.

Scitula pruinosa. Appearing in swarms on summer evenings, doing a lot of damage to foliage.

Schizorrhina atropunctata. Rare.

Paropsis reticulata. Uncommon.

Paropsis liturati. Rare.

Aulacophora hilaris. Often seen.

Leptos gladiator. Comparatively plentiful. I have found it mostly on a mistletoe (*Phrygilanthus celastroides*).

HYMENOPTERA.

Myrmecia forficata. A soldier ant not seen on the basalt, but at the edges of the Plateau on sedimentary strata.

Myrmecia pyriformis. Also seen only at the edges of the Plateau.

Leptomyrmech erythrocephalus. Rather uncommon, and found on the basalt or mixed strata.

Scolia soror. Very plentiful in the summer months, feeding on the nectar of certain flowers. The cocoon is frequently ploughed up from the ground. It is a long oval, made of parchment-like material.

DIPTERA.

Plusiomyia gracilis. Fairly common during the summer months, and resting in shady places in the day time.

Scaptia pulchra. Only seen once.

Scaptia xanthopilis. Also rare.

Trichophthalma obscura. Not plentiful.

Asilus ferrugineiventris. Very plentiful.

Blepharotes splendidissimus. This is uncommon.

Sciapus pachygyna. Plentiful.

Xanthogramma grandicorne. Rare.

Sarcophaga tryoni. A species seen frequently on flowers and fairly common.

Rutilia (inornata?). Seen rarely.

SIPHONAPTERA.

Pulex irritans. The common flea is very prevalent on the basalt.

LEPIDOPTERA—RHOPALOCERA.

Danaida hamata. Locally rare; seen twice in early February this year.

Danaida affinis. This still rarer form I was fortunate to see twice this year, in January and March.

Hypolimnas nerina. Seen this year for the first time; many examples of both male and female seen in February and March.

Miletus delicia. Very rare here. I only saw it once: in early January this year.

Huphina scyllaria. Rare, seen once.

Catopsilia pomona. This year (1928) none were seen, but they were plentiful in January and February, 1927, the first and only time noticed here. Although they were flying across the garden all day, I never saw one settle on the flowers, in contrast to *C. gorgophone* and *C. pyranthe*, which frequently settled on them. I also had *Cassia sophera* growing there, which *C. pyranthe* frequently made use of for laying its eggs, but it apparently had no attraction for *C. pomona*.

Hesperilla picta. Occasionally seen in the brush.

Padraona flavovittata. Fairly plentiful and often seen on garden flowers.

Cephenes sperthias. The Palm Skipper. I expressed a doubt about seeing this form in my first paper (*Aust. Zool.*, iv., 1925, 59), but have since identified it. It is not often seen.

Euschemon rafflesia. Only seen once, in the month of January. It appears to be a rare form here, though its food plant *Wilkiea macrophylla* is plentiful.

LEPIDOPTERA—HETEROCERA.

Theretra latreillei. The larva feeds on *Colocasia macrorrhiza* (Cungevoil lily). Seen in February and March, but not plentiful.

Theretra oldenlandiae. I mentioned this in my first paper with a slight doubt about its identity, but have since verified its occurrence. It is uncommon. One of the food plants is the cultivated grape. Seen in February and March.

Theretra nessus. Only one seen, which I caught while feeding on nectar from *Penstemon* flowers.

Macroglossus errans. This is a comparatively rare species here, as I have only seen it a few times. It is extremely shy and difficult to take, and very quick in its movements.

Hippotion scrofa. Mentioned in my first paper (p. 60) under the name of *Chaerocampa scrofa*. Occurs here in two forms, with varying degrees of intermediate colouring between them. I have seen this species flying and feeding in bright sunlight, as also *H. celerio* and *Chromis erotus*.

Ardices curvata. Seen occasionally.

Chalciope hyppasia. Seen occasionally.

Plusia argentifera. Flies to light. Seen on summer evenings.

Plusia chalcites. Also flies to light. Feeds on tomato, potato, and other *Solenaceae*.

Phalaenoides tristifica. A rare moth here.

Cruria donovani. Occasionally seen. Both these last are day flying, the former feeding in the larval stage on *Epilobium glabellum*.

Cosmodes elegans. Frequently flies to light.

Antheta acuta. Occasionally seen as it flies in to the light.

Entometa australasiae. This species, the larva of which feeds on various species of *Acacia*, to which it does a considerable amount of damage, displays protective mimicry of a high order, especially in the larval stage. It is then with difficulty distinguished from the bark of the limbs upon which it lies, being of exactly the same colour. The moth itself also closely resembles a dried leaf. It is a night feeder in the larval stage.

Zenkenia recurvata. A small moth, flying by day, and found often on garden flowers.

VERTEBRATA.

REPTILIA—OPHIDIA.

Pseudelaps krefftii. A small snake found under logs and stones, two or three of which have come under my notice. The average length of those I have seen is about 14 inches.

LACERTILIA.

Lialis burtoni. A slow worm of nocturnal habit, and fairly common about rocky situations at the edge of the Plateau. It feeds on small insects.

Gymnodactylus platurus. I mentioned this in my second paper (p. 297) with a doubt as to its species. This has now been confirmed as definitely *platurus*.

AMPHIBIA.

Hyla gracilentata. Occasionally seen.

AVES.

Elanus axillaris. Black Shouldered Kite. This is rare here; I saw it only on one occasion in March, 1927.

Orthonyx temmincki. Spine-tailed Logrunner. Has in the past been fairly

plentiful, but owing to the destruction of the brushes, many have been destroyed, and others hunted away to more remote brushes. I had been on the look-out for this bird for a long time, and was rewarded last year in seeing a pair. It is a noisy bird when disturbed. It lives on the ground in the thick brushes.

Cinclorhampus cruralis. Brown Song Lark. Only one bird seen.

Stomiopera unicolor. White-gaped Honeyeater. This species was seen once by me in my garden at close quarters. I saw it first settle about 60 yards away, and was puzzled as to its species, though I guessed it to be a honeyeater from its flight and shape. It finally flew on to a *budleia* blossom, within 17 feet of me (measured distance), and remained there in an exposed position long enough for me to study it thoroughly. I had the field glasses on it in the first instance. Two outstanding features about it were its conspicuously white gape, and the other its uniformly grey colour. I recognised that it was a new species to me. The only species with a conspicuous white or pale yellow gape known to me is *Meliphaga lewini*, the common honeyeater of the brushes, and known to me for over 40 years. I immediately consulted authorities, and found that *Stomiopera unicolor* fitted it exactly in description. A few weeks after this I looked *S. unicolor* up and handled it at the Australian Museum, and recognised the bird I had seen here at once. I am giving these details in full, for I am fully aware that my statement may be doubted. It would seem extremely improbable that a bird whose known habitat is in the gulf country of Queensland and the extreme north of Australia, about 1,000 miles distant, would be seen so far south. This bird was seen by me on February 2, 1927. It was solitary.

Carduelis elegans. The English Goldfinch. In my second paper (*Aust. Zool.*, iv., 1926, 295) I stated that this bird was reported as having been seen, but that I had not met with it personally. The record is now verified, as I saw a pair two or three times in May this year in my garden. This and the starling, *Sturnus vulgaris*, are the only two introduced birds here, *Passer domesticus*, House Sparrow, not having made its appearance to this date (July, 1928).

MAMMALIA—MARSUPIALIA.

Acrobates pygmaeus. Flying Mouse or Feather-tail. I mentioned this as occurring here in my first paper (*Aust. Zool.*, iv., 1925, 72). Lately I had a dead specimen sent to me which had been killed after the tree in which it had its home had been felled. This animal measured 5½ inches in total length, of which the head and body were 3 inches, and the tail 2½ inch. It weighed ⅓th of an ounce. The general colour is blue-grey above and creamy white beneath. Tail flattened, edged with long hairs, giving it the appearance of a feather, hence one of its vernacular names. The tail is almost devoid of hair underneath. The anterior half of the ear is grey, the posterior half being white, with a black mark in front of the eyes. The width of the body, which is considerably flattened, was one inch, and with the flying membrane 1¾ inch when at rest.

CHEIROPTERA.

Nyctophilus timoriensis. Probably fairly common.

My thanks are due to Dr. C. Anderson and members of the staff of the Australian Museum, to Dr. G. A. Waterhouse and Mr. George Lyell, Dr. Mackerras and the late Dr. E. W. Ferguson for the identification of many forms.

ERRATUM. In my second paper, "Additional Fauna of the Comboyne Plateau" (*Aust. Zool.*, iv., 1926, 295-8), p. 297, line 5 from the bottom, read "Canines" for "Cavities."

STRANGE MOLLUSCS IN SYDNEY HARBOUR.

By TOM IREDALE.

(By Permission of the Trustees of the Australian Museum.)

Many years ago, before the huge seaborne traffic that now traverses Sydney Harbour had developed, keen naturalists searched the many coves and inlets, that are now unrecognisable through masses of wharfage. Then Woolloomooloo was a happy hunting ground, its low muddy foreshore presenting a rich field of exploit for the marine zoologist. To-day, amazement would momentarily paralyse one of those old searchers could he revisit the scene of his former triumphs. In other classes the same story may be true, but I deal here only with molluscs, as an interesting phase of molluscan history has been revealed these past few weeks.

Included in our List of New South Wales Mollusca there appears quite a number of species with which present-day collectors are more or less unfamiliar, yet the early records seemed unimpeachable. During the last five years quite a lot of collecting has been done, the beaches being regularly searched and the Bottle and Glass Rocks in the Harbour being often visited. Mr. Melbourne Ward has also dredged quite often on the Sow and Pigs Reef, searching for crustacea, but never neglecting molluscan finds. A wonderful field was opened up in Gunnammatta Bay, Port Hacking, where the same conditions exist to-day as were observed by our predecessors in Sydney Harbour. A survey of that locality provided a great deal of important information as to the habits and occurrence of many species, especially with regard to Tectibranchs.

The present essay will however deal with a feature of the Sydney Harbour fauna hitherto unsuspected. Last month (January) when engaged in the study of the Harbour Pile Pests in connection with the Harbour Trust Authorities, a visit was made, through the thoughtfulness of our co-worker, Mr. Roy Johnston, to the Dredge "Triton," a well known object to every traveller across the Harbour. The Master, Captain Comtesse, had been found to be interested in molluscs, and had been collecting the attractive forms brought up by the dredge while working. A very large number of shells was inspected on the dredge, and to my surprise several tropical species were recognised. The Captain then made available his treasures, with almost bewildering results, as more than twenty species were found to have been previously unrecorded for New South Wales, and as many more were only known from odd specimens collected on the far northern beaches of the State.

The most amazing feature of this discovery is the prominence of a strong tropical element of which previous odd reports had met with some distrust. Thus Hedley, after many years' study of this fauna, wrote: "Tropical forms such as *Bonellia* incessantly attempt to colonise our coast, when the Notonectian floods the port, these gain a footing, but perish when the stream swings off shore. *Strombus lukuanus*, a common and conspicuous shell on coral reefs was once abundant at the Bottle and Glass rocks. Then it disappeared from May, 1865, till April, 1896, when it again made its appearance. A living specimen of the tropical *Bursa mammata* Bolten (= *venustula* Reeve) was found alive in the Harbour by T. Rossiter, but, in the forty years that have since elapsed, it has not once been seen again." (Journ. Proc. Roy. Soc. N.S.W., xlix., p. 27, 1915).

In the Comtesse collection, not only were there many *Strombus lukuanus*, but also other unrecorded species of *Strombus*, and, though *B. mammata* was not included, I anticipate seeing it very soon.

It may be emphasised, in view of Hedley's conclusion, that all the species recognised appear to possess swimming larvae, but probably most are permanent residents.

As Captain Comtesse is most enthusiastic, I confidently expect to record many more novelties from this source, some more species having come to hand since the beginning of this note.

Since the preceding was written a day has been spent on the Dredge "Triton," when a bewildering mass of shells and sand was examined. As a load weighed 1,250 tons and was some thousands of cubic feet in extent, very little was critically tested, four bucketsful being washed and sorted. Sufficient was seen to understand the collection of any species in quantity was a matter of time and patience, many varieties being secured by me in the one day, while shells hitherto regarded as uncommon were seen in hundreds, in abnormal size. However, quite recently Captain Comtesse has dredged up two valves (not a pair) of *Hippopus hippopus* L., and this in connection with the other records leads to the suggestion that we may be here dealing with a relict fauna, a reminder of the times when Sydney Harbour enjoyed a tropical climate, a supposition that has often been confidently put forward from geological studies, but the time required from such data has always referred to an age much previous to the apparent age of the present collection of mollusca.

VEPRICARDIUM PULCHRICOSTATUM gen. & sp. nov.

Plate xxxvii., figs. 4-5

One of the largest and most attractive of the shells found on the beach at Caloundra (Austr. Zool., vol. iv., pp. 331-336, 1927) is commonly known as *Cardium multispinosum*. A couple of very fine valves in the Comtesse collection were notable on account of the heavy prickly sculpture, a feature rarely perfect on the Caloundra shore shells. The original reference given by Hedley is to Sowerby, Proc. Zool. Soc. (Lond.), 1840, p. 106; then to Reeve, Conch. Icon., vol. ii., pl. 2, fig. 10, 1844. The species came from the Philippines, and was described as having thirty-three ribs, sharply angled on both sides, with a larger variety having twenty-four to twenty-eight ribs. Our shell is very much larger and has thirty-eight to forty ribs, which are rounded, not angulate.

Shell very large, subcircular, obese, beaks central, almost touching, lunule large, oval, smooth, escutcheon elongate, smooth save growth wrinkles.

Colour pale cream, suffused with rose pink towards the margin.

Sculpture consists of thirty-eight to forty elevated narrow ribs, separated by narrower deep gutters, which are apparently smooth in this juvenile state, but show cross latticing through growth lines in the adult; the ribs are rounded and bear scalloped prickles, the hollows facing the apex, closely set, missing on earliest portion of shell (beach worn shells usually have most missing); on a central rib thirty-two scales remain, another thirty-two scars, which are crescent shaped, can be counted and then the apparently smooth area would easily carry as many more.

Inside white showing the rib sculpture and margins deeply denticulate.

Height: 80 mm.; breadth, 75 mm.

Habitat: New South Wales and South Queensland.

It is necessary to introduce a new generic name for this species, as it is quite unlike the type of *Cardium* (a Palaearctic species, *aculeatum* Linné, has often been wrongly cited) the bizarre *C. costatum* Linné. The present species has been classed with the Palaearctic *aculeata*, but it does not appear to have any real relationship with it.

NOTOCALLISTA LAEVIGATA Sowerby.

An excellent figure portrays a shell common at Caloundra, South Queensland, and which is also found in Sydney Harbour, and present in the Comtesse collection. This figure (Thes. Conch., vol. ii., p. 738, pl. clix., figs. 156-158) was included by Hedley in the synonymy of *Marcia nitida*, and when I wrote about these things (Proc. Linn. Soc. N.S.W., vol. xlix., p. 210, 1924) I allowed it but without con-

fidence. I suggested Sydney as Strange collected it, but now indicate Moreton Bay, whence Strange sent many shells and where it is very common. The name must be eliminated from synonymy, and added to our List as the correct name for the northern species confused with the southern *disrupta*, which differs in shape and size and occurred at Twofold Bay, as recorded.

PROXICHIONE MATERNA gen. & sp. nov.

Plate xxxvii, figs. 2-3.

The magnificent shell called by some the Mother Cockle (Austr. Mus. Mag., vol. ii., p. 287, fig. in text, 1925) differs from the West Australian shell which was called *Venus laqueata* by Sowerby (Thes. Conch., vol. ii., p. 706, pl. cliii, fig. 15) in shape and sculpture.

Shell very large, inequilateral, crass, lunule distinct, anterior margin short, posterior prolonged rather truncate, lower margin of medium convexity. Colour dirty brownish cream when alive, paler when dead. The sculpture consists of well developed lamellae, closely set, recurved and finely crenulated on edge, crenulations becoming strong frills at each side. The early whorls show fine linear longitudinal striation, but this disappears as the shell grows, only the wrinkling on the lamellae indicating its former presence, and a weak concentric striation taking its place. On a large shell seventy well marked lamellae can be counted, the many smaller ones near the umbones not being taken into the count. The lunule is narrowly heart shape and longitudinally closely wrinkled, as is the distinct elongate escutcheon: the margins of the whole shell are very finely denticulate. Internally the shell is white, the muscle scars large and distinct, the pallial sinus short and subangulately rounded. The hinge teeth are very strong, the middle left markedly bifid, with a conical left anterior lateral; not grooved.

Height: 85 mm.; length, 113 mm.

Habitat: Sydney Harbour, living in mud from below low water to five fathoms.

This species does not agree well with any of the named groups and is perhaps restricted to southern Australia, and moreover this Cockle appears to be the largest of its kind in Australia.

PARATAPES POLITA Sowerby.

This name must replace *Paphia semirugata* of Hedley's List. The species was admitted through a note by Smith (Zool. Res. Challenger, vol. xiii., p. 115, 1885) who wrote: "*Tapes polita* of Sowerby (Thes. Conch., vol. ii., p. 682, pl. cxlv., figs. 15-16, 1852) is merely the younger state . . . his specimen is said to have been dredged near Sydney, at a depth of 6 fathoms, on a mud bottom."

The species appears in the Comtesse collection, but otherwise it was not in this Museum from New South Wales. Queensland specimens differed in shape and colouring, and apparently sculpture, and are nearer the true *semirugata* Philippi (Zeitsch. für Malak., 1847, p. 88; Abbild. Beschr., vol. iii., pp. 24-76, pl. 7, fig. 4, 1848), but as that was from unknown locality that identity is not even certain. *Paratapes* was proposed by Stolickza (Cret. Pal. India, p. 144, 1871) to replace *Textrix* Romer, preoccupied, the type being *Venus textile* Gmelin.

TALOPIA MORTI sp. nov.

Plate xxxvii., fig. 9.

Included in the New South Wales List there is a rare shell known as *Monilea lentiginosa* A. Adams, which was described (Proc. Zool. Soc. (Lond.), 1851, p. 188, 1853) from the Island of Panay, Philippines. As Trochoids generally have limited distribution this record was viewed with suspicion, and when the opportunity was offered me of collecting a series on the beach at the Daintree River, North Queensland, it was greedily grasped. My reward came when I found in the

Comtesse collection many specimens of the New South Wales shell which obviously differed at the first glance and is here described.

Shell elevated trochoid, whorls slightly shouldered; mouth a little oblique, subcircular, umbilicate.

Colour pale creamy buff, obscurely flamed longitudinally with brown. Sculpture consists of spiral lirae with faint longitudinal striae; the apical whorls minute, smooth, the succeeding whorls (six in number) bearing spiral lirae which are developed in pairs, set very close together, a narrow interval intervening before the next pair; the subsutural pair being less pronounced, about four on the earlier whorls, six pairs on last whorl, where longitudinal threads may be seen; the longitudinal sculpture begins as strong slanting threads which decrease in importance as the concentric lirae strengthen, but persist as a subrenulation even to the last whorl where the threads may be still seen on the base.

Columella curved, anteriorly truncate and medially developing a nodular projection into the umbilicus from which a rib proceeds internally; a slight glaze connecting the posterior end of the columella and the outer lip.

Umbilicus of medium width, perspective, lower edge lirate, internally smooth.

Aperture subcircular, outer lip sharp, strongly grooved, internally, agreeing with the external sculpture.

Height: 24 mm.; breadth, 24 mm.

Habitat: New South Wales and South Queensland.

This species is named in honour of Mr. H. S. Mort, an enthusiastic Sydney conchologist.

It will be as well here to describe the North Queensland species.

TALOPIA DIVIDUA *sp. nov.*

Plate xxxvii., fig. 10.

Shell smaller than the preceding, more depressed, sutures less marked; whorls more flattened, with less shouldering.

Colour similar, but flames less notable, general hue darker.

Sculpture of like nature, but stronger longitudinal threads traverse the spirals and cut them into ill-defined nodules; the twin lirae are not so well developed and would not be noticed on the base without special search; the general appearance of the shell suggests obscure nodulation, whereas in the southern species the lirae strongly predominate; the columella is a little shorter and more curved; the umbilicus narrower.

Height: 14 mm.; breadth, 17 mm.

Habitat: North Queensland; type from Daintree River mouth beach.

FAMILY NATICIDAE.

The members of this family are very interesting molluscs and apparently there are many more species than have yet been commonly accepted. With regard to the tropical fauna, I will have some interesting facts to record and these introduce the matter of *Natica filosa* Reeve, which appeared in Hedley's List as *Polinices filosus*. One of the last pieces of conchological research published by Hedley was concerning the Queensland forms, with horny operculum previously classed with *mammilla* L. Using the genus *Uber*, Hedley showed that *mammilla* L. must be restricted to the West Indian form; he then indicated three sections for which names were available as *Mammilla* Schumacher (Essai. nouv. Syst. vers. test, pp. 58-190, 1817) for *M. fasciata* = *Uber mammatum* Bolten. Regarding Reeve's *filosa* as identical, this name would replace that on the N.S.W. List. Specimens in the Comtesse collection show the Sydney shell to differ from the North Queensland shell, which agrees better with the Boltenian species, and to come between

siniae Deshayes and *simioides* Recluz (from Fiji), and may be called *propesimiae* nov. (plate xxxviii., fig. 5).

BARTSPIRA (ALOCOSPIRA) DYSPETES *sp. nov.*

Plate xxxviii., fig. 12.

Dealing with Twofold Bay shells, I added *A. marginata* var. *tasmanica* Ten-Woods to this fauna, but since then Master Consett Davis brought me in shells from Austinmer and Bulli, on the South Coast, which were of this association, but differed appreciably.

Angas recorded *A. marginata* from Sydney sixty years ago, and this record was rejected by Hedley, but in the Comtesse collection appeared a shell which might easily be mistaken for the southern species, but is here described.

Shell medium, mouth open, a little obese, spire very short, attenuate.

Colour white, post sutural band yellow, as is an anterior canal.

Apical whorls two rounded, adult whorls five, nearly smooth, a medial indistinct spiral lira only present, half a dozen grooves on the base.

Inner lip spread as a glaze, extending up and past the aperture to the previous whorl.

Length: 22 m.; breadth, 12 mm.

Habitat: New South Wales (Sydney Harbour, type). Austinmer, Bulli.

CANCELLARIA UNDULATA *Sowerby.*

A few years ago I wrote: "Sowerby's name was given to a Tasmanian shell, but the Sydney form does not appear to differ much from the specimens so far studied." This is a good instance of the value of extensive material, as a little later I was able to collect large series, and upon handling them in numbers the Sydney shell was seen to be larger, comparatively narrower and with fewer broader longitudinal ribs. These are apt to disappear on the last whorl, eleven indistinct ones against the same number well-defined ones on the antepenultimate.

In order to provide a new generic name, *Sydaphera*, for this group, the Sydney shell is taken as type and named *Sydaphera renovata* *sp. nov.*, the figure being taken from one of Comtesse's shells, not by any means the largest, though measuring 37 mm. x 20 mm. Plate xxxviii., fig. 3.

PERIRHOE MELAMANS *sp. nov.*

Plate xxxviii., fig. 7.

A magnificent Terebrid of tropical aspect caught the eye, and in the Australian Museum was found a similar shell labelled "Port Stephens," but the record had not been accepted as the species appeared alien. Bartsch unfortunately published A Key to the Family Terebridae (Nautilus, vol. xxvii., pp. 60-64, 1923) which must be referred to, but it is an unenviable task. He there introduced *Terebrina*, new subgenus, with type *Terebra cingulifera* Lamarek, for species having the spiral lines punctate, *Perirhoe* having the spiral lines not punctate. *Terebrina* had been introduced into conchological literature more than one hundred years before by Rafinesque (Anal. Nat., p. 145, 1815; Cf. Iredale, Proc. Mal. Soc., vol. ix., p. 262, 1911), so I propose a new subgeneric name for the present species, *Dimidacus*.

Shell narrowly elongate, creamy fawn.

Nuclear whorls missing. Adult whorls remaining twenty in number.

Whorls flattened, encircled by four linear grooves, which are punctate; the first groove cuts off a broad subsutural collar, the second marks off a less space, the succeeding two still less, being closer together. A longitudinal striation cuts earlier whorls a semi-nodulose design, the collar showing it most, but even this soon loses strength, and the later whorls only show very obscure indications, while even the punctuation in the grooves becomes less distinct. The last whorl shows

a broad rounded peripheral band, succeeded by nine or ten closely set punctate grooves.

Outer lip thin, sharp, basally rounded, forming with the anterior twist of the columella a short slightly recurved open canal. Columella with a scarcely noticeable anterior fold, the inner lip showing as a slight glaze continued on the body whorl to the posterior edge of the outer lip.

Length: 75 mm.; breadth, 14 mm.

Habitat: New South Wales (type, Sydney Harbour), Port Stephens.

COLUS SINOVELLUS sp. nov.

Plate xxxviii., fig. 15.

The Comtesse collection included a species of *Colus* which was obviously not the southern *C. novaehollandiae* in any form, but was of tropical aspect. It did not agree with the species known as *turrispictus* Martyn, which was included in Hedley's Check List, nor with specimens so determined from northern New South Wales.

Shell small, regularly fusiform, whorls with slight sloping shoulder, apex missing, seven adult whorls remain, canal long, open, and nearly straight, slightly sinuate.

Colour pale brownish white, marked longitudinally with darker brown markings.

Sculpture consists of spiral lirae, over-ridden by longitudinal ribs, which are more pronounced on the earlier whorls, and fade away on the last whorl. On the antepenultimate whorl about thirteen ribs may be counted, and on the preceding whorl the same number crossing about twelve cords, which are weak on the shoulder below the suture and strongest on the periphery.

Inner lip curved, with a mere callus, outer lip thick, but not varicose.

Canal very long, narrow, sinuate, nearly straight.

Length: 85 mm.; breadth, 31 mm.

Habitat: New South Wales (Sydney Harbour).

COLUS CONSETTI sp. nov.

Plate xxxviii., fig. 19.

A small *Colus*, quite unlike the southern *novaehollandiae*, and strongly recalling the West Australian *philippi*.

Shell small for the genus, whorls shouldered, apex missing, canal bent, long and open, rather solid, but translucent, with a short brown periostracum.

Colour: white spotted with brown.

Adult whorls seven, first corded with seven ridges, anterior three smaller, median two a little stronger, succeeding two not quite so strong; with age the median two become more pronounced, the preceding three on the shoulder less marked, and the succeeding two, sometimes with an intervening third, nearly as strong as the peripheral pair. As the periostracum wears off these are seen to be boldly marked with brown red spots, and sometimes lines of spots are observed. On the last whorl below the shoulder half a dozen strong cords can be counted, more than a dozen more succeeding along the canal and inner lip.

Canal long, open, longer than in the specimen figured, which has the canal broken.

Columella smooth, but sculpture shows through fine glaze of inner lip.

Length: 62 mm.; breadth, 28 mm.

Habitat: New South Wales. All specimens collected by Master Consett Davis, after whom the species is named.

FAMILY MITRIDAE.

The members of this family are in such systematic confusion that recognition of more novelties for New South Wales is not exactly welcomed. It necessitates the criticism of many species scattered without any recent attempt at order, and therefore the classification here used may require alteration in the near future. *Mitra* has been restricted to the forms about *tessellata* Martyn, the genus dating back to that origin. Therefore I introduce

CHRYSAME LEMMA *sp. nov.*

Plate xxxviii., fig. 6.

Shell small for the family, obtusely fusoid, aperture about equal to spire, canal short and broad.

Colour cream blotched with red brown.

Apical whorls missing, nine adult whorls remain.

Sculpture consists of narrow flattened encircling cords with broad interspaces, sometimes twice as broad as cords; sutures appressed; on the last whorl fifteen cords can be counted; on the antepenultimate five, on the two preceding four each, the earlier two three each; a microscopic longitudinal striation is clearly seen between the cords on the earlier whorls, but becomes obsolete on the later ones.

Columella five-plaited, the anterior one very small.

Outer lip strongly roundly erenately thickened; aperture narrow, canal short and broad.

Length: 32 mm.; breadth, 14 mm.

Habitat: Sydney Harbour, New South Wales.

Apparently related to *Mitra crassa* Swainson, and *M. ferruginea* Lamarck, but not specifically identical, being shorter and narrower and differently coloured from the first, more like the latter. This may be classed in the genus *Chrysame* as above mentioned, but when Dall showed Martyn's usage to be the earliest recognisable, he proposed *Papalaria* (Bull. U.S. Nat. Mus., No. 90, p. 60, 1915) for "the red-spotted Mitras"; he overlooked Rafinesque's *Mitraria* for *Mitra* Lam., which was the same thing, while Melvill, with the custom of his time, used *Eumitra* as a subgeneric name for the typical Mitres of his recognition, i.e., the "mitra" group. Under a recent nomenclatural ruling of the International Commission a lot of confusion can be caused by reviving curious interpretations of generic usage, as in the present case.

VICIMITRA PROSPHORA *gen. & sp. nov.*

Plate xxxviii., fig. 17.

Roy Bell dredged a number of Mitres which interested me and I could not easily determine them, but found they had been determined as *Mitra solida* Reeve. As mentioned above, this is a difficult group, and I allowed them to pass as that. Again meeting with the species in the Comtesse collection, I re-investigated the matter, and found that, although there was a superficial resemblance, the Sydney shell differed in sculpture, and as Reeve's species was from unknown locality I describe the Sydney species as above. The genus name is necessary, as the species does not agree with any of the ordinary named groups, and Cooke has shown from a study of the radulae the discordant elements classed as "Mitra." Peile (Proc. Mal. Soc. (Lond.), vol. xv., p. 93, fig. 1, in text, 1922) has figured the radula of the species here described under the name *M. solida* Reeve.

FAMILY STROMBIDAE.

As heretofore noted the occurrence of *Strombus luhuanus* in Sydney Harbour has been cited as a classical instance of the migration of tropical species to our locality. Years ago when *S. luhuanus* was first collected here, another species, *S. floridus*, was found living alongside. When *S. luhuanus* was rediscovered the

second species was still missing. The late G. McAndrew, however, sent both species from Shellharbour, many miles south of this place.

In the Comtesse collection were quite a few examples of *S. luhuanus*, but with them half a dozen of an entirely different species and an odd one of still a third, *floridus* not being yet observed.

I have prepared a Review of the Australian Strombs in which essay complete details will be given concerning the history and classification of all the Australian species.

Here may be recorded the names to be used for the New South Wales species: thus *Conomurex* Fisher must be the generic name for the *luhuanus* group, and *Canarium* Schumacher for the *floridus* form. This appears in Hedley's List as *urceus* Linné, but is the species referred to as *floridus* Lamarek and which should bear the earlier name of *flammeum* Link.

The species Hedley determined as *ustulatus* Schumacher is the true *urceus* Linné, and the odd specimen is referable to this species. There are several forms or species ranging about *urceus* Linné, so that if series can be collected the name may need emendation.

The half dozen shells agree very well with *Strombus dilatatus* Swainson (Zool. Illus., 1st ser., vol. ii., pl. 71, October, 1821) (no locality) whose name was changed, on account of a prior (?) *S. dilatatus* Lamarek, by Reeve to *S. swainsoni*. Lamarck's name was, however, later in date (Hist. Anim. s. Vert., vol. vi., pt. 2, August, 1822). Kobelt recorded this species from New Caledonia, and Shirley introduced it to the Queensland fauna. Shirley's records are worthless, but the species really occurs there, as Mr. Melbourne Ward collected it on the beach at Friday Island, Torres Straits. It belongs to the *succinctus-epidromis* series for which Oostingh (Medel. Landb. Wagen. (Ned.) Deel., 29, 1, p. 58, 1925) has provided the genus name *Labiostrombus*, *succinctus* being designated as type.

DISTORSIO RETICULATA Bolten.

Plate xxxviii., fig. 2.

The first astonishing shell I noted was the species known as "*Distorsio cancellinus*," but the correct name of which appears to be *Distorsio reticulata* Bolten (Mus. Bolten, pt. ii., p. 133, 1798, based on Martini, 2, t. 41, fig. 405, 406, from I. Hïtoe, one of the Molluceas). Three specimens in various stages of growth were in the Comtesse collection, and a genus as well as a species is added to the New South Wales List. Perry (Conchology, pl. x., 1811) proposed a new genus *Distorta* with two species *D. acuta* and *D. rotundata*, the latter being the well known *D. anus*, the former given as "a native of New South Wales." Unfortunately it is not the present species, but is the American shell named *Triton clathratum* Lamarek (Expl. Liste, p. 4, 1816, for Ency. Meth., pl. 413, fig. 4a-b) which name it anticipates. Moreover, Bolten had proposed *Distorsio clatrata* (sic) for an undescribed variety of *Murex anus* Gmel., and this would invalidate Lamarck's name.

FAMILY SCALIDAE.

In Hedley's Check List *Scalaria perplexa* Pease (Amer. Journ. Conch., vol. iii., pt. iv., p. 268, April 2, 1868) was included, apparently on the figure given by Lankavel and Martens. Pease, however, described the species from Hawaii, with 9-10 varices, aperture abbreviately oval; dark brown at the sutures, rarely the whole space between the varices coloured dark purplish brown and dimensions given as 32 x 13 mm. The New South Wales shell, so named, differs in proportions, being 36 mm. x 11 mm., has never any colour and has twelve or thirteen varices and may be named *Scala perplicata* sp. nov. In the Comtesse collection were some beautiful shells which agreed with other in the Australian Museum collection determined as *S. alata* Sowerby (Thes. Conch., vol. i., p. 84, pl. xxxii., figs. 10-11, 1844, Luzon), but which differed in form and sculpture, being much

more unrolled and having ten varices instead of eight. I here name the Sydney shell figured (pl. xxxviii, fig. 14) *Scala parspectiosa* sp. nov.; the type measures 21 mm. by 14 mm. broad.

CYMATIUM PYRUM Linné.

One of Hedley's last molluscan notes was the addition of this species (Proc. Linn. Soc. N.S.W., xlviii., 1923, p. 311) to the Australian fauna. Captain Comtesse has now brought in a specimen which agrees best with this species, though it shows a little variation. With it were specimens of the species included by Hedley as *C. exaratum* Reeve (Conch. Icon., ii., pl. 13, fig. 50, 1844) which was described from Port Essington; while some shells agreed fairly with Reeve's figure: others varied appreciably and may be the basis of the record of Reeve's *gemmata*: such may be called *zimara* (Plate xxxviii., fig. 11). Another interesting addition is the species known as *C. chlorostomum* Lamarck (Hist. Anim. s. Vert., vol. vii., p. 185, 1822) described from "l'Océan des Antilles." It does not much matter whether this species came from the West Indies or not, as there is an earlier name *Tritonium nicobaricum* Bolten (Mus. Bolten, pt. ii., p. 126, 1798) based on Martini, 4, t. 132, figs. 1246-1247 (Nicobar Is.) which is apparently the shell under notice, though here again a little variation from the tropical form can be seen.

FAMILY TONNIDÆ.

In Hedley's Check List, 1918, p. M.68, there appeared *Tonna perdix* and *T. variegata*. Later, Hedley reviewed the family, and, rejecting the former from the New South Wales fauna, determined the latter as a new species *T. cerevisina* and added another new species *T. tetracotula*, and another named species *T. cumingii* (Rec. Austr. Mus., xii., p. 329, et seq., 1919). A trawler brought in a specimen of the *perdix* type from off Botany, and as the specimen was in poor dead condition I was included to disallow it, but in view of the Comtesse collection it must be reinstated. Among Comtesse's shells, not only were *T. cerevisina* and *T. cumingii* not rare as small specimens, but there was a dwarf of *T. tetracotula*, an absolutely unexpected species, and still more extraordinary, a stunted "*Dolium pomum*." This is quite a delightful addition and allows rectification of the genus name to be used. For some years *Malea* was used as the species (*pomum*), obviously was generically separable from either the type of *Tonna*, *galea* Linné, or of *Cadus* Bolten, *perdix*, and I had anticipated using *Cadium* Link., but, in order to preserve *Malea* for his American shells, Woodring (Carnegie Publ., 385, p. 311, 1928) has designated *perdix* as the type of *Cadium* also. *Malea*, however, is not applicable to *pomum*, as its type species (*latilabris*) is just as definitely not congeneric, as either of the "*Tonnas*" with unarmed mouth. It becomes, therefore, necessary to introduce a new generic name *Quimalea*, naming *pomum* Linné as type.

The case of the Linnean species *Buccinum perdix* requires consideration, as forms are found in the West Indies, as well as in the Pacific Ocean, and these are certainly distinguishable. The Linnean species name should be restricted to the former, and Blainville's name *rufum* used for our species, which is not uncommon in the Capricorn Group, so that the additions would read: *Cadus rufus* Blainville, and *Quimalea pomum* Linné. The specific references would read:—

Dolium rufum Blainville, Dict. Sci. Nat. (Levrault), vol. 54, p. 503, 1829; type locality "Australasie" = Queensland.

Buccinum pomum Linné, Syst. Nat., xth. ed., p. 735, 1758; type locality, here selected, Amboina, from Rumph. Mus., t. 27, fig. B.

Shell of medium size for the family, regularly fusoid, aperture and spire about equal, rarely the spire a little longer, sutures impressed.

Colour of dead shell, pale creamy buff with a few white spots below the sutures.

Apical whorls missing, nine adult whorls present, the earlier ones sculptured with three or four flattened, faintly crenulated, lirae with narrow interstices; the crenulations vanish first, the lirae becoming less marked and the interstices apparently finely punctate; on the whorl preceding the penultimate only five faint lines appear and on the next these are scarcely recognisable, a couple near the shoulder being most prominent; the last whorl still shows this pair, but the rest of the body whorl is practically smooth, half a dozen faint lines reappearing on the base.

Columella four plaited, plaits strong; inner lip reflected as a heavy glaze, which crosses the body whorl to the outer posterior angle of the lip. Outer lip thickened, sharp, smooth inside. Canal short, broad, open.

Length: 46 mm.; breadth, 17 mm.

Habitat: New South Wales (Sydney Harbour, type).

Reeve's species is much larger and the cancellation of the upper part of the whorls near the sutures is missing in our species; the youngest shells show a slight longitudinal striation, but none of the older ones; Reeve wrote: "Columella five-plaited"; in the present species four plaits can only be counted; only a faint indication of a fifth in immature shells; otherwise the coloration and form of Reeve's *solida* recall this species, but Melvill has recorded *M. solida* Reeve from the Persian Gulf.

MITROPIFEX QUASILLUS gen. & sp. nov.

Plate xxxviii., fig. 18.

Shell elongately fusiform, spire twice as long as aperture, canal long and narrow, whorls flattened, sutures impressed.

Colour (dead shell) reddish fawn, a white band encircling the periphery (living shell reddish brown).

Apical whorls missing, eleven adult whorls remaining, sculptured with narrow sinuous longitudinal ribs, the interstices a little wider than the ribs; the inter-spaces are spirally lirae, these lirae showing spaces a little narrower between. There are twenty ribs on the last whorl, the encircling lirae being about twenty, while on the antepenultimate whorl just the half dozen, seen above the periphery of the last whorl, can be counted, the longitudinal ribs being reduced to twenty and so on up the spire.

Aperture small, narrow, canal lengthened, narrow, outer lip thin and sharp.

Columella with three strong plaits, a fourth anterior one scarcely visible.

Inner lip reflected as a thickish glaze, continued across to the corner of the outer lip.

Length: 31 mm.; breadth, 11 mm.

Habitat: Sydney Harbour, New South Wales.

Another tropical shell, which was not quickly recognised, but a specimen collected by Mr. Melbourne Ward in the Albany Passage was found to agree in general, but was not so broad basally, nor so attenuate and with fewer ribs and concentric lirae; it was living or very recently dead, and was richer in coloration.

The varied names provided for "Mitres" must be considerably increased before the natural groups can be easily recognised so another name is here added. It is one of the many series grouped under *Verillum*, and more strictly, *Costellaria*, whose radula indicates that two families are confused in the common acceptance of "*Mitra*," and consequently much splitting must be done.

FAMILY LATIRIDAE.

A heterogeneous assemblage of species has been referred to *Latirus* and *Peristernia*, and fortunately none has hitherto been recorded from New South Wales. Angas named *Peristernia brazieri*, but Hedley pointed out that the columella did not bear plaits, the essential feature of the "Latiroid" alliance; he pro-

posed *Nodopelagia* for that species, transferring it to the family *Buccinidae*. Hedley further designated *nassatula* as type of *Peristernia*, but years before Cossman had selected *crenulata*, a selection perfectly valid.

Melville has written about these things, another unfortunate occurrence, as lumping very unlike shells together, he apologised by stating it was as natural a genus as "*Mitra*," a name which was known to cover species probably belonging to different families. In order to assist in the re-ordering of the species, I introduce

CLIVIPOLLIA IMPERITA gen. & sp. nov.

Plate xxxviii., fig. 10.

Shell small, regularly fusiform, spire about equal to length of aperture, canal a little lengthened, narrow, a little recurved.

Colour pale brownish cream, mouth white.

Apical whorls missing, eight adult whorls remaining sculptured with revolving cords over-ridden by longitudinal rounded ribs; on the body whorl a dozen major cords with half a dozen minor ones may be counted with about ten ribs with deep interstices, while a microscopic striation can be seen under a lens; the antepenultimate whorl shows half a dozen cords, preceding ones four, three, the longitudinal ribs decreasing in the same manner; sutures well marked, not channelled.

Aperture a little pearshaped, canal narrow, open, a little recurved and lengthened; columella short, two-plaited, plaits rather weak; inner lip slight, passing as a glaze to the outer lip. The latter is thickened, a little incurved, not varicose, but bearing internally four strong nodules.

Length: 29 mm.; breadth, 13 mm.

Habitat: Sydney Harbour, New South Wales.

This species has a tropical facies, but does not correlate with any of the North Queensland species yet seen, but will probably turn up there later.

NASSARIUS GEMMULATUS Lamarck.

The name *Buccinum gemmulatum* Lamarck, the basis of the above name in Hedley's List is preoccupied by Wood (Index Test, p. 115, 1818), but Lamarck previously had given in the Explanatory Liste, p. 2, 1816, the name *Nassa clathrata* to the species figured in the Ency. Meth., p. 394, fig. 5a-b., the same figure afterwards named as above.

Shells in the Comtesse collection are very large and more closely ribbed than North Queensland shells, while Lifu shells so determined are smaller and abundantly distinct. Tryon included as synonym *N. conoidalis* Deshayes, which Hedley revived for the species known as *cremata* Hinds. I would regard Deshayes figure as nearer the conventional *gemmulatus* than the finely ribbed differently shaped *cremata*, and I therefore describe the New South Wales shell as a new species in order to obviate any further confusion, and have great pleasure in dedicating it to Captain Comtesse as

NIOTHA COMTESSEI sp. nov.

Plate xxxviii., fig. 13.

Shell large for the genus, spire elevated, body whorl swollen, mouth small.

Colour shining creamy white.

Apex missing, seven adult whorls with beautiful gemmulate sculpture, sutures flattened canaliculate. Last whorl with ten distinct spiral rows cut into gemmules by twenty-five longitudinals before the growth lines, which are packed six deep behind the aperture, are reached. The antepenultimate whorl shows five spirals, the preceding three whorls four each, similarly sculptured, the number of longitudinals being reduced as the apex is reached.

Columella short, nearly straight, wrinkled; inner lip recurved, forming a steep wall of glaze and extending across to the outer lip, the gemmulate sculpture showing through the glaze.

Outer lip strongly crenulate throughout, thickened, but not varicose.

Aperture small, ovate; outer lip strongly lirate within, ten lirae being counted running well inside; a long tooth also on the inside of body whorl; canal very short, a little recurved, bounded by a deep narrow fasciole.

Length: 37 mm.; breadth, 24 mm.

Habitat: New South Wales (type, Sydney Harbour); South Queensland.

The North Queensland shell is smaller, with fewer longitudinals.

RAPANA NODOSA A. Adams.

Plate xxxviii., fig. 9.

Hedley has included a little shell in the N.S.W. List, having given a figure of it in the Proc. Linn. Soc. N.S.W., xxxviii., p. 331, pl. xix., fig. 80, 1913, suggesting the Philippine locality is wrong, and that the types originally came from Port Jackson. While tentatively accepting this conclusion, the generic location must be amended, and the present species would be better placed near Hedley's *Corallophila lischkeana*.

COLSYRNOLA SERICEA gen. & sp. nov.

Plate xxxviii., fig. 16.

From Japan, Arthur Adams (Thes. Conch. ii., 810, pl. clxxi., fig. 35, 1854) described *Obeliscus brunneus*, figuring an elongate brown shell with flattened whorls, but describing it as having "rather convex whorls with sutures crenulated," from Japan.

To meet with a similar shell in Sydney Harbour was a novelty, and Mr. Melbourne Ward dredged similar shells in the Albany Passage, at Cape York. The Sydney shell, here figured, is larger than the North Queensland one, the whorls noticeably deeper, otherwise they agree in detail.

Shell elongate, awl shaped, imperforate, whorls flattened.

Colour glossy orange brown; living shell (from North Australia) deep red brown.

Whorls, apex missing, sixteen in number, flattened, suture deeply impressed.

Sculpture consists of microscopic concentric striae only discernible with a lens, superficially apparently smooth and glossy; the upper edge of each whorl is slightly flattened and closely crenulate, lower edge of preceding whorl smooth, a slight peripheral keel forming the deep suture. Last whorl semi-keeled at the periphery, base rounded.

Columella straight, effuse and truncate anteriorly, posteriorly bearing a single strong twist; inner lip extending as a broad thin glaze over the body whorl. Outer lip, thin, sharp, not plicate within.

Length: 26 mm.; breadth, 7.5 mm.

Habitat: New South Wales (Sydney Harbour, type). North Queensland.

The North Queensland shell has the apex perfect, and this consists of a helicoid, one and a half whorls, inverted anastrophe.

ATYS NAUCUM Linné.

To my surprise in the Comtesse collection appeared a shell I had collected at Low Island, North Queensland, only a few weeks earlier. This adds a genus as well as species to the N.S.W. List.

Atys was introduced by Montfort (Conch. Syst., vol. ii., p. 343, 1810) with type *A. cymbulus* = *Bulla naucum* L. A few years later, Schumacher (Essai. nouv. Syst. vers. test., 1817, pp. 79, 259) proposed *Naucum* for the same species.

In recent years the genus name has been used as a refuge for very unlike

shells as *Bulla cylindrica* Helbling, a common Queensland shell which is the type of *Aliculastrum* Pilsbry (Man. Conch., xvi., 237, 1896; new name for *Alicula* Ehrenberg, 1831, not Eichwald, 1830) and "*Atys*" *dentifera* A. Adams, 1850, a shell that led me a long way astray, it is so different, and one that has a genus name *Dinia* H. & A. Adams (Gen. Rec. Moll., ii., p. 21, 1854) available; the little shell Brazier named *Atys dubiosa*, and which Hedley transferred to *Cylichna*, I now take as type of a new genus *Ozorattis*.

QUIBULLA *gen. nov.*

This genus name is here introduced with *Bulla botanica* Hedley, as here figured, as type. It is obvious that a group name is necessary, and, owing to the confusion about the genus name *Bulla*, it is necessary to introduce some alternative at once. *Bulla* was introduced for a large series of molluscs by Linné, after he had utilised the same name for a subgenus of insects. The usage of the genus name for the mollusc continued until very recently, when it was discarded for *Bullaria* Rafinesque. Unfortunately this action has been questioned and the revival of *Bulla* demanded, a most unfortunate suggestion as this has necessitated the re-opening of the matter with annoying results. Of the long series allotted by Linné to *Bulla*, the first was *ovum*, and the sixth *Bulla naucum*, the first synonym being "*Bulla Rumph*"; by Linnean tautonymy this species automatically becomes the type of *Bulla* Linné, 1758. The conventional type of *Bulla* is not that species, but *ampulla*, which does not figure until later on in Linné's list, and pretty obviously was not considered by Linné as his "type" species. Furthermore, many later workers did not so regard it, but, as Lamarck used it as an example, it gained some acceptance. A substitute for *Bulla* Linné follows its tautonymic type, and consequently *Bullaria* Rafinesque cannot be used for the *ampulla* series. *Bullus* Montfort is simply a mis-spelling and cannot be seriously considered as a substitute. I write this advisedly as the acceptance of mis-spellings would paralyse all progress in conchology, as these are very abundant owing to such writers as J. E. Gray and Swainson, who were notoriously careless in proof-reading. *Vesica* was introduced by Swainson in 1840 for *ampulla* and *naucum*, but it need not inconvenience us as it is preoccupied by Humphrey (Mus. Calonn., 1797, p. 21).

Gray's species *Bulla australis* was simply localised as from Australia, and, as Hedley's *botanica* was only proposed as a new name, I here designate as type locality, Sydney Harbour, where the species is very common. As no type of Gray's species is in existence, I figure a new type (Plate xxxviii., fig. 4).

A feature which requires notice is the presence of incised spiral lines about the base; this is present in most specimens, and has hitherto been regarded as a distinctive character of the Neozelanic *quoyii*. The *ampulla*-like form is here described as

QUIBULLA SELINA *sp. nov.*

Plate xxxviii., fig. 1.

Shell large, rounded oval, comparatively narrower than traditional "*ampulla*," but otherwise recalling it.

Colour brown, red, pink and grey, confusedly forming a mottled pattern, with no outstanding feature.

Sculpture consists of fine growth lines, no spiral striae being observed even near the base; the apical perforation very small and deep, and bearing an internal furrow, but no striae.

Aperture rounded anteriorly and rapidly narrowing towards the apex; outer lip running rather backwards and then rapidly curving inwards to meet the last whorl above the apex.

Columella thick, slightly curved and reflected as a heavy white callus.

Inner lip deposited as thick white glaze extending to the apex.

Height: 60 mm.; breadth, 37 mm.

Habitat: Sydney Harbour, New South Wales.

Much larger specimens have been seen in a broken condition.

With these were found quantities of the small "*Bulla*" Hedley included in the New South Wales List as *punctulata* A. Adams. Pilsbry recorded this species from Panama, etc., and then stated that Australian specimens showed no variation. However, he described the "interior of the umbilicus sculptured with deep spiral grooves, about a dozen in number," which is in disagreement with our species. Pilsbry determined as a distinct species "*A. (sic) angasi*" and figured it. Hedley regarded this as synonymic with *punctulata*, but it is quite distinct, and is here figured. A "punctulate" species also occurs in Sydney Harbour and will be dealt with later, while there is also a "punctulate" shell in North Queensland which does not harmonise with Pilsbry's description of the Mid-West American species.

BULLINULA MELIOR *sp. nov.*

Plate xxxvii, fig. 7.

A common little, but attractive, shell, is listed by Hedley under the name *Bullinula ziezac* Muhlfeldt, but as Muhlfeldt's (recte Megerle's) name is invalid recourse must be had to *Bulla lineata* Gray (Ann. Philos. (Thomson), vol. xxv., p. 408, June, 1825) described from New Holland and figured (back view) in Wood. Suppl. Index Test (p. 9, pl. 3, *Bulla*, fig. 1, 1828).

Associated with this species is another which is here described under the above name, *melior*; it is broader, with a more depressed spire and stronger sculpture, apical whorls apparently white.

Shell broadly ovate, spire depressed, thin, columella truncate.

Colour bluish white, with two encircling bands of deep lake, one broad, one about the suture, the other nearly as broad, about the middle of the whorl; a few thick longitudinal streaks of the same colour also appear.

Apex white, anastrophic, tilted, nearly immersed, first adult whorl wound in nearly the same plane, and almost hidden by the succeeding one, the suture being deep and subcanaliculate; next two whorls increasing rapidly and descending.

Sculpture consists of flat-topped lirae, with interstices about half the width of the lirae; the interstices filled with oblong punctures.

Columella nearly straight, abruptly truncate, anteriorly, reflected, leaving a very narrow umbilical chink; internally bearing a strong fold medially, and posteriorly appressed to the body whorl with a thin glaze.

Height: 17 mm.; width, 12 mm.

Habitat: Sydney Harbour, New South Wales, dredged in 4 fathoms.

While the common *B. lineata* Gray (Plate xxxvii, fig. 7) occurs commonly on all the beaches as dead shells and can be met with living in rock pools on the littoral, the present species has only been dredged.

The variation seen in *B. lineata*, whether from here (thousands have been examined) or from the Pacific Islands never causes confusion with this shell, the form, coloration and sculpture easily separating it. With these two was a third species of more elegant build and which differed at sight in the non-truncate columella, although the sculpture was of the same style. I had seen this form from Norfolk Island previously, and as it apparently occurs through the Indo-Pacific Region along with the true *Bullinula*, it is certainly deserving of generic rank and it is so here described.

PERBULLINA ERRANS *gen. & sp. nov.*

Plate xxxvii, fig. 6.

This beautiful shell is another of the curious tropical forms, as it is very closely related to a shell from the Island of Reunion, South Indian Ocean, which

Pilsbry described (Man. Conch., xv., 178, pl. 45, figs. 28-28, 1893) as *Bullina deshayesii*, a new name, as it had been figured by Deshayes (Moll. Reunion, p. 56, pl. 8, figs. 2-3, 1863) as *Bullina vitrea* Pease, but that species has the columella truncated and is a *Bullinula*.

Shell elongate oval, spire depressed, imperforate, thin.

Colour bluish white, encircled with two narrow distant black brown lines.

Apical whorls anastrophic, smooth, tilted, adult whorls sculptured, with flat-topped lirae and punctately grooved interstices; sutures rather deeply canaliculate.

Columella slightly twisted, but not truncate, nor does the twist develop into a fold as in the preceding genus; reflected and entirely covering the umbilical area so that only a chink is seen in young specimens.

Aperture basally effuse, towards the apex narrowing, outer lip thin.

Height: 17 mm.; breadth, 9.5 mm.

Habitat: Sydney Harbour, New South Wales.

When Gray introduced his *Bulla lineata* he also proposed *Bulla wallisii* (Ann. Philos. (Thomson), vol. xxv., p. 408, 1825), also from New Holland, but which has never been recognised. Pilsbry (Man. Conch., vol. xv., p. 373, 1893) reproduced the description under *Haminea* without comment; but a few pages (363) earlier he had described *H. crocata* Pease from the Sandwich Islands, observing, "Angas reports this from Lake Macquarie, New South Wales." Comparison of the two descriptions show that undoubtedly Gray's species was the same as Angas's, and therefore *wallisii* Gray should replace *crocata* Pease in our List. The true *crocata* Pease may be a very different species.

Pilsbry (Proc. Acad. Nat. Sci. Philad., 1920, p. 367, March 4, 1921) has introduced *Liloa* with type *Haminoea tomaculum* Pilsbry, and noted that *H. papyrus* A. Ad., *H. brevis* Q. & G., *H. cairnsiana* Mel. & St., and *H. cuticulifera* belong to *Liloa*, which may be nearer *Atys* than *Haminoea* s. str.

Bulla wallisii Gray (*crocata* Angas) does not generically agree with the *brevis* series, and I therefore introduce the new generic name *Penthominea*, naming the Sydney species as type.

PARAPLYSIA PIPERATA Smith.

In confirmation of the preceding records probably many slugs could be cited, but here notice will only be made of two. I picked up (living) on the little beach inside Sydney Harbour, known as Manly Cove, an "Aplysioid" slug of strange facies, which was determined as referable to the above species, the genus *Paraplysia* having been introduced by Pilsbry (Man. Conch., xv., p. 64, November 26, 1895) for the species *piperata* Smith and *mouhoti* Gilchrist. Smith had described *Aplysia piperata* (Zool. Coll. Alert., p. 89, 1884) from Thursday Island, Torres Straits, and it had been redescribed and figured by Gilchrist (Ann. Mag. Nat. Hist., Ser. 6, vol. xv., p. 403, pl. 18, figs. 2-4, 1895), and is here named as type of *Paraplysia*. The genus will be easily recognised again by the position of the rhinophores between the anterior ends of pleuropodial lobes, the latter being completely free; this indicates it is a swimming form and some of these slugs do not swim under great provocation, while others keep on swimming all the time.

NOTARCHUS PETAURISTA sp. nov.

Plate xxxvii., fig. 1.

An extraordinary little slug was dredged by Mr. Melbourne Ward on the Sow and Pigs Reef in about 4 fathoms of water, and it amused everybody by turning somersaults when disturbed in the aquarium. It seemed very different to anything hitherto seen, but upon reference to Pilsbry (Man. Conch., xvi., pp. 136-7, pl. 17, figs. 12-13, 1895) excellent figures were found, reproduced from Quoy and Gaimard (Voy de l'Astrol. Zool., vol. iii., 312, pl. 24, figs. 3-4, 1835) from Mauri-

tius. Pilsbry recorded that "The figures given by Quoy and Gaimard represent the living animal; but are so different from the others as to excite suspicion that a distinct species may be represented. Quoy and Gaimard called it *Aplysia gelatinosa* after Rang, and Pilsbry regarded Rang's names as equivalent to *Notarchus cuvieri* Blainville, 1824, and *Notarchus indicus* Schweigger, 1820, the monotype of *Notarchus* Cuvier. This adds a genus to the Australian fauna as the species already classed under *Notarchus*, viz., *Aclesia glauca* Cheeseman, may resume the named used by Cheeseman, as it is obviously a different generic type, or better still, *Ramosaclesia*, nov., for the New Zealand species.

EXPLANATION OF PLATES.

Plate xxxvii.

- Fig. 1. *Notarchus petaurista* Iredale.
 2, 3. *Proxichione materna* Iredale.
 4, 5. *Vepricardium pulchricostatum* Iredale.
 6. *Perbullina errans* Iredale.
 7. *Bullinula melior* Iredale.
 8. *Bullinula lineata* Gray.
 9. *Talopia morti* Iredale.
 10. *Talopia dividua* Iredale.

Plate xxxviii.

- Fig. 1. *Quibulla selina* Iredale.
 2. *Distorsio reticulata* Bolten.
 3. *Sydaphera renovata* Iredale.
 4. *Quibulla botanica* Hedley.
 5. *Mammilla propesimiae* Iredale.
 6. *Chrysame lemma* Iredale.
 7. *Perirhoe melamans* Iredale.
 8. *Quibulla angasi* Pilsbry.
 9. *Coralliophila nodosa* A. Adams.
 10. *Clivipollia imperita* Iredale.
 11. *Cymatium zimara* Iredale.
 12. *Baryspira dyspetes* Iredale.
 13. *Niotha comtessei* Iredale.
 14. *Scala parspectiosa* Iredale.
 15. *Colus sinovellus* Iredale.
 16. *Colsyrnola sericea* Iredale.
 17. *Vicimitra prospora* Iredale.
 18. *Mitropifex quasillus* Iredale.
 19. *Colus consetti* Iredale.

ADDITIONS TO THE CHECK-LIST OF THE FISHES OF
NEW SOUTH WALES.

No. 2.

By GILBERT P. WHITLEY,

Ichthyologist, Australian Museum.

(By permission of the Trustees of the Australian Museum.)

The publication of the late A. R. McCulloch's "Check-list of the Fishes and Fish-like Animals of New South Wales" placed our knowledge of the ichthyology of this State on a very sound footing, and the comparatively small amount of additional information which has since come to hand can be summarised in this paper.

Dates of Publication of the Check-List.

Part One.—November 27, 1919.

Part Two.—April 11, 1921.

Part Three.—February 10, 1922.

Handbook.—May 16, 1922.

Second Edition.—July 14, 1927.

The detailed bibliographic references are as follows:—

"Check-list of the Fish and Fish-like Animals of New South Wales." Part i., *Austr. Zoologist* i, 7, 1919, pp. 217-227, pls. xvi.-xviii. Author's separates unpagged but with the plates numbered xvi.-xviii. This paper was reprinted with minor alterations and additions and issued with separates of part ii., paged 1-13, pls. i.-iii., and 1 text-figure.

"Check-list, etc." Part ii., *Austr. Zoologist* ii, 2, 1921, pp. 24-68, pls. iv.-xxiv. Author's separates paged 14-56 and issued with the revised part i. as "Check-list, etc.," parts i.-ii., 1921, pp. 1-56, pls. i.-xxiv., and 1 text-figure.

"Check-list, etc." Part iii., *Austr. Zoologist* ii, 3, 1922, pp. 86-130, pls. xxv.-xlili.

"The Fishes of New South Wales." *Austr. Zool. Handbook*, No. 1. Check-list, etc., 1922, pp. i.-xxvi. and 1-104, pls. i.-xlili., and 1 text-figure. Bound in boards.

"The Fishes and Fish-like Animals of New South Wales." Second edition with additions by Gilbert P. Whitley (of which the present paper is a continuation). Pagination as in Handbook, but with three un-numbered pages of additions following the title page. Bound in paper covers. 1927.

Only one new name was proposed in the Check-list, but, as it has been overlooked by compilers of the Zoological Record, attention is drawn to it here. This is *Platycephalus caeruleopunctatus* McCulloch (*Austr. Zoologist*, ii, 3, February 10, 1922, p. 120; Handbook, p. 94) for *P. bassensis* Stead (*non*. C. & V.).

Recent additions to the Check-list.

To the second edition of the Check-list, I added the following species:—
Acanthidium quadrispinosum McCulloch, *Squatina tergocellata* McCulloch, *Aptychotrema bougainvillii* (Müller & Henle), *Uropterygius marmoratus* (Lacépède), *Aeoliscus strigatus* (Günther), *Coelorhynchus (Paramacrurus) mirus* McCulloch, *Pseudorhombus duplici-cellatus* Regan, *Rhadinocentrus ornatus* Regan, *Megalaspis cordyla* (Linnaeus), *Choerodon olivaceus* (De Vis), *Bleekeria vaga* McCulloch & Waite, *Histiophryne bougainvillii* (C. & V.), *Lophiomus laticeps* (Ogilby), and *Aluterus monoceros* (Linnaeus).

These species were either identified from New South Wales specimens by me

or their inclusion in the list was necessitated by records in the following papers:—
 WAITE, E. R. Illustrations of and Notes on some Australian Fishes.

Rec. S. Austr. Mus., ii., 4, April 30, 1924, 479-487.

McCULLOCH, A. R. Studies in Australian Fishes. No. 8.

Rec. Austr. Mus., xv., 1, April 15, 1926, 28-39.

WHITLEY, G. P. Fishes. In the Biology of North-west Islet, Capricorn Group.

Austr. Zoologist, iv., 4, April 30, 1926, 227-236.

McCULLOCH, A. R. Report on some Fishes obtained by the F.I.S. "Endeavour." . .

Biol. Res. Endeavour, v., 4, June 8, 1926, 157-216.

NORMAN, J. R. A Report on the Flatfishes (Heterosomata). . . .

Biol. Res. Endeavour, v., 5, June 15, 1926, 219-308.

WHITLEY, G. P. A Check List of Fishes Recorded from Fijian Waters.

Journ. Pan-Pacif. Res. Inst., ii., 1, December, 1926, p. 8, appendix.

NORMAN, J. R. A Synopsis of the Rays of the Family Rhinobatidae, with a Revision of the genus *Rhinobatus*.

Proc. Zool. Soc. Lond., 1926, iv., December 30, 1926, 941-982.

WHITLEY, G. P. Studies in Ichthyology. No. 1.

Rec. Austr. Mus., xv., 5, April 6, 1927, 289-304.

Further Additions.

VI.

Family CARCHARHINIDAE.

- 8b. CARCHARHINUS MACRURUS Whaler Shark. *Carcharias macrurus* Ramsay & Ogilby, *Proc. Linn. Soc. N.S.W.* (2), ii., 1, 1877, 163 and 1024. Port Jackson.

This species has been fully described by McCulloch (*Proc. Linn. Soc. N.S.W.*, xlv., 1, 1921, 457, pl. xxxvii., figs. 1-4), but in the Check-list it is wrongly called *C. brachyurus* Günther, an allied New Zealand species.

384. RHIZOPRIONODON, gen. nov.

Rhizoprion Ogilby (*Mem. Q'ld. Mus.*, iii., January 28, 1915, p. 132) is pre-occupied by *Rhizoprion* Jourdain (*Comptes Rendus, Paris*, liii., 22, July-December, 1861, 959-962; *vide* Palmer, *Ind. Gen. Mamm.*, 1904, 608), a genus of mammals, so I rename it *Rhizoprionodon* with *Carcharias (Scoliodon) crenidens* Klunzinger (*Sitzb. Akad. Wiss. Wien.*, lxxx., 1, 1879, 426 (102 of reprint), pl. viii., fig. 3, teeth. Queensland) as orthotype. No. 8(A)a of the Check-list now becomes *Rhizoprionodon crenidens* (Klunzinger).

X.

Family SCYLIORHINIDAE.

385. FIGARO Whitley, *Rec. Austr. Mus.*, xvi., 4, March 28, 1928, 238. Orthotype, *Pristiurus (Figaro) boardmani* Whitley.

- 385a. FIGARO BOARDMANI. Boardman's Shark. *Pristiurus (Figaro) boardmani* Whitley, *loc. cit.*, 238, pl. xviii., fig. 3. Off Montague Island. Type in Austr. Museum.

A deep-sea shark of which only the male is so far known. Length, 22 inches.

XIX.

Family RHINOBATIDAE.

- 30a. APTYCHOTREMA BANKSII (Müller & Henle).

Add to synonymy: *Rhinobatus tuberculatus* Macleay (*Proc. Linn. Soc. N.S.W.*, vii., 1882, 12. Port Jackson), *nomen nudum*.

XXII.

Family DASYATIDAE.

- 39a. UROLOPHUS SUFFLAVUS sp. nov. Yellow-backed Stingaree.

Urolophus sufflavus is proposed as a new name for "*Urolophus aurantiacus*?" McCulloch (*Biol. Res. Endeavour*, iv., 4, October 31, 1916, 171 and 172, pl. xlix.) which is specifically separable from the Japanese *U. aurantiacus* Müller & Henle (*Plagiost.*, iii., 1841, 173, pl. lvi.).

Type locality: Off the coast of New South Wales, between Port Hacking and Wollongong, trawled in 40-70 fathoms.

XXXIV.

Family SALMONIDÆ.

- 60c. SALMO GILBERTI. Kern River Trout or Gilbert's Trout. *Salmo gairdneri gilberti* Jordan, Thirteenth Biennial Rept. Fish. Comm. Calif., 1894, 143 and pl. Kern R., Cal., U.S.A. (*vide* Jordan & Evermann, Bull. U.S. Nat. Mus., xlvii, Fish. N. & Mid. Amer., i., 1896, 501 and 502).

Mr. Walter Hannam brought a specimen of a supposed spent male Rainbow Trout or a hybrid, with another of *Salmo irideus*, to the Australian Museum for identification. Both had been caught by Dr. H. O. Lethbridge below the Blue Water Hole, above the falls at the head of the Goodradigbee River, New South Wales, early in November, 1928. I determined the novelty as *Salmo gilberti* Jordan, though it lacked white tips to the anal and ventral fins, so this species must be added to the list of fishes which have been introduced into Australia. *Salmo gilberti* is common throughout the North Island of New Zealand, according to Phillipps and Hodgkinson (N.Z. Journ. Sci. Tech., v., 1922), and it seems feasible that its eggs may have been introduced into New South Wales from New Zealand mixed with those of *S. irideus*, the Rainbow Trout. A detailed account of the American *Salmo gilberti* has been given by Evermann (Bull. U.S. Bur. Fish., xxv., 1905, published May, 1906, 18, pl. xv., coloured; Juday, *ibid.*, 47 records the food of this Trout).

XLII.

Family CYPRINIDÆ.

386. CYPRINUS Linnaeus, Syst. Nat., ed. 10, 1758, 320. Logotype, *C. carpio* Linnaeus, designated by Guichenot, Diet. pitt. d'Hist. Nat., ii., 1835, p. 8.
- 386a. CYPRINUS CARPIO. Carp., *Id.*, Linnaeus, Syst. Nat., ed. 10, 1758, 320; *ibid.*, ed. 12, 1766, 525. Based on Artdi, Faun. Svec., and Gronow. "Habitat in Europa."

The Carp has been introduced into New South Wales and lives in large numbers in Prospect Reservoir, inland from Sydney, where it is known as "Prussian Carp" and sometimes "Crucian Carp." A specimen which died in captivity in Taronga Park Aquarium, Sydney, was presented to the Australian Museum (regd. No. 1A.3660), and is the subject of this record. This species was not included in the Check-list, but Anderson (Austr. Mus. Magazine, iii., 1927, 87) states that the "Crucian Carp" was introduced in 1888. The Carp is common in Thermal Lakes and ponds throughout New Zealand (*vide* Phillipps, Jour. Pan.-Pacif. Res. Inst., ii., 1, 1927, published December, 1926, 15).

Macleay stated that a species of *Carpiodes* was introduced into New South Wales and McCulloch noted this in his Check-list, but the identification was probably incorrect and may have referred to *Cyprinus carpio*. Thanks to the kindness of Dr. E. W. Gudger, Bibliographer and Associate of the American Museum of Natural History, I am able to reproduce here a transcription of an anonymous article, credited to F. H. Bean, in Dean's "Bibliography of Fishes," which appeared in "Forest and Stream," xxxii., January 24, 1889, p. 10.

Introduction of a Supposed Carp Sucker into New South Wales.

"At the meeting of the Linnean Society of New South Wales at Sydney, October 30, 1888, Mr. Macleay exhibited four specimens of a species of carp sucker, which had been taken from a nearly dry water-hole close to the Wingecaribee River, at Elvo, Burradoo, a few days before. Several hundred of these fishes were removed from the holes and placed in the river in the immediate vicinity. Mr. Macleay finds the sucker to belong to the genus *Carpiodes*, which includes several species, all of them presumably limited to fresh waters of the United States, and concludes by saying that 'it would be interesting to know how

and when the fish was introduced into this country, where its acclimatisation, as far as Wingecaribee is concerned, seems to have been so perfectly successful.' If the carp sucker has gone to New South Wales from the United States, it may have been carried unintentionally along with carp or bass, associated species in some Eastern waters of our country. We hope, however, that this inferior fish, which has nothing to recommend it but its pleasing form and colors, may not eventually be charged against us. We have failed to find any record of a shipment of carp from the United States Government ponds to Australia."

XLVI.

Family ANGUILLIDAE.

77a. ANGUILLA AUSTRALIS Richardson.

Since the appearance of the second edition of the Check-list, Schmidt has revised the Australian species of *Anguilla* and has named from Eastern Australia a new form, *Anguilla australis occidentalis* (Trans. N.Z. Inst., lviii, 4, March 19, 1928, 388, and Rec. Austr. Mus., xvi, 4, March 28, 1928, pp. 181, 198-9, and 203, figs. 2-8 and 9d-f). In accordance with the rules of zoological nomenclature, however, *Anguilla australis occidentalis* Schmidt should be called *Anguilla australis australis* Richardson, whilst *A. australis orientalis* Schmidt, named from New Zealand in the same papers, should apparently be called *Anguilla australis schmidti* Phillipps (N.Z. Journ. Sci. Tech., viii, 1, 1925, 29-30, fig. 4).

LV.

Family SYNGNATHIDAE.

387. RUNCINATUS, gen. nov.

Differs from *Solegnathus* Swainson in having the dorsal ridges of trunk and tail continuous; the mediolateral ridges expand below the dorsal fin (at least in males) and terminate on the sides of the tail. Orthotype, *Solegnathus dunckeri* Whitley.

387a. RUNCINATUS DUNCKERI. Spiny Sea Horse. *Solegnathus dunckeri* Whitley, Rec. Austr. Mus., xv, 5, April 6, 1927, 293-295, pl. xxiv., fig. 1. Lord Howe Island. Type in Austr. Museum.

I recently received a specimen from Grafton, New South Wales, so this species is Australian and must be added to the Check-list. It had previously been doubtfully reported from New South Wales.

XXIV.

Family ATHERINIDAE.

148b. MELANOTAENIA NEGLECTA Rendahl, Medd. Zool. Mus. Kristiania, No. 5, 1922, 179 and 181. Cudgegong River at Ryleston, N.S.W. Types in Zoological Museum, Oslo.

A species nominally distinct from the northern Freshwater Sunfish, *M. nigrans* (Richardson).

CXXX.

Family CALLIONYMIDAE.

285e. CALLIONYMUS MACDONALDI Ogilby, Ann. Q'ld. Mus., x, November 1, 1911, 56, pl. vi., fig. 2. Moreton Bay. Type in Queensland Museum. *Id.* McCulloch, Biol. Res. Endeavour, v., 4, 1926, 205, pl. liv., fig. 1 (holotype).

Mr. T. C. Roughley has presented to the Australian Museum a specimen from the Manning River, at Taree, which was collected on October 18, 1928, by Dr. S. M. Ware. Regd. No. 1A.3656. Recorded by me in Abstr. Proc. Linn. Soc. N.S.W., 421, November, 1928, third page.

CXL.

Family GOBIIDAE.

388. GUNNAMATTA Whitley, Rec. Austr. Mus., xvi, 4, March 28, 1928, 225. Orthotype, *G. insolita* Whitley.

- 388a. GUNNAMATTA INSOLITA Whitley, *loc. cit.*, 225, pl. xvi., fig. 3. Gunnamatta Bay, Port Hacking. Type in Austr. Museum.

Only known from the type and a specimen recently collected by the writer in the lagoon at Narrabeen, north of Sydney.

CXXI.

Family BLENNIIDAE.

389. CLINUS Cuvier, *Regn. Anim.*, ed. 1, ii., "1817" = December, 1816, p. 251. Logotype, *Blennius superciliosus* Linnaeus, designated by Jordan, *Gen. Fish.*, i., 1917, 101.

Note.—Swainson (*Nat. Hist. Classif. Fish. Amphib. Rept.*, ii., July, 1839, p. 75) designated *Clinus acuminatus* Cuv. & Val., as type of this genus, but that species was not mentioned by Cuvier in 1816.

- 389a. CLINUS PERSPICILLATUS Cuv. & Val., *Hist. Nat. Poiss.*, xi., July, 1836, 372. Westernport, Victoria. *Id.* McCulloch, *Rec. Austr. Mus.*, vii., 1, 1908, 43, pl. xi., fig. 4.

Mr. William Driscoll found a specimen of this southern species in a rock-pool at Bermagui in September, 1927. New record for New South Wales. *Regd. No.* 1A.3642.

CLIV.

Family ANTENNARIIDAE.

390. TRICHOPHYRNE McCulloch & Waite, *Rec. S. Austr. Mus.*, i., 1, May 24, 1918, 66 and 68. Orthotype, *Antennarius mitchelli* Morton.

- 390a. TRICHOPHYRNE MITCHELLI Prickly Angler Fish. *Antennarius mitchelli* Morton, *Proc. Roy. Soc. Tasm.*, 1896 (1897), pp. xiv. and 98. East Tasmania [= Lisdillon]. Type in Tasmanian Museum, Hobart, *Trichophyrne mitchellii* McCulloch & Waite, *Rec. S. Austr. Mus.*, i., 1918, 68, pl. vi., fig. 1. (South Australian specimen).

One specimen was recently trawled off the southern coasts of New South Wales. *Austr. Mus.*, *Regd. No.* 1A.3614. New record for the State. Only grows to about 4½ inches long.

CLVa.

Family CHAUNACIDAE.

391. CHAUNAX Lowe, *Proc. Zool. Soc. Lond.*, xiv., November, 1846, p. 81. Haplotype, *C. pictus* Lowe.

- 391a. CHAUNAX ENDEAVOURI, sp. nov.

The specimen figured by McCulloch (*Biol. Res. Endeavour*, iii., 3, April 21, 1915, 165, pl. xxxiii., figs. 1-1a) is apparently distinct from the Japanese *Chaunax fimbriatus* Hilgendorf and may be named *Chaunax endeavouri*, the type locality being east of Flinders Island, Bass Strait; 70-100 fathoms.

Another specimen, trawled near Montague Island (*Austr. Mus.*, *Regd. No.* 1A.3591) shows that this species enters the New South Wales fauna.

CLX.

Family TETRAODONTIDAE.

392. LIOSACCUS Günther, *Cat. Fish. Brit. Mus.*, viii., 1870, 272 and 287. Logotype, *Tetrodon cutaneus* Günther, designated by Jordan, *Gen. Fish.*, iii., 1919, 357.

- 392a. LIOSACCUS AEROBATICUS Whitley, *Rec. Austr. Mus.*, xvi., 4, March 28, 1928, 237, pl. xvi., fig. 2. Trawled off Montague Island. Type in Austr. Museum.

A Toado whose spineless skin is minutely wrinkled and which is capable of expanding its body to an enormous extent. Length about eight inches.

THE BIRD OF PROVIDENCE.

By TOM IREDALE.

Plates xxxix. and xl.

Probably there is more romance connected with the Petrel, entitled by Captain John Hunter "the Bird of Providence" about one hundred and forty years ago, than with any other bird on the Australian List.

Thus wrote Hunter: "In the month of April (1790) we found that Mount Pitt (Norfolk Island), which is the highest ground on the island, was, during the night, crowded with birds. This hill is as full of holes as any rabbit warren; in these holes at this season these birds burrow and make their nests, and, as they are an aquatic bird, they are, during the day-time, frequently at sea in search of food; as soon as it is dark, they hover in vast flocks over the ground where their nests are. Our people (I mean seamen, marines, and convicts), who are sent out in parties to provide birds for the general benefit, arrive upon the ground soon after dusk, where they light small fires, which attract the attention of the birds, and they drop down out of the air as fast as the people can take them up and kill them; when they are upon the ground, the length of their wings prevents their being able to rise, and, until they can ascend an eminence, they are unable to recover the use of their wings; for this purpose, nature has provided them with a strong, sharp, and hooked bill, and in their heel a sharp spur, with the assistance of which, and the strength of their bill, they have been seen to climb the stalk of a tree sufficiently high to throw themselves upon the wing. This bird, when deprived of its feathers, is about the size of a pigeon, but when clothed, is considerably larger, for their feathers are exceedingly thick; they are web-footed, and of a rusty black colour; they make their holes upon the hills for breeding their young in; they lay but one egg, and that is full as large as a duck's egg. They were, at the end of May, as plentiful as if none had been caught, although for two months before there had not been less taken than from two to three thousand birds every night; most of the females taken in May were with egg, which really fills the whole cavity of the body, and is so heavy that I think it must fatigue the bird much in flying. This *bird of Providence*, which I may with great propriety call it, appeared to me to resemble that sea bird in England, called the Puffin; they had a strong fishy taste, but our keen appetites relished them very well; the eggs were excellent. For a further description, and an engraving of this bird, see the Norfolk Island Petrel, in Phillip's Voyage, 4th Edition."

In Lieut. King's Journal, included by Hunter, there is the first note in May, 1788, where King reported "they have not the least fishy taste, and their flesh is very fine . . . they afforded us many fresh meals."

In Phillip's Voyage there is an excellent figure (see plate xxxix.) of the Norfolk Island Petrel, which is well described by Latham, the plate being dated August 6, 1789, and the wording reading like that of King's Journal, but otherwise there is no mention of the bird nor acknowledgment to King, a discrepancy obviously due to the editor.

If we now refer to Collins we read the tragic ending to the wholesale murder of these defenceless birds. "The great havoc and destruction which the reduced ration had occasioned among the birds frequenting Mount Pitt had so thinned their numbers, that they were no longer to be depended upon as a resource. The convicts, senseless and improvident, not only destroyed the bird, its young, and its egg, but the hole in which it burrowed; a circumstance which ought most cautiously to have been guarded against; as nothing appeared more likely to make them forsake the island." This appeared under date August, 1792.

Among the Watling drawings there are included pictures which are credited to the Norfolk Island Petrel, but which apparently covered two species, one a

Shearwater, the other a Dove Petrel. As these are associated it may be that more than one species was included in the account by Hunter, but it is noteworthy that it was the Dove Petrel that was figured in Phillip's account, and as it also appears in the Watling pictures it could not have been uncommon.

The prognostication that they would forsake the island proved correct, but we have no data as to when this event occurred. Apparently few birds were preserved as specimens, as with the exception of the one from which the plate in Phillip's Voyage was prepared there is no other record. That specimen has been entirely lost and there is no other recorded in any Museum. The species entirely disappeared in mystery as far as the scientific world was concerned, and therein remained until within the last twenty years.

In the meanwhile a few interesting events happened. Thus, Gould on his voyage to Australia, nearly one hundred years ago, made a special study of sea-going Petrels, and when travelling up the Australian coast from Melbourne (not then named) procured, in Bass Strait, in 1839, an entirely different bird which he called *Procellaria solandri*, recording that Natterer, a great Austrian ornithologist, had suggested that it was a species named by Solander, *melanopus*, but that he, Gould, did not agree with this suggestion and therefore named the species after Solander.

Then, twenty years later, Gray, cataloguing the birds of the Pacific Ocean, observed that the Petrel figured in Phillip's Voyage had not been recognised, and that consequently it had no technical name. As it seemed a very distinct species he proposed the name *Procellaria philippii*. Apparently no birds were coming from Australia then or the bird had become extinct. So the matter remained for many years.

Then Dr. Metcalfe discovered a Dove Petrel, breeding on Norfolk Island, and this was determined, not as Phillip's Norfolk Island Petrel, but as the Kermadec Island Petrel (*Aestrelata neglecta* Schlegel), thus causing more perplexity. Consequently, when Salvin monographed the group in the British Museum he was compelled to ignore *P. philippii*, as there were no specimens extant, ranked Dr. Metcalfe's record under the Kermadec species, and allowed Gould's *P. solandri* as distinct, but probably an aberration. They were rather prone to this refuge in cases of difficulty in this order thirty or forty years ago, and it has not been entirely discarded yet.

Then came a surprising denouement, when Mr. A. F. Basset Hull investigated the avifauna of Lord Howe and Norfolk Islands. He found species of Shearwaters breeding on both islands, but could not find on Norfolk Island any trace of Dove Petrels, neither Dr. Metcalfe's kind nor the lost "Bird of Providence." On Lord Howe Island, however, he found a magnificent Dove Petrel which was certainly not the Kermadec Island species, though North, ornithologist at the Australian Museum, had determined it as such. Quite correctly he described it as a new species, *Oestrelata montana*, drawing attention to its resemblance to the missing "Bird of Providence" of Norfolk Island and its distinction from the Kermadec Island Petrel.

The specimen was sent then to England to Mr. G. M. Mathews, who was working at the group for his Birds of Australia. At that time I was associated with Mr. Mathews, and we were able to work out the complex history of the species with unexpected results. When the bird arrived it somehow seemed familiar as we had just worked through the entire collection of Petrels in the British Museum, as well as those in Lord Rothschild's Museum, at Tring, and specimens from various other Museums.

It was only after re-examining the Dove Petrels that we realised we were handling the same species that Gould had named *P. solandri*, as in accordance with the views then extant we had allowed this to be an aberration, but had been un-

able to trace any associate. Now with Hull's specimen and full account, we recognised its absolute distinction, and were then led to compare the account of *P. philippii* which we found to agree in every general particular. This led to the criticism of Solander's *melanopus*, when access to Solander's manuscript showed that it could not be reconciled with his detailed account, but a good description by Gmelin of a bird he had named *melanopus* was found to agree well. Further study definitely determined that the Gmelinian name had been given to this species, probably to a specimen collected by Solander, but through some mishap the locality had been given as "Said to inhabit North America." American students had been unable to recognise the species, and therefore it had also been lost, but the description is an excellent one of the "Bird of Providence" when the dubious locality was forgotten.

The complete history of the species could then be deciphered and a perfect fabric woven of the scattered strands until now apparently unconnected.

The Norfolk Island Petrel bred in numbers, and was exterminated in that locality through stress of food demand at a very early date, perhaps before the year 1800. Fortunately, a specimen had been illustrated in Phillip's Voyage, and through the picture it was possible to recognise the Black-toed Petrel of Latham's. The specimen described by Latham was in the Leverian Museum, and had apparently been given by Sir Joseph Banks or some of his party, as the name allotted to it was one invented by Solander for this and allied species. The locality label had been lost and a fictitious one, "North America," added. This specimen was apparently lost when the Leverian Museum was dispersed.

Many years later a similar bird was shot in Bass Strait and remained unrecognised for over seventy years, when the original species was again found living, not on Norfolk Island, but on Lord Howe Island.

It still breeds there and apparently wanders through the Tasman Sea as the example captured by Gould indicated.

Since I arrived in Sydney I have been searching the beaches for this species, as it seemed a natural corollary that after some storm a bird might be washed ashore. Many black Petrels were found, and each one was examined for the tell-tale bill, as instead of being long, thin and pale coloured like that of the Shearwaters, it is short, stout and black. During this time, *Puffinus gavia* Forster and *P. griseus* Gmelin, which had hitherto been regarded as rare birds, were found to occur, not uncommonly, and on February 10, 1929, I was rewarded by picking up on the Queenscliff end of Manly beach a fine freshly dead specimen of the "Bird of Providence" which has been deposited in the Australian Museum. This is the first mainland record since Gould's 1839 bird, and is an addition to the New South Wales Avifauna.

This bird is very easily identifiable by means of its size, its very strong black bill and its pale mottled face. An excellent photograph by Mr. Roy Bell, taken on Lord Howe Island, is here reproduced for comparison with Phillip's plate xl.

The whole of the complex history is given in full detail in Mathews' Birds of Australia, but the chief references may here be appended for use by the student.

Pterodroma melanopus.

- Black-toed P(etrel) Latham, Gen. Synops. Birds., vol. iii., pt. 2, p. 408, 1785. Said to inhabit North America. Lev. Mus. This locality is erroneous and should be Norfolk Island.
- Procellaria melanopus* Gmelin, Syst. Nat., p. 562, 1789. Given to Latham's description only.
- Norfolk Island Petrel, Phillip, Voyage to Botany Bay, p. 161, and pl., 1789. Norfolk Island.
- Bird of Providence, Hunter, Hist. Journal, pp. 181-2, 315, 1793. Norfolk Island.

- Mount Pitt Bird, Collins, Account. New South Wales, 2nd ed., pp. 67, 125, 133, 178, 1804.
- Procellaria solandri* Gould, Ann. Mag. Nat. Hist., vol. xiii., p. 363, 1844. Bass Strait. May 13, 1839.
- Procellaria philippii* Gray, Ibis., 1862, p. 246. Name given to the Norfolk Island Petrel figured in Phillip's Voyage.
- Oestrelata solandri* Godman, Monog. Petrels, p. 219, pl. 61, 1908. Unique type, figured for first time in colour.
- Oestrelata neglecta* Basset Hull, Proc. Linn. Soc. N.S.W., vol. xxiv., p. 649, 1910. Lord Howe Island.
- Oestrelata montana* Basset Hull, Proc. Linn. Soc. N.S.W., 1910, vol. xxxv., p. 785, pl. xxiv., xxv., 1911. Lord Howe Island.
- Pterodroma melanopus* Mathews, Birds Austr., vol. ii., p. 141, pl. (84), 1912. Complete account. Hull's type figured in colour.
- Pterodroma melanopus* Mathews & Iredale, Manual Birds Austr., vol. i., p. 34, 1921. Short technical account.

A couple of minor points call for attention. The first is the vernacular name, Brown-headed Petrel, used by Mathews, Mathews & Iredale, and in the Official Check List, 2nd edition. It is a senseless name in connection with this bird, and should be rejected, but what alternative to propose is perplexing. Already there are available, Norfolk Island Petrel, Phillip's Petrel, Solander's Petrel, and Lord Howe Petrel, and as alternatives may be added Mottled-face Petrel or, better, the Providence Petrel. The bird is known to the Lord Howe Islanders as the "Big Hill Mutton Bird."

The second is the usage of the genus name *Pterodroma*. After the validity of usage of this name had been accepted by British, American and Australian workers, Oliver has re-opened the matter (*Emu*, vol. xxviii., p. 128, 1928) through a misreading of Article 28 of the Zoological Code, which does not apply, and consequently there is no necessity to consider Oliver's argument.

I may here note that on Manly Beach on December 24, 1928, I had picked up a specimen of the Little Grey Noddy (*Procelsterna albivitta* Bonap.) full particulars of which will be published in the *Emu* of April 1, 1929.

OBITUARY.

FREDERICK FLOWERS.

Portrait, Plate xli.

Born at Wollstanton, Staffordshire, England, 1864.

Died at Sydney, New South Wales, 14th December, 1928.

After his arrival in Australia as a young man, Frederick Flowers began to interest himself in industrial union and political affairs. He was president of the Australian Labour Party for many years, and was appointed a member of the Legislative Council of New South Wales in 1900. In 1910 he became representative of the Government in the Council, as a member of the Holman Government. In this year he was appointed one of the Government representatives on the Council of the Royal Zoological Society. In this capacity he took an active interest in the affairs of the Society, and particularly in the question of providing a more suitable site for the Zoological Gardens than the one at Moore Park. When the present site was eventually dedicated by the Government and vested in Trustees, Mr. Flowers was selected as one of such Trustees and their Chairman. From this time onwards he devoted practically the whole of his leisure to the preparation and building up of the Taronga Zoological Park. His practical knowledge and abundant energy were of great value to the project, and his position as a member of the Government in the earlier stages was of considerable weight in

the matter of finance. In 1914 he was appointed President of the Legislative Council, a position that allowed him abundant leisure in the periods during which Parliament was in recess, leisure which he devoted wholeheartedly to Taronga Park. The Aquarium was built under his personal supervision, and practically on his plans. During the last two years of his life his failing health frequently interfered with his work, but to within two months of his death he was in almost constant daily attendance at the Park. The success of Taronga Zoological Park as a pleasure and educational resort, and also financially, is due largely to the disinterested labours of the Honorable Frederick Flowers, M.L.C., to whom the beautiful Gardens will long stand as a monument.

GEORGE WILLIAM McANDREW.

Born at Sydney, New South Wales, March, 1875.
Died at Shellharbour, 2nd November, 1928.

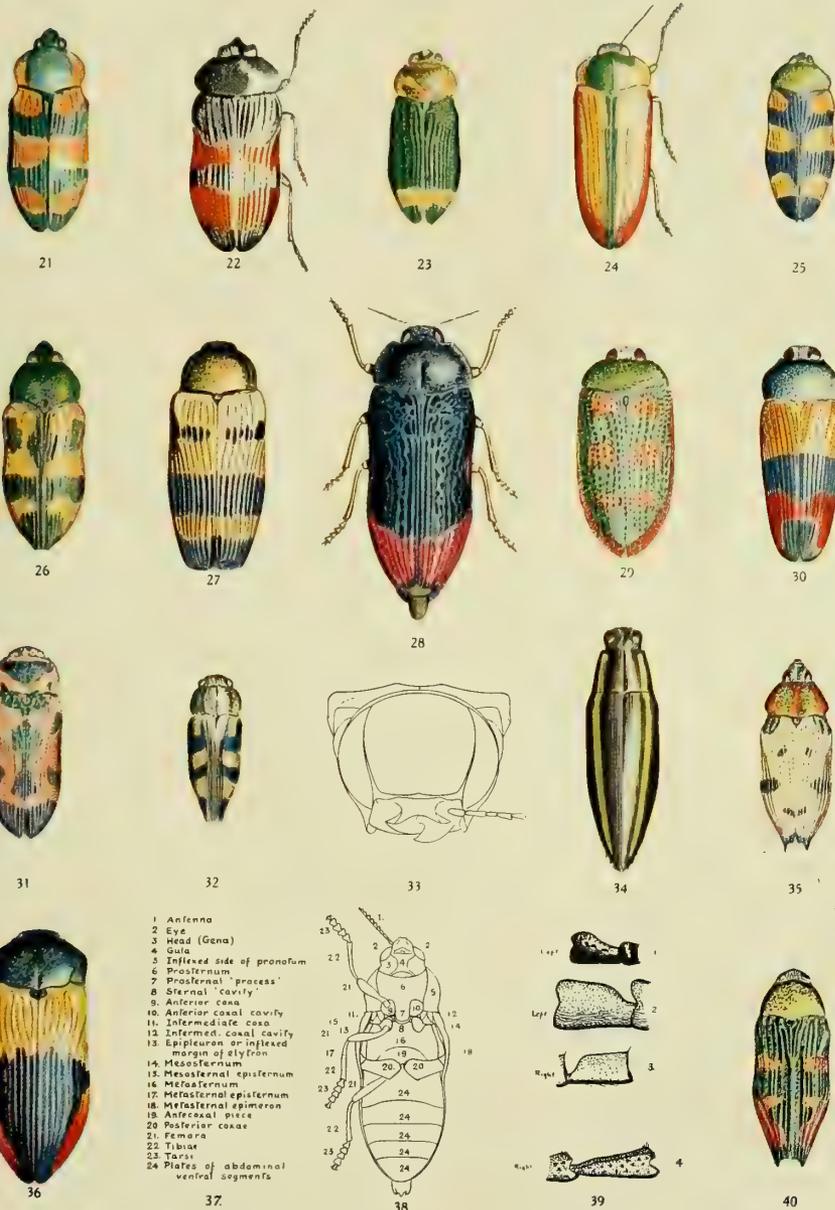


A born naturalist, George McAndrew employed the little leisure available to a working man in the collection of the shells so plentiful on the coast near his residence at Shellharbour. His early efforts resulted in the accumulation of many rare and beautiful marine molluscs, particularly of the attractive family *Cypraeidae*. In 1920 he made the acquaintance of the late Robert Grant, Taxidermist at the Australian Museum, who interested him in the more scientific pursuit of his hobby. From this time McAndrew became an enthusiastic worker for the Museum, spending his week-ends in the water amongst the rocks, gleaning many rare things and new records of species previously known only from more northerly localities. In April, 1926, he was elected Honorary Correspondent of the Museum in recognition of his valuable services as a voluntary collector, a distinction of which he was very proud. His keen naturalist's eye was unailing in detecting a new species or record, and his toil-worn hands were as delicate and skilful as a woman's in the preparation of specimens, either for preservation in alcohol or for the cabinet.

George McAndrew was one of nature's gentlemen and an intense lover of all objects of natural history study, but particularly of the Loricata group of the Mollusca, his collection including one named after him, *Notoplax macandrewi*.



AUSTRALIA BUPRESTIDAE.



- 1 Antenna
- 2 Eye
- 3 Head (Gena)
- 4 Gula
- 5 Inflated side of pronotum
- 6 Prosternum
- 7 Prosternal 'process'
- 8 Sternal 'cavity'
- 9 Anterior coxa
- 10 Anterior coxal cavity
- 11 Intermediate coxa
- 12 Intermed. coxal cavity
- 13 Epipleuron or inflated margin of elytron
- 14 Mesosternum
- 15 Mesosternal episternum
- 16 Mesosternum
- 17 Mesosternal episternum
- 18 Mesosternal epimeron
- 19 Antcoxal piece
- 20 Posterior coxae
- 21 Femora
- 22 Tibiae
- 23 Tarsi
- 24 Plates of abdominal ventral segments



41



42



43



44



45



46



47



48



49



50



51



52



53



54



55



56



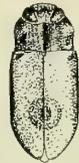
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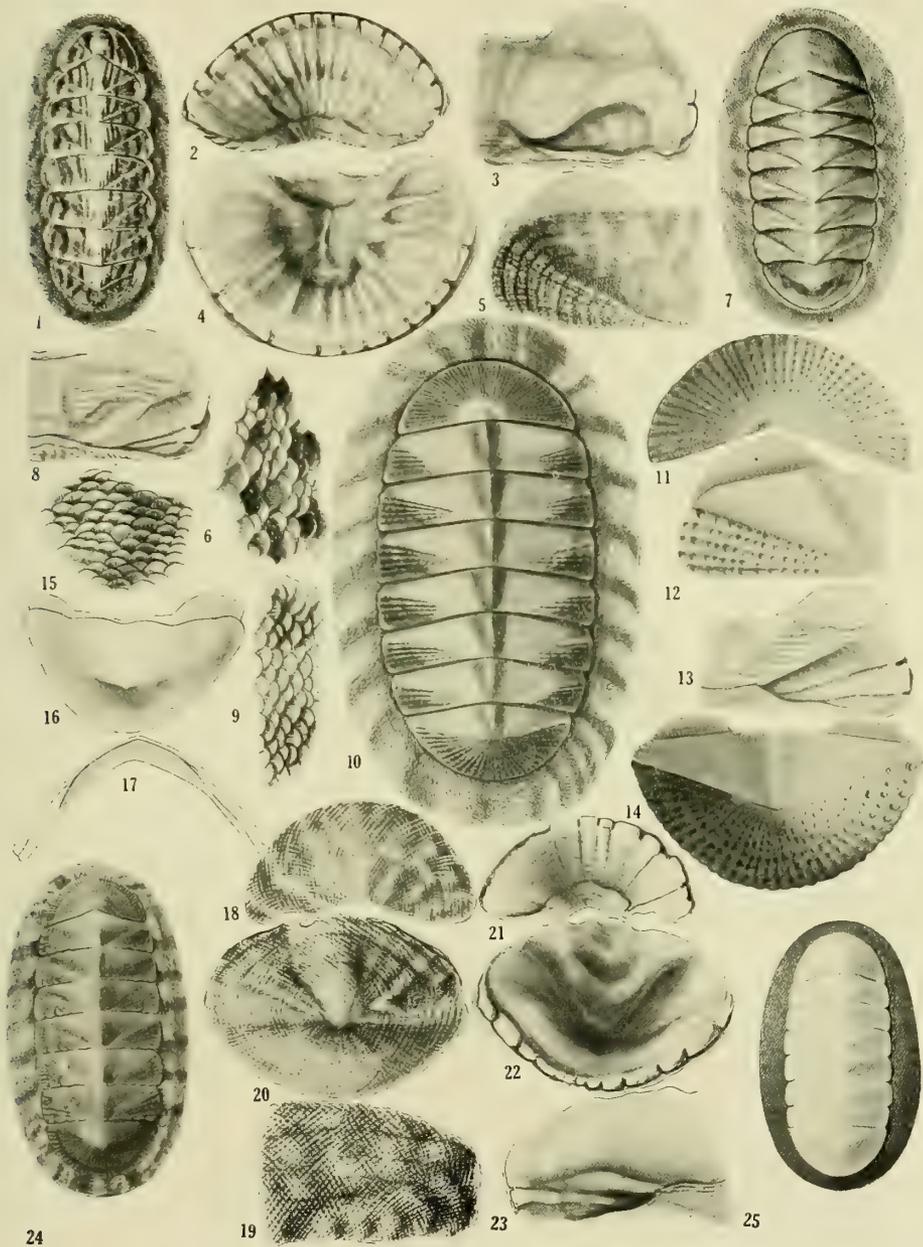
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59



60

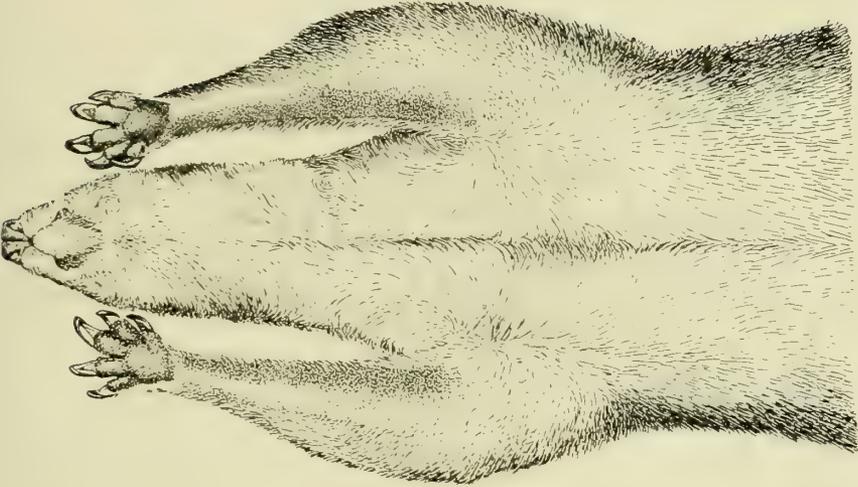


NEOZELANIC LORICATES.

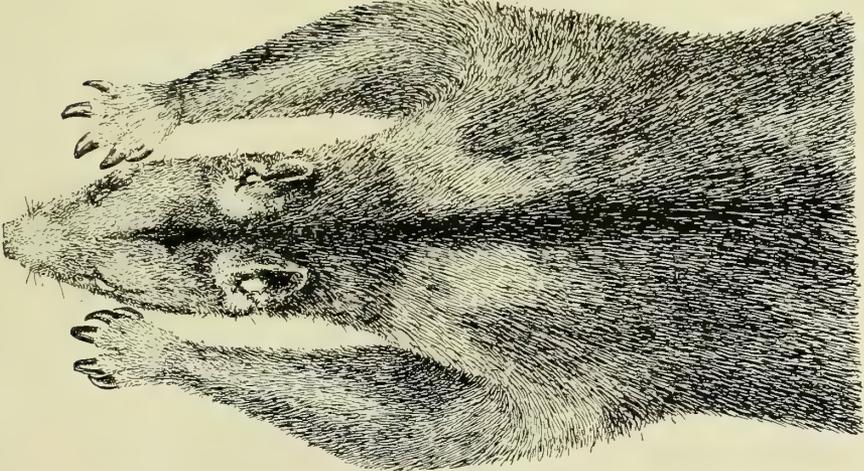


EGG-MASS OF *Crinia laevis* Günther.

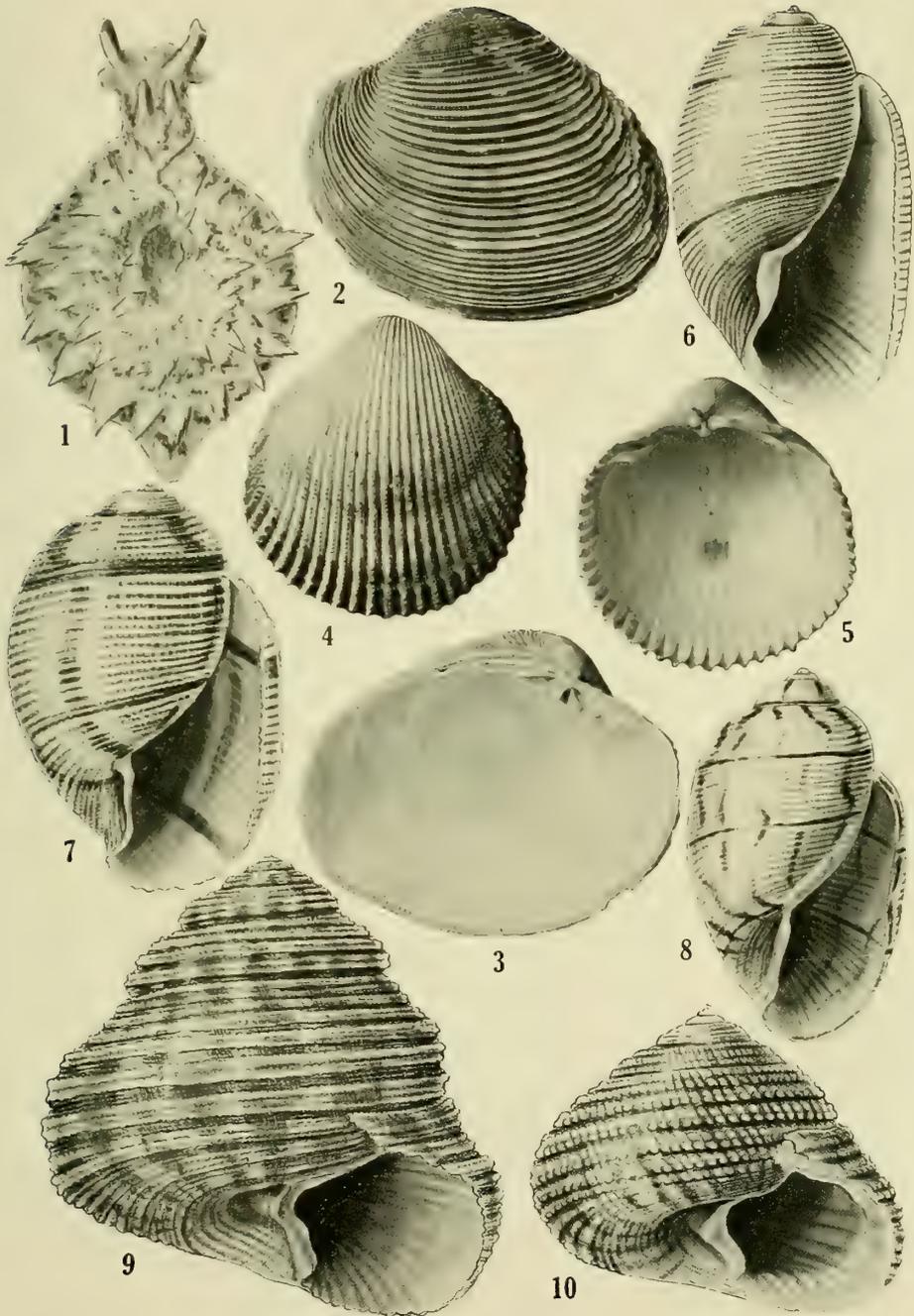
Photograph by Frank N. Blanchard.



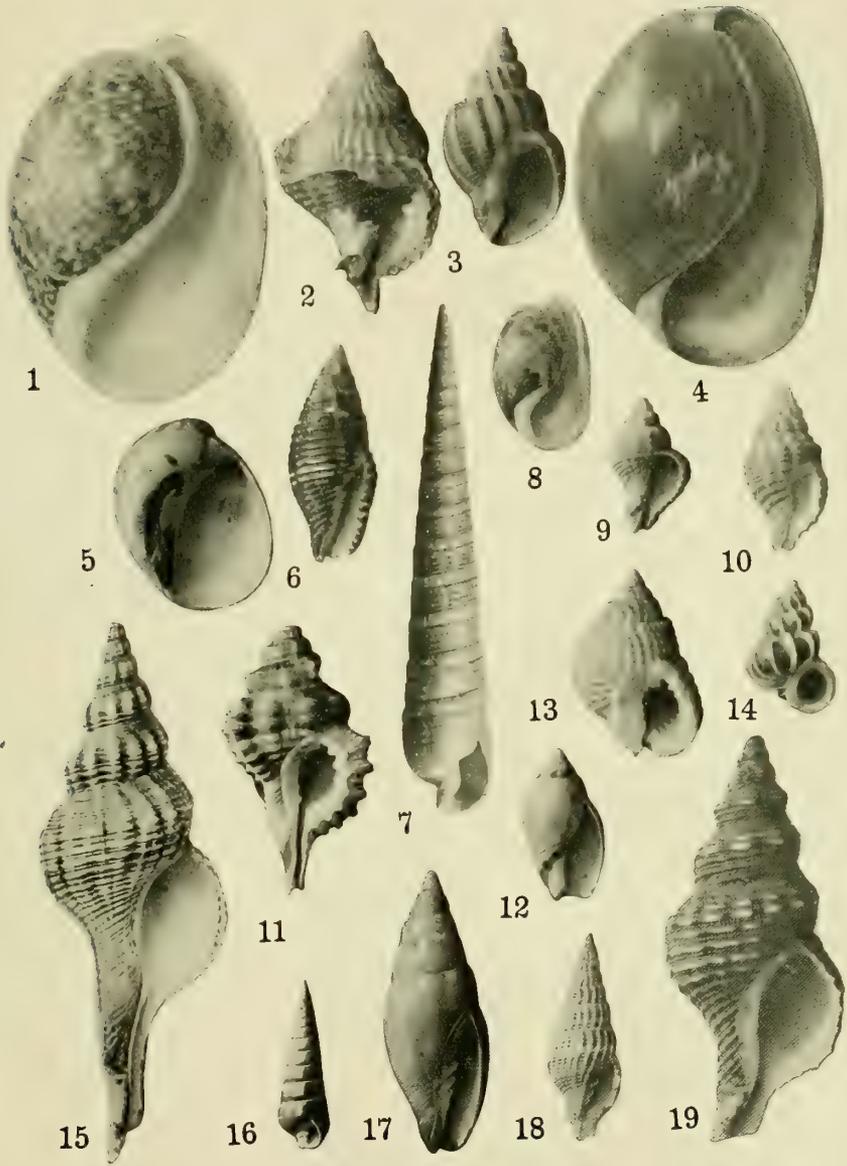
E. King



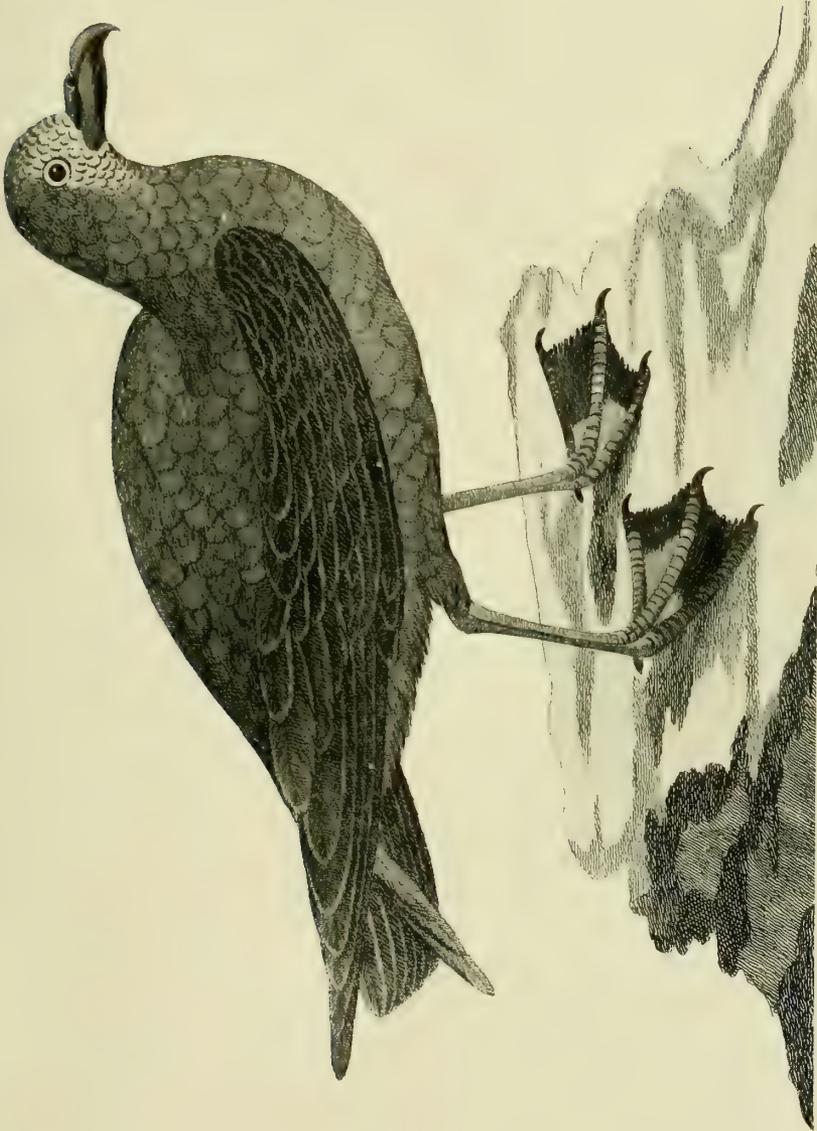
RUFOUS-BELLIED WALLABY, *Thylogale billardieri* Desmarest.



AUSTRALIAN MOLLUSCS.



AUSTRALIAN MOLLUSCS.



THE "BIRD OF PROVIDENCE."

Copied from Phillip's "Voyage to Botany Bay" (1789).



THE LORD HOWE ISLAND PETREL.

From a photograph by Roy Bell.



Yours Faithfully,

David Coleridge

Chairman.

Royal Zoological Society of New South Wales

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