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JOSEPH GARNETT WOOD, D.SC., F.A.A.

Summary

JOSEPH GARNETT WOOD, D.Sc., F.A.A.

Professor of Botany, University of Adelaide

1900–1959

Joseph Garnett Wood's most tangible memorials are the Botany School of the University of Adelaide with its graduates of the last thirty years, together with a body of research work in plant physiology and ecology. More diffused is his share in the building up of science in Australia.

The salient features of his life are these. He was born and bred in South Australia. After a distinguished undergraduate course in the University of Adelaide and a two years' post-graduate period at Cambridge University, he returned to Adelaide in 1927 as Lecturer in Botany. This was the beginning of his thirty-two years in charge of the Adelaide University Botany Department, so that in its present form it is largely his creation.

The measure of Wood's stature among his scientific colleagues was firstly his appointment in 1948 to the Interim Council working to establish the *Australian National University*, and subsequently to its Council (1952-59); secondly, his connection with the *Commonwealth Scientific and Industrial Research Organization* as Member of the Advisory Council (1950-56, 1959) and Chairman of the South Australian State Committee (1953-56, 1959); thirdly, and above all, his election as a Fellow of the *Australian Academy of Science* in 1954 and to its Council in 1956-58. These three organizations were founded in Wood's scientific lifetime, the C.S.I.R. (as it was first called) at the dawn of his undergraduate days and the other two institutions in his actively participating years; he found it extremely exciting to share in their work.

His association with our Society, the Royal Society of South Australia, has been a long and profitable one, many of his ecological papers were published in our Transactions and he was a member of the Council for ten years, and President in 1942; he was our representative on the Fauna and Flora Board, and the Society has honoured him with the award of its Verco Medal (1944).

Some of the details of the preceding summary will now be filled in. Joseph Garnett Wood was born in Mitcham, September 2nd, 1900. His father was John Wood, there were two other children, a brother and a sister who survive Joseph. His childhood in South Australia certainly influenced his later work, particularly that in local ecology. He attended the Unley High School from 1913-1916 and matriculated from there with a Government Bursary tenable at the University. He first took an Honours B.Sc. Degree (1922) in Chemistry under Professor E. H. Rennie, studying also Assaying and Metallurgy, and had come top in first year Botany (John Bagot Scholarship and Medal) when halfway through this chemical, physical and mathematical course. He then turned from Chemistry, in which he had been an honours student and a demonstrator, to Botany, where he became a demonstrator in 1923, simultaneously studying the second and third year botany courses and then lecturing to the senior students in plant physiology and also to certain elementary students. In addition, he carried out research on photosynthesis (John L. Young post-graduate Scholarship) and water relations in plants.

At that time (1925), the University's Koonamore Vegetation Reserve in the arid saltbush region south of Lake Frome was newly established and Wood collaborated in the work. He evidently found Professor T. G. B. Osborn's Botany Department a satisfying and stimulating place, and plant biochemistry and

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physiology offered him a more challenging field than did pure chemistry; of course, he always retained the stamp of his extensive grounding in chemistry. Osborn welcomed such a man in his Department, and probably exercised a critical influence in Wood's choice of a botanical career.

After two or three years in the Botany Department, he was awarded an 1851 Exhibition Scholarship as a result of work on the transpiration of arid plants, and went as a Research student to Gonville and Caius College, Cambridge University. Here he came under the influence of Dr. F. F. Blackman and G. E. Briggs in Plant Physiology, and Professor Sir Gowland Hopkins and the Hon. Mrs. Onslow in Plant Biochemistry; he also served as Junior Demonstrator in Botany to first year students at Cambridge. He was now highly trained in plant chemistry and physiology, but he still retained a strong interest in plant ecology, in which he had collaborated earlier with Professor Osborn. After making the most of his two years abroad with some travel on the Continent during vacations and visits to six research institutions in Great Britain, upon which he reported to the Empire Marketing Board and to C.S.I.R. in Australia, he returned to Adelaide late in 1927 to take up a lectureship in Botany. In 1928, when Osborn transferred to the Chair in Sydney, Wood became Lecturer-in-Charge of the Adelaide Department and had nearly all the teaching on his hands.

He had fine qualities as a teacher and in his early years taught over the whole range of his subject. Latterly he lectured to his students in plant physiology, directed most of the research students and though he had delegated the routine teaching in ecology, he was an examiner for a majority of the theses in plant ecology written in Australia for higher degrees; he also administered his Department very smoothly. To his research students, he was always very stimulating; part of the story of their collaboration with him appears in the appended list of publications, but this is by no means a record of all his best students, some of whom were attracted from overseas. His influence will live through his students.

He saw his position very clearly as intermediate between the school life and the professional life of his students, and he interested himself energetically in the school curriculum for science as well as in the spheres which claimed his best students after graduation, turning them to the vanguard of Australian botanical research and teaching whenever he could. Few persons come to know the quality of young graduates so well as their teachers, and Wood had a fine appreciation of the potentialities of his students and the way in which they could be developed and strengthened by opportunities and responsibilities. He took a long view of their careers and was always ready to help them with his influence at the critical turning points of their lives in steering them to a post where the greatest mutual benefit might come to them and their country. He had a very strong belief that Australia's science could be developed best by her own University graduates, with opportunities for them of experience abroad. This part of his activities probably gave a great deal of satisfaction to Wood in his later years. It enabled him to realise many of his ambitions in an impersonal way and was certainly one of his strongest reasons for participation in the work of so many important but time-consuming, high-level committees, to the detriment of his personal research work (see appendix). Also, he developed undoubted genius for committee work with his balanced, agile, wonderfully disciplined mind, his capacious and retentive memory, his very equable temperament together with a genuine understanding and sympathy for opposing points of view. He apparently really loved such large-scale planning and had a remarkable facility for seeing the core of any problem free of its trimmings; of a sanguine outlook and an abiding sense of proportion, he always had the major goals in mind, and was not ruffled by the inevitable miscarriage of details, a philosophy not achieved by many.

His bent for the ecological approach in botany, combined with the physiological and biochemical one, becomes crystal clear when one realises the cast of his mind with its natural aim for fundamentals, its skill and efficiency in controlling volumes of detail and rising above them. He was probably the most influential Australian ecologist of his time.

Wood was promoted to the long-vacant Chair of Botany in 1935, after some seven years as Lecturer-in-Charge, it was an example of an Adelaide graduate rising from the ranks in his own university; he had received the D.Sc. (Adelaide) in 1933. Such appointments have always been rare in Adelaide, as they are in a majority of other universities, and they usually cause comment when they are made; this attitude no doubt acted as a spur to Wood, and those early years were productive of much personal or collaborative research with various colleagues who stimulated his thinking; his own students were, of course, drawn into these projects to their considerable advantage and many have since made their mark.

Now that we have a view of his whole career, it can be seen that the local appointment was amply justified; it produced some fine research work in local ecology which was a tradition that could only develop locally and in a gradual way with the considerable personal continuity which we have been so fortunate as to have in the Adelaide Botany School, beginning with the youthful and vigorous Professor T. G. B. Osborn from Manchester in 1912-27. His student Wood next directed the destinies of the Department for 32 years with gradual developments of policy rather than major changes.

In these days, when so much store is set on a wide experience in more than one university, what can we learn from this career which continued from personal choice in one department for thirty-two years? One comment is that Australia needs this kind of continuity in her formative period, and the deep understanding of national needs that develops from it; Wood has undoubtedly served this ideal very well, and in later years it took with him the place of the more closely personal ambitions of youth. A pertinent criticism of steady careers of this kind is that the individual does not have breadth of outlook. The valuable contacts made by scientific literature, however, cannot be too greatly emphasised, and from his earliest years Wood worked to build up the highest standard in young Australian scientific journals; he was on the Editorial Board of the *Australian Journal of Experimental Biology and Medical Science* from 1932-1959, this very successful journal was founded in Adelaide (1924) and later sponsored by the University; he laboured most strenuously for the *Australian Journal of Scientific Research* (as it was first called) published by C.S.I.R.O. in various subjects, from its beginnings in 1947 until his death. He contributed frequently to the first journal until 1947, after that sending his plant physiology papers to the new C.S.I.R.O. journals. He was also on the Editorial Board of a Dutch journal, *Plant and Soil.*

Wood was not narrow in outlook; he went abroad four times, first to Cambridge University as a Ph.D. student; second to travel in the long vacation and study the tropical vegetation in the Malay Archipelago, much to the enrichment of his ecology lectures; third, on study leave in 1938 for eleven months to Leiden and Cambridge; fourth, again on study leave in 1953 for five months to Holland and the United Kingdom especially to see work dealing with the mineral nutrition of plants, he also represented his University on this occasion at the Seventh Congress of Universities of the Commonwealth.

In his own University his ability and long experience were invaluable, he held some very responsible positions and was senior professor for his last two years. As Chairman of the two most important research committees and member of three others, he had great influence on research both within the University and in its momentous and exacting dealings with the national commissions set up since 1950 to enquire into the present and future needs of Universities, viz. the Murray Committee and subsequently the Australian Universities Commission, it was he who prepared the case for a greatly increased grant to research.

The main developments in the Botany Department during Wood's 32 years were as follows. The Staff at first consisted of one lecturer (himself), a secretary-technician and a very few piece-work demonstrators recruited from among post-graduate students and even undergraduates. This finally increased to a professor and eight full-time graduates plus technical assistants. Student numbers had risen accordingly and included an increased percentage of agricultural students as this new Faculty developed, also a few forestry students. First year courses in biology were gradually planned and developed largely by Wood, and carefully integrated with the introduction of biology more generally into the secondary schools, a step also chiefly initiated by him, these biology courses now meet the needs of large numbers of students; he thought of biological understanding in terms of human happiness. The teaching of mycology and plant pathology had been delegated to the Waite Institute before Wood's time, and in 1952 the teaching in genetics was assumed by a new Department in that subject, the first such University Department in Australia being in Adelaide.

Other outstanding developments in this period were the steady building up of the courses and research in plant physiology; the continuation of the emphasis on plant ecology, especially of South Australia, relating it to some serious soil deficiencies typified by heath country of the Ninety Mile Plain; continued observations at Koonamore Vegetation Reserve; much specialist work on the taxonomy and ecology of marine algae; the successful completion of the second edition of J. M. Black's *Flora of South Australia* posthumously; the foundation of a State Herbarium of South Australia in connection with the Botanic Garden, the nucleus being the University collections on long-term loan and the Schomburgk collection originally at the Botanic Garden.

There was also expansion of space. In 1939, just before the outbreak of World War II, the Benham Building was erected, largely designed by Wood and shared equally by the Departments of Botany and Zoology. In his last years Wood was again working hard at various alternative plans for urgent further expansion of space for his Department.

His own research work, in brief, was firstly in Australian plant ecology, particularly of South Australia, with investigations into the physiology and regeneration of arid plants; secondly, in detailed studies of the paths of plant metabolism, particularly those leading from nitrogen to protein, and of the relationship to them of some vital plant processes.

He published one book, *The Vegetation of South Australia* (1937), now out of print, and over fifty papers; his work is surveyed in the analytical bibliography appended to the present account. Death interrupted his work on the Coorong and its waters.

In 1930 he married Joan Hazel, and she shared his arduous career with devotion and loyalty, three daughters were born to them; all survive him. His family life was characterized by happiness, hard work and simplicity, but not austerity; visiting colleagues and staff were delightfully entertained in the family circle at his home. The Woods had extracted tremendous pleasure in the last few years from making a lovely hillside garden at their new home, rapidly and with characteristic industry. Another of their pleasures was painting and the world of art, especially Australian art. Wood's recreation came largely from various aspects of his work, whether it was in his garden, an ecological trip in the country, travel abroad or in the choice of his friends, though his circle of friends was by no means narrow; he enjoyed good company and conversation and understood very well how to be gay.

To celebrate his Silver Jubilee in the Chair of Botany in the middle of 1959, there were two happy parties which now are particularly precious memories; one at his home, for the Botany Department Staff, the other at the University for him as a gesture from many past and present students and staff, when the history of his Department was revived and he was presented with a silver salver. His teacher, Professor Osborn, now retired and again a member of the Adelaide Department, was present on both occasions.

Wood had generally good health and powers of endurance, but the problem that was overtaking him in his last weeks was how to conduct life to suit his energetic mind, quick actions and code of obligations, with a heart disease. He had a way of accepting graciously what fate meted out to him, but his friends saw vividly some very irksome and laborious years ahead of him at the very least. His much regretted sudden death on December 8, 1959, at the age of 59, undoubtedly spared him great unhappiness; his life has been a very full one, to the great benefit of his University, his country and the science of botany. But J. G. Wood was more than a distinguished botanist, he was modest, kindly, tolerant and wise; it is a rare privilege to have been his student and colleague and to have seen his character grow to a rich maturity.

> His life was gentle; and the elements
> So mix'd in him that Nature might stand up
> And say to all the world, "This was a man!"

C.M.E.

AWARDS, SOCIETIES AND OFFICES

1920.	John Bagot Scholarship and Medal in Botany.
1923.	John L. Young Scholarship for Post-graduate Research, on *Photosynthesis in plants*.
1925.	Scholarship of the Exhibition of 1851, for research in Plant Physiology.
1922.	Degree of B.Sc., Adelaide. (Honours Chemistry.)
1928.	Degree of M.Sc., Adelaide. (Subject: *Transpiration of arid Australian plants*.)
1932.	Degree of Ph.D., Cambridge. (Subject: *Photosynthesis*.)
1933.	Degree of D.Sc., Adelaide. (Subject: *Arid Plants*.)
1923–59.	Fellow, Royal Society of South Australia.
1946–59.	Fellow, Royal Australian Chemical Institute.
	Fellow of Aust.-N.Z. Assoc. Advanc. Sci. and Member of Qualification and Mueller Medal Committees.
1952–59.	Fellow, Royal Society of Arts, London.
	Medical Sciences Club, South Australia.
	Agricultural Sciences Club, Australia.
	Field Naturalists' Society of South Australia.
1944.	Verco Medal, Royal Society of South Australia.
1952.	Clarke Memorial Medal, Royal Society of New South Wales.

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1932–59.	Editorial Board, *Australian Journal of Experimental Biology and Medical Science*.
1937–40 } 1946–48 }	Dean, Faculty of Science.
1949–59.	Waite Committee (recommends all academic appointments at Waite Research Institute).

1956–59.	Chairman, Research Executive Committee and Chairman, Board of Research Studies.
	Member, Public Examinations Board.
1958–59.	Member, Equipment Committee.
1958–59.	Vice-Chairman, Education Committee.

GENERAL.

1939.	President, Section M. Aust.-N.Z. Assoc. Advanc. Sci.
1939–59.	Member, Board of Commonwealth Forestry School, Canberra.
1938–48	Member, Council, Royal Society of South Australia.
1942	President, Royal Society of South Australia.
1942–59.	Member of Board, Girton Girls' School.
1947–57	Editorial Board, *Australian Journals of Scientific Research*, C.S.I.R.O. (Foundation Member.)
1957–59	Chairman, Board of Standards, *Australian Journals* . . . . (C.S.I.R.O. and Australian Academy of Science.)
1950–59.	Editorial Board, *Plant and Soil* (Holland).
1948–51	Member, Interim Council, Australian National University.
1952–59	Member, Council, Australian National University.
1950–59.	Member, Noxious Weeds Committee, South Australia.
1950–59.	Member, Nuffield Fellowship Selection Committee (Australia).
1950–56, 1959	Member, Advisory Council, C.S.I.R.O., Australia.
1953–56, 1959	Chairman, South Australian State Committee, C.S.I.R.O.
1952–59.	Member, Arid Zone Biology Panel, U.N.E.S.C.O.
1953–59.	Member, Board of Governors, Botanic Garden, South Australia.
1954–59	Fellow, Australian Academy of Science.
1956–58	Member, Council, Australian Academy of Science.
1958–59.	First President, Australian Society of Plant Physiologists.
1940–59.	Member, Fauna and Flora Board of South Australia (representing Royal Society, South Australia).

Delegate to:

1949.	7th Pacific Science Congress, New Zealand (representing Australia).
1952.	British Commonwealth Scientific Conference (representing Australian National Research Council).
1953.	Seventh Congress of Universities of the Commonwealth (representing University of Adelaide).

Obituary notices have appeared in the following publications:

Nature, **185**: 4709. January 1960.
Aust. J. Science, **22**: 10. April 1960.
Australian Academy of Science Year Book, 1960.

ANALYSIS OF PUBLICATIONS[1]

Some 57 publications are grouped under ten headings; there are 26 items in ecology and 31 in plant physiology, but these two classes merge.

A. PLANT ECOLOGY (26 contributions in five groups).

(1) *The Halophytic Habit*

Three early papers of a very apt student in collaboration with his professor.

1923 (a) (Appendix to paper by T. G. B. Osborn.) Analyses of soil samples from Pearson Islands. *Trans. Roy. Soc. S. Aust.*, 47, pp. 111-14.

(b) (With T. G. B. Osborn.) Zonation of vegetation in the Port Wakefield District. *idem*, pp. 244-254.

(c) (With T. G. B. Osborn.) Some halophytic and non-halophytic plant communities in arid South Australia. *idem* 47, pp. 388-99.

(2) *Physiology of Xerophytism in Australian Plants*

Eight independent early papers, 1923-39, the prelude to Wood's increasingly fundamental approach to plant tolerances.

[1] The records of the Botany Department, University of Adelaide, were freely available to the writer in the compilation of this paper.

1923. Transpiration of some arid plants . . . . with notes on anatomy. *Trans. Roy. Soc. S. Aust.*, 47, pp. 259-278.
1924. Relations between distribution, structure and transpiration of arid South Australian plants. *ibid.*, 48, pp. 226-235.
1925. Selective absorption of chlorine ions; and absorption of water by leaves in genus *Atriplex*. *Aust. J. Exp. Biol.*, 2, pp. 45-56.
1929. The relation between water content and amount of photosynthesis. *Aust. J. Exp. Biol.*, 6, pp. 127-131.
1932. Carbohydrate metabolism of plants with tomentose, succulent leaves. *Aust. J. Exp. Biol.*, 10, pp. 89-95.
1933. Carbohydrate changes in the leaves of sclerophyll plants. *Aust. J. Exp. Biol.*, 11, pp. 139-150.
1934. Stomatal frequencies, transpiration and osmotic pressure. *J. Ecol.*, 22, pp. 69-87.
1939. The plant in relation to water. *Rep. Aust.-N.Z. Assoc. Advanc. Sci.*, 24, pp. 281-290. (Presidential Address, Section M.)

(3) *Koonamore Vegetation Reserve (the Arid Flora Research Station of the University of Adelaide)*

Four major joint papers (1931-1936) and one minor (1947), the reports of extensive field work at Koonamore with some long-term observations. The latter are still being continued.

1931. (With T. G. B. Osborn and T. B. Paltridge.) The autecology of *Stipa nitida*. *Proc. Linn. Soc. N.S.W.*, 56 (4), pp. 299-324.
1932. (With T. G. B. Osborn and T. B. Paltridge.) Growth and reaction to grazing of the perennial saltbush, *Atriplex vesicarium*. *Proc. Linn. Soc. N.S.W.*, 57 (5-7), pp. 377-402.
1935. (With T. G. B. Osborn and T. B. Paltridge.) The climate and vegetation of the Koonamore Vegetation Reserve to 1931. *Proc. Linn. Soc. N.S.W.*, 60 (5-6), pp. 392-427.
1936. Regeneration of the vegetation on the Koonamore Vegetation Reserve. 1926-1936. *Trans. Roy. Soc. S. Aust.*, 60, pp. 96-111.
1947. (With K. Woodroffe and H. C. Trumble.) South Australia, 25-29, in *The use and misuse of shrubs and trees as fodder*. Imperial Agricultural Bureaux, Joint Publication No. 10. Aberystwyth. Great Britain.

(4) *Descriptive and Analytical Ecology*

Two early independent papers and one book (1937) which is still the best available treatment of the subject, together with four contributions of Wood's final decade to large collaborative works about Australia.

1929. Floristics and ecology of the mallee. *Trans. Roy. Soc. S. Aust.*, 53, pp. 359-378.
1930. Analysis of the vegetation of Kangaroo Island and the adjacent peninsulas. *ibid.*, 54, pp. 105-139.
1937. The vegetation of South Australia. 1-164. Adelaide: Govt. Printer. (A *Handbook of the Flora and Fauna of South Australia* series.) Out of print.
1949. Vegetation of Australia. Chapter VI in *The Australian Environment*. Ed. 1. Melbourne: C.S.I.R.O.
1950. *Idem.* Ed. 2. Without revision. Melbourne: C.S.I.R.O.
1960. (With R. J. Williams.) *Idem.* Ed. 3. Much revised. Melbourne: C.S.I.R.O.
1958. The vegetation of South Australia. Chapter 9 in *Introducing South Australia*. Ed. R. J. Best for Aust.-N.Z. Assoc. Advanc. Sci. Adelaide: Govt. Printer.
1959. The phytogeography of Australia (in relation to radiation of *Eucalyptus*, *Acacia*, etc.). Ch. XVIII in *Biogeography and Ecology in Australia*. Ed. A. Keast and others. Den Haag. W. Junk. (Monographiae Biologicae. Vol. 8.)

(5) *Ecological Concepts*

Three philosophical studies demonstrating the author's pre-occupation with fundamentals, based on personal experience.

1937. (With L. G. M. Baas Becking of Leiden.) Notes on convergence and identity in relation to environment. *Blumea.*, 2, pp. 329-338.
1939. Ecological concepts and nomenclature. *Trans. Roy. Soc. S. Aust.*, 63 (2), pp. 215-223.
1947. (With R. L. Crocker.) Historical influences on development of South Australian vegetation communities and their bearing on concepts and classification in ecology. *ibid.*, 71 (1), pp. 91-136.

B. Plant Physiology and Biochemistry (31 papers in 5 groups).

(6) *Studies on the Nitrogen Metabolism of Plants*

Nine papers (1933-48) chiefly in collaboration with his colleague Petrie of the Waite Institute until the death of the latter, then in collaboration with four of Wood's students. The 1938 papers were published outside Australia in the *Annals of Botany*, the remainder all in Australia.

1933. Nitrogen metabolism of leaves of *Atriplex nummularium*. *Aust. J. Exp. Biol.*, 11, pp. 237-252.

1938. (All with A. H. K. Petrie.):

I. Relation between content of proteins, amino-acids and water. *Ann. Bot. N.S.*, 2, pp. 33-60.

II. Inter-relations among soluble nitrogen compounds, water and respiration rate. *idem.*, pp. 729-750.

III. Effect of water content on relation between proteins and amino-acids. *idem.*, pp. 887-898.

1939. (With G. L. Amos.) Effects of variation in nitrogen supply and water content on carbohydrates in leaves of grass plants. *Aust. J. Exp. Biol.*, 17, pp. 285-320. (No. IV in this seriees was a paper by Walkley and Petrie, 1941, *Ann. Bot.* N.S.5, pp. 661-673.)

1942. V. (With A. H. K. Petrie.) Relation of carbohydrate content to protein synthesis in leaves. *Aust. J. Exp. Biol.*, 20, pp. 249-256.

VI. Inter-relations among respiration rate, carbohydrates and soluble nitrogen compounds in leaves. *idem.*, pp. 257-262.

1948. VII. (With M. R. Hone, M. E. Mattner and C. P. Symons.) Toxicity of some oximes and oximino-acids to *Azotobacter*. *Aust. J. Sci. Res.* B. 1, pp. 38-49.

VIII. (With M. R. Hone.) Utilization of α-oximino-carboxylic acids by oat plants. *idem.*, pp. 163-175.

(7) *The Metabolism of Leaves*

Eight papers (1941-45), chiefly on starving leaves with his student and colleague, Miss Cruickshank and some other students. All these were published in *Aust. J. Exp. Biol.* (Adelaide).

1941. Relations between respiration rate and metabolism of carbohydrate, protein, and organic acids in leaves. *Aust. J. Exp. Biol.*, 19, pp. 313-321.

1943. (a) (By the late A. H. K. Petrie and J. I. Arthur, compiled by J. G. Wood.) *Physiological ontogeny in the tobacco plant.* The effect of varying water supply on drifts in dry weight, leaf area and various components of leaves. *idem.*, pp. 191-200.

Metabolism of Starving Leaves.

1943. (b) I-III. (With D. H. Cruickshank and R. H. Kuchel.) I. The nature of respiration rate/time curves in air and in nitrogen and their relation to carbohydrates. II. Changes in amounts of total and chloroplast proteins, chlorophyll, ascorbic acid and soluble nitrogen compounds. III. Changes in malic and citric acid contents and their inter-relation with soluble nitrogen compounds. *Aust. J. Exp. Biol.*, 21, pp. 37-53.

1944. IV. (With F. V. Mercer and C. Pedlow.) Respiration rate and metabolism of leaves during air-nitrogen transfers. *ibid.*, 22, pp. 37-43.

V. (With D. H. Cruickshank.) Changes in amounts of some amino-acids during starvation of grass leaves and their bearing on the nature of the relationship between proteins and amino-acids. *idem.*, pp. 111-123.

1945. VI. (With D. H. Cruickshank.) Nitrogen balance sheet and changes in organic acid content during starvation of oat leaves. *ibid.*, 23, pp. 243-247.

(8) *Studies on the Sulphur Metabolism of Plants*

Four papers (1939-41) with his student and colleague, Miss Barrien (*New Phytol.*) and Hanson (*Aust. J. Exp. Biol.*).

1939. (All with B. S. Barrien.) *Studies on sulphur metabolism of plants.* I. The effects of different external concentrations of sulphate, ammonia and cystine on the amounts of sulphur-containing compounds in leaves. *New Phytol.*, 38, pp. 125-149.

II. The effect of nitrogen supply on the amounts of protein sulphur, sulphate sulphur and on the ratio of protein nitrogen to protein sulphur in leaves at different stages during the life cycle. *idem.*, pp. 257-264.

III. On changes in amounts of protein sulphur and sulphate sulphur during starvation. *idem.*, pp. 265-272.

1941. (With E. A. Hanson and B. S. Barrien.) Relations between protein-nitrogen, protein-sulphur and chlorophyll in leaves. *Aust. J. Exp. Biol.*, **19**, pp. 231-234.

(9) *Studies on Some Metallic Micro-nutrient Elements in Plants, viz. Copper, Zinc, Molybdenum and Sodium*

Six papers with advanced students (1946-57). Three of these papers with his student Miss Sibly (1950, '51, '52) were on zinc and the enzyme carbonic anhydrase. Any of these elements except sodium may be deficient in various South Australian soils. All these papers were published in Australia except the letter to *Nature* on sodium.

1946. (With H. B. S. Womersley.) Development and metabolism of copper-deficient oat plants. *Aust. J. Exp. Biol.*, **24**, pp. 79-94.
1950. (With P. M. Sibly.) The distribution of zinc in oat plants. *Aust. J. Sci. Res.*, B. **3**, pp. 14-27.
1951. (With P. M. Sibly.) The nature of carbonic anhydrase from plant sources. *ibid.*, B. **4**, pp. 500-510.
1952. (With P. M. Sibly.) Carbonic anhydrase activity in relation to zinc content. *ibid.*, B. **5**, pp. 244-255.
1954. (With D. Spencer.) The role of molybdenum in nitrate reduction in higher plants. *Aust. J. Biol. Sci.*, **7**, pp. 425-434.
1957. (With P. F. Brownell.) Sodium as an essential micronutrient element for *Atriplex vesicaria* Hew. *Nature*, **179**, pp. 635-636.

(10) *Reviews*

Three independent papers (1942-53), dealing with plant aspects of *sulphur* and *nitrogen*, in important international publications, and one more limited review (1949).

1942. Metabolism of sulphur in plants. *Chronica Botanica*, **7**, pp. 1-4.
1945. Nitrogenous constituents of plants. *Ann. Rev. Biochem.*, **14**, pp. 665-684.
1949. Some aspects of nitrogenous metabolism of plants. Paper presented to *British Commonwealth Specialist Conference in Agriculture—Australia*, 1949. (Plant and animal nutrition in relation to soil and climatic factors.) Melbourne: Cyclostyle.
1953. Nitrogen metabolism of higher plants. *Ann. Rev. Plant Physiology*, **4**, pp. 1-22.

(11) *Miscellaneous*

1929. Physiological derangements in vines subsequent to injury by cold. *Aust. J. Exp. Biol.*, **6**, pp. 103-106.

SOME ACARINA FROM AUSTRALIA AND NEW GUINEA PARAPHAGIC UPON MILLIPEDES AND COCKROACHES AND ON BEETLES OF THE FAMILY PASSALIDAE.

BY H. WOMERSLEY

Summary

The genotype of the genus *Brachytremella* Tragardh 1946 from New Guinea, B. *spinosa,* is redescribed from freshly discovered specimens, and two new species belonging to this genus of the Diarthrophallidae are described from Passalid beetles from Australia. Two other species of the family requiring two new genera, *Lombardiniella* and *Brachytremelloicles,* are also described from Australia from similar hosts. This is the first record of the family of Diarthrophallidae from Australia.

SOME ACARINA FROM AUSTRALIA AND NEW GUINEA PARAPHAGIC UPON MILLIPEDES AND COCKROACHES AND ON BEETLES OF THE FAMILY PASSALIDAE.

by H. WOMERSLEY*

[Read 12 May 1960]

SUMMARY

The genotype of the genus *Brachytremella* Trägårdh 1946 from New Guinea, *B. spinosa*, is redescribed from freshly discovered specimens, and two new species belonging to this genus of the Diarthrophallidae are described from Passalid beetles from Australia. Two other species of the family requiring two new genera, *Lombardiniella* and *Brachytremelloides*, are also described from Australia from similar hosts. This is the first record of the family of Diarthrophallidae from Australia.

Pt. 4.—The family Diarthrophallidae (Mesostigmata-Monogynaspida).

The family Diarthrophallidae and genus *Diarthrophallus* were erected by Trägårdh 1946 for *Uroscius quercus* Pearse *et al.*, 1936. It comprises some small and little known, rather flattish and poorly sclerotised mites found under the elytra of Passalid beetles.

Trägardh recognised three genera *Diarthrophallus* g. nov., *Brachytremella* g. nov. and *Passalobia* Lombardini 1926 as belonging to the family. None of these have hitherto been found in Australia. The genotype of *Brachytremella*, *B. spinosa* Träg. 1946 has only been known from a single female described from New Guinea.

This species has now been rediscovered in New Guinea and is here redescribed from both sexes and the nymph. Two other species of *Brachytremella*, *B. trägårdhi* sp. nov., and *B. bornemisszai* sp. nov. are described from Australia, while two new genera are erected for two other species of the family, *Lombardiniella lombardinii* g. et sp. nov. and *Brachytremelloides striata* g. et sp. nov., both from Australia.

Concurrently with this publication a further study of the Diarthrophallidae as a whole will be presented in which all known genera and species will be considered, with special reference to the genus and species of *Passalobia* described by Lombardini.

Genus BRACHYTREMELLA Trägårdh, 1946.

Trägårdh, I., 1946. Diarthrophallina, a new group of Mesostigmata, found on Passalid beetles. Ent. Medd., **24** (6), p. 384.

This genus was diagnosed as follows:

"Body flat, oval, with six pairs of long plumose bristles of the same type as in *Diarthrophallus*. Tritosternum with praesternal hairs. Legs and gnathosoma of the same type as in *Diarthrophallus*. Epigynial shield not separated from the ventral shield by a suture.

Type *B. spinosa* nov. spec."

* South Australian Museum.

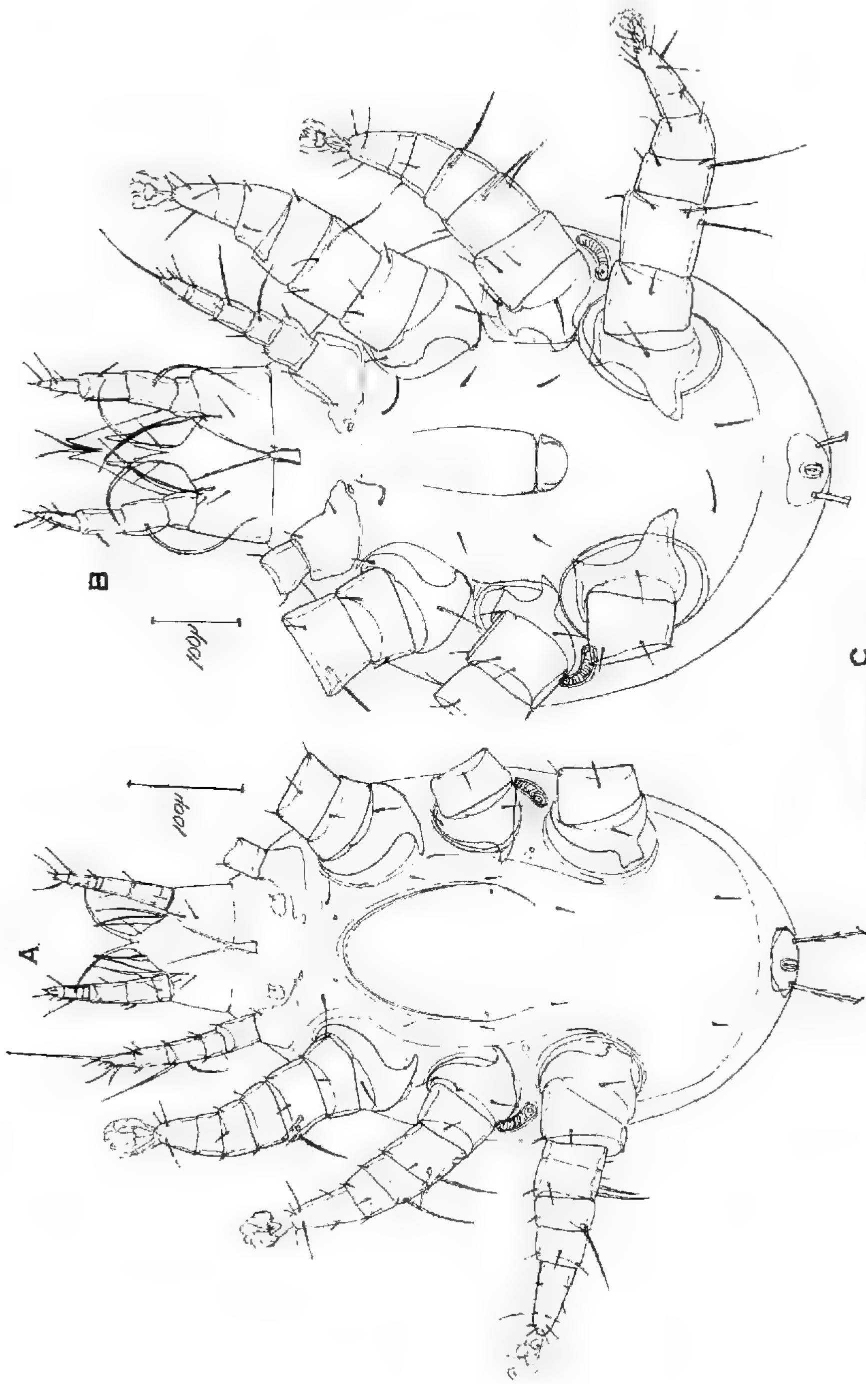

Fig. 1.—*Brachytremella spinosa* Träg. A, female in ventral view; B, male in ventral view; C, mandible of female.

Brachytremella spinosa Träg. 1946.

Text Fig. 1, A-C, 2, A-H.

Trägårdh, I., 1946. Diarthrophallina, a new group of Mesostigmata, found on Passalid beetles. Ent. Medd., 24 (6), p. 384.

This species was described by Trägårdh from a single female found on a specimen of *Protomocerus* sp. (Passalidae) from New Guinea, from the collection of the Zoological Museum of Copenhagen and was made the type of a new genus *Brachytremella*.

Inquiries of my friend, Dr. S. L. Tuxen, of the Copenhagen Museum, have, unfortunately, failed to trace the specimen, nor has it been found amongst the Trägardh material in the Stockholm Museum. It must, therefore, be presumed to be lost.

The genus was separated from *Diarthrophallus* Trägårdh 1946 by Trägårdh, on the fact that posteriorly the genital opening was not marked off by a semicircular suture, and the genital shield was coalesced with the ventrol shield. Although some workers in correspondence have been inclined to disregard this difference, I am convinced, after having examined specimens of *D. quercus* as well as several species of *Brachytremella* and allied genera, including Lombardini's species of *Passalobia*, that the separation from *Diarthrophallus* is valid.

In 1954 I was able to collect Passalids in New Guinea and from them obtained a male, a female and two nymphs of what seem undoubtedly to be Trägårdh's *B. spinosa*. As his description was inadequate and he only gave a sketch figure of the intercoxal part of the ventral surface, the species is now redescribed from the female, and descriptions and figures of the male and tritonymph are given.

Redescription of female. A lightly chitinised flattish species. Idiosoma 526μ long, 351μ wide. Shape broadly oval.

Dorsum.—Fig. 2A; dorsal shield entire, but not completely covering dorsum, surrounded by a narrow strip of cuticle, it is 470μ long by 336μ wide, as stated by Trägårdh it bears a pair of distinct pores on a level with the middle of coxae III and a number of very minute setae (?pores), it is furnished with 5 pairs of long shortly ciliated and apically knobbed setae of which three pairs are lateral on the shield, the other two pairs are posterior and on the cuticle, the setae from anterior backwards are approximately 312μ, 312μ, 340μ, 360μ and 264μ long.

Venter.—As figured, Fig. 1A; tritosternum (Fig. 2E) with a fairly elongate base flanked by a pair of setae and with paired filamentous laciniae; sternal, metasternal and ventral shields coalesced and extending broadly behind coxae IV and reaching to within a short distance, 30μ, of the anal shield, from the middle of coxae IV it fuses with the endopodal shields to surround the posterior border of acetabula IV, the whole shield is 403μ long and 144μ wide across the almost straight anterior margin, anterior to the middle of coxae II the shield narrows to 125μ and then expands to 182μ between coxae II and III, between coxae III and IV it begins to contract to 125μ between coxae IV and posterior of coxae IV it is 250μ wide and then becomes evenly rounded, the shield is furnished with 5 pairs of setae of which the anterior pair are close to the anterior margin and much longer than the others, the fifth pair are of intermediate length and lie close to the posterior margin; the genital orifice is large and tongue-shaped and lies in the middle of the sternal shield between coxae II and III, it encloses the similarly shaped genital shield which is 168μ long by 135μ, the genital shield is completely fused posteriorly with the ventral

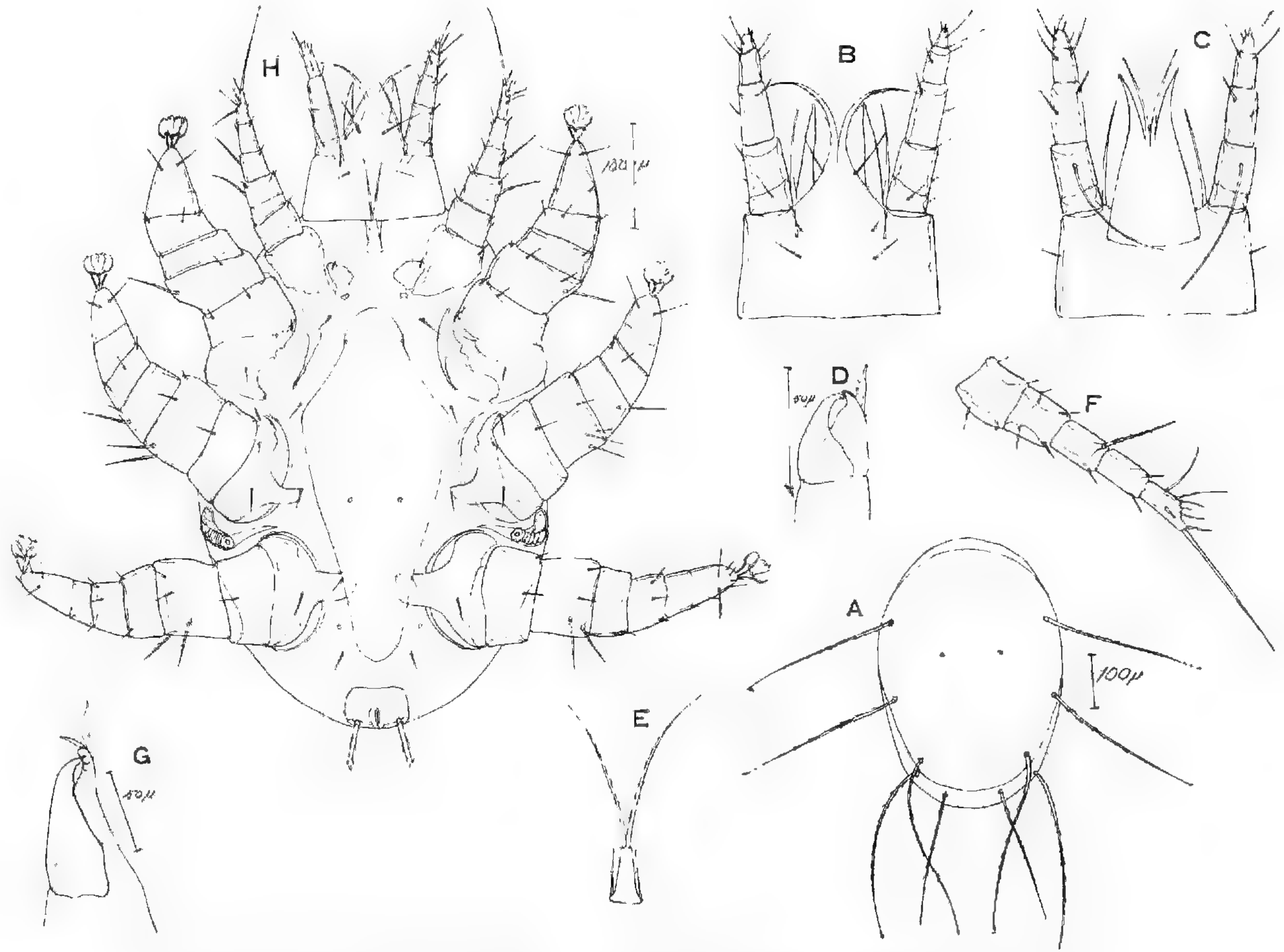

Fig. 2.—*Brachytremella spinosa* Träg. A, dorsum of female; B, gnathosoma from below; C, gnathosoma and tectum from above; D, chelicerae of female; E, tritosternum of female; F, leg I of female; G, chelicerae of male; H, ventral view of tritonymph.

shield but appears to be flexible on lateral pivots of the more sclerotised margin of the orifice at 125μ from the front; the anal shield is roughly rectangular with the anterior margin straight and slightly excavate medially, and approximately 60μ wide, it carries a pair of long ciliated capitate setae 384μ long; stigma between coxae III and IV with an anteriorly curved peritreme 43μ long.

Gnathosoma.—Hypostome as figured (Fig. 2B), with three pairs of setae of which the maxillary pair are fairly long, as are also the anterior pair which are situated on the margins of the base of the long ciliated outwardly curved styli; the labial cornicles are about 4 times as long as broad at the base, slender salivary styli are present, dorsally the gnathosoma (Fig. 2C) is covered by a distinct conical apically quadrifurcate tectum as figured, with slightly outwardly curved apical arms between which arises a pair of longer and more slender ciliated laciniae; *palpi* 5-segmented as shown, dorsally the femur carries a very long slender shortly ciliated seta; *chelicerae* as figured (Fig. 1C), movable digit with small tooth at about one-fourth from apex, fixed digit with two small subapical teeth, a small tooth midway and apically with hyaline excrescence.

Legs.—All 6-segmented, I (Fig. 2F) the shortest and tapering, without ambulacra on tarsi but tarsi apically bifid with a long apical seta, with one long shortly ciliated seta on femur and genu, length 192μ. II-IV longer and very much stouter, II 307μ long, femur with one long and one rather shorter ciliated seta, III 312μ long with two long ciliated setae on femur and one on genu, IV with two medium length ciliated setae on femur and genu with one much longer; tarsi II-IV with large pad-like ambulacra without claws; coxae of leg I well defined, fragmented, with the seta on the larger fragment.

Male Allotype.—Somewhat larger and more chitinised than the female. Idiosoma 608μ long, 560μ wide. Shape broadly oval.

Dorsum.—Dorsal shield entire as in female, 561μ long by 491μ wide, furnished with 5 pairs of long ciliated capitate setae arranged as in female, anterior pair of setae 432μ long, second pair 490μ, next 432μ, next 528μ and posterior 480μ.

Venter (Fig. 1B).—Tritosternum as in female; sternal, metasternal and ventral shields coalesced together with the endopodal shields of coxae II-IV, the whole shield is 456μ long, its anterior margin almost straight and 230μ wide, the sides contract between coxae II to a width of 187μ and then widen between coxae III to 283μ, after which they contract to 133μ between coxae IV and posterior of acetabula IV reach a width of 288μ, the posterior margin is evenly rounded and reaches to 43μ from the anterior of the anal shield the shield is furnished with 4 pairs of setae of which the anterior and the posterior are the longest; the genitalia lie in an elongate oval cavity containing the posteriorly directed genital shield (bi-articulated penis of Trägårdh), it is 134μ long and 82μ wide with a posterior head about 40μ long; the anal shield is as figured, 90μ wide and carries a pair of long ciliated capitate setae 384μ. Peritreme 77μ long and strongly curved forward, with the stigma between coxae III and IV.

Gnathosoma with palpi, chelicerae as in female but somewhat larger.

Legs.—Generally and proportionally as in the female.

?*Tritonymph* (Fig. 2H).—Of the same general facies as in the female. Length of idiosoma 468μ, width 339μ.

Dorsum.—Dorsal shield as in female, 436μ long by 307μ wide, furnished with three pairs of long ciliated capitate setae situated laterally, two other pairs of such setae posteriorly of the shield, the anterior pair of setae are 360μ long, the second pair 432μ, the next 480μ, next 480μ and posterior 432μ.

Venter.—With the ventral shield as figured, 336μ long and 139μ wide, anteriorly it is in a line with the anterior margin of coxae II and evenly rounded, it gradually expands to between coxae II and III at the maximum width and then gradually tapers to the posterior margin of coxae IV where it is again rounded, only the fourth pair of setae are actually on the shield, there is a pair of pores in a line with coxae III; endopodal shields II, III and IV, especially II, well developed; anal shield as in the female, 67μ wide; peritreme 53μ long.

Gnathosoma with palpi and chelicerae as in female.

Legs.—As in female, I 206μ long, II 312μ, III 336μ, IV 365μ.

Remarks.—Despite the brief description given by Trägårdh of the genotype, *B. spinosus*, the female and nymph described above can without question be referred to his species. The male, however, is considerably larger but otherwise agrees in the number and arrangement of the dorsal setae and also in the ventral shield, as well as other morphological characters. Except for the size difference it agrees generically with the female.

Brachytremella trägårdhi sp. nov.

Text Figs. 3A-F, 4A-F.

Types.—Holotype female, two tritonymphs and one deutonymph in the collection of the South Australian Museum.

Localities.—The holotype female and one tritonymph from *Mastochilus* sp. Mt. Lamington, Queensland, Dec. 1948 (coll. H.W.), and one tritonymph and the deutonymph from a Passalid, 8 miles east of Wondecla, Queensland, 30/10/43 (coll. R. V. Southcott).

Description.—Female. (Fig. 3A-F). A flattish lightly sclerotised species. Length of idiosoma 560μ, width 374μ. Shape oval.

Dorsum (Fig. 3B).—Dorsal shield entire, 490μ long by 340μ wide, not completely covering dorsum, separated marginally by a fairly wide band of cuticle; furnished with six pairs of long slender setae which are shortly ciliated and end in a small but distinct knob, all except the second pair from the anterior are to 270μ long, the second pair are only about half this length, 144μ, the anterior four pairs of setae are on the margin of the dorsal shield, the posterior two pairs on the posterior margin of the body, on the shield are a number of pores (Fig. 3B).

Venter.—As in Fig. 3A; tritosternum as shown, with conical base flanked by a pair of setae, and with paired laciniae; sternal, metasternal and ventral shields coalesced and extending past coxae IV, the combined shield is 394μ long, the anterior margin is almost straight, between coxae II the shield narrows to 115μ and then widens to 192μ between coxae III, contracts slightly between coxae IV and then expands behind coxae IV to 206μ, the posterior margin is rather flattened, the shield carries 5 pairs of setae of which the first pair are fairly long, the others shorter; the genital opening is large and tongue-shaped in which the genital shield fits, it is 178μ long by 134μ at the widest part, posteriorly the genital shield is coalesced with the ventral shield, the front portion of the shield, however, is probably capable of being lifted up in a line between the second and third sternal setae where a strong chitinisation of the anterior margin of the orifice ends; the anal shield is transversely diamond shaped, and furnished with only two long 312μ setae similar to the dorsal setae, the shield is 72μ wide; the endopodal shields are well chitinised on coxae III and IV and not fused with the sternal; the stigma lies between coxae III and IV and has only a short peritreme of 28μ length; metapodal shields absent.

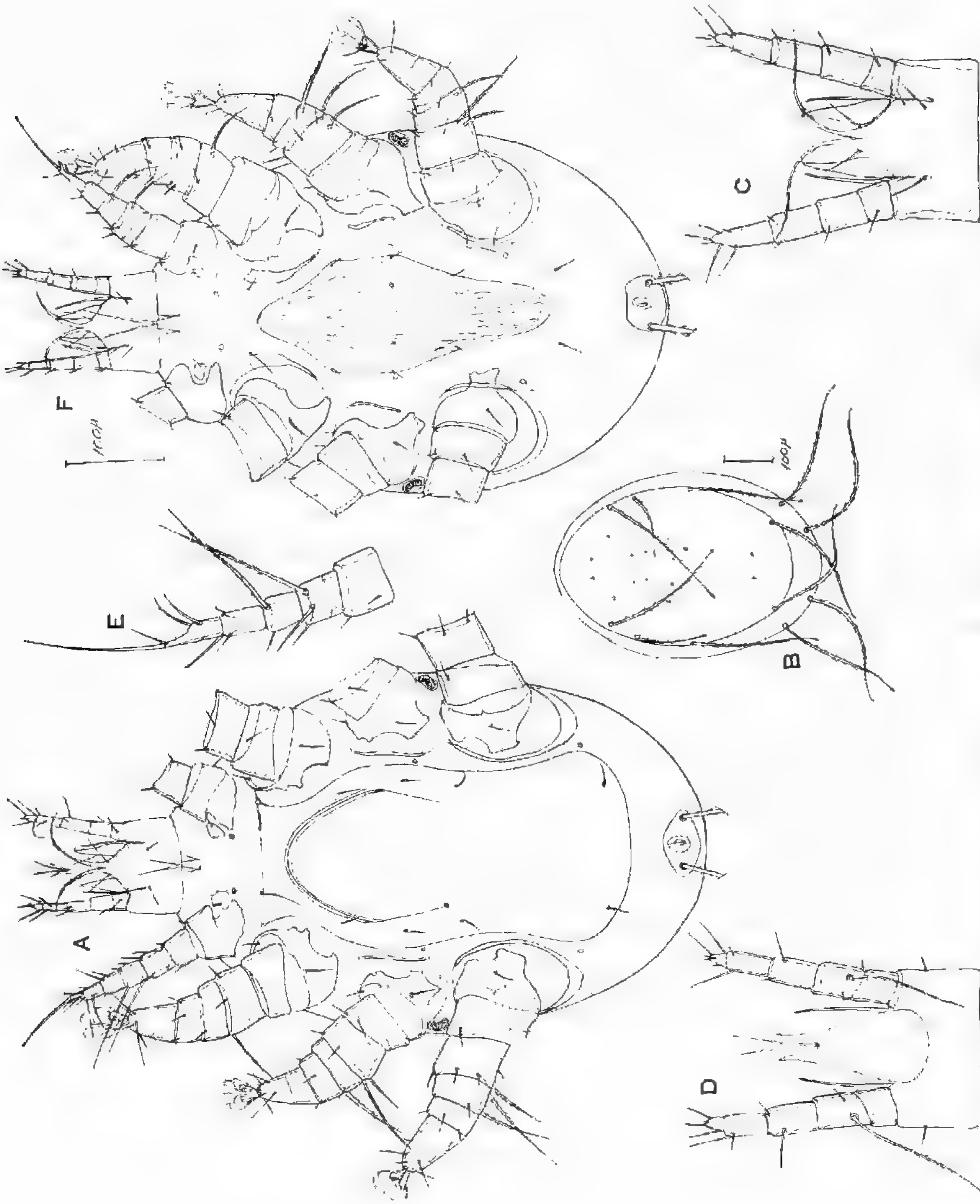

Fig. 3.—*Brachytremella trägårdhi* sp. nov., from Mt. Lamington, Q. A, female in ventral view; B, dorsum of female; C, gnathosoma from below; D, gnathosoma and tectum from above; E, leg I; F, tritonymph in ventral view.

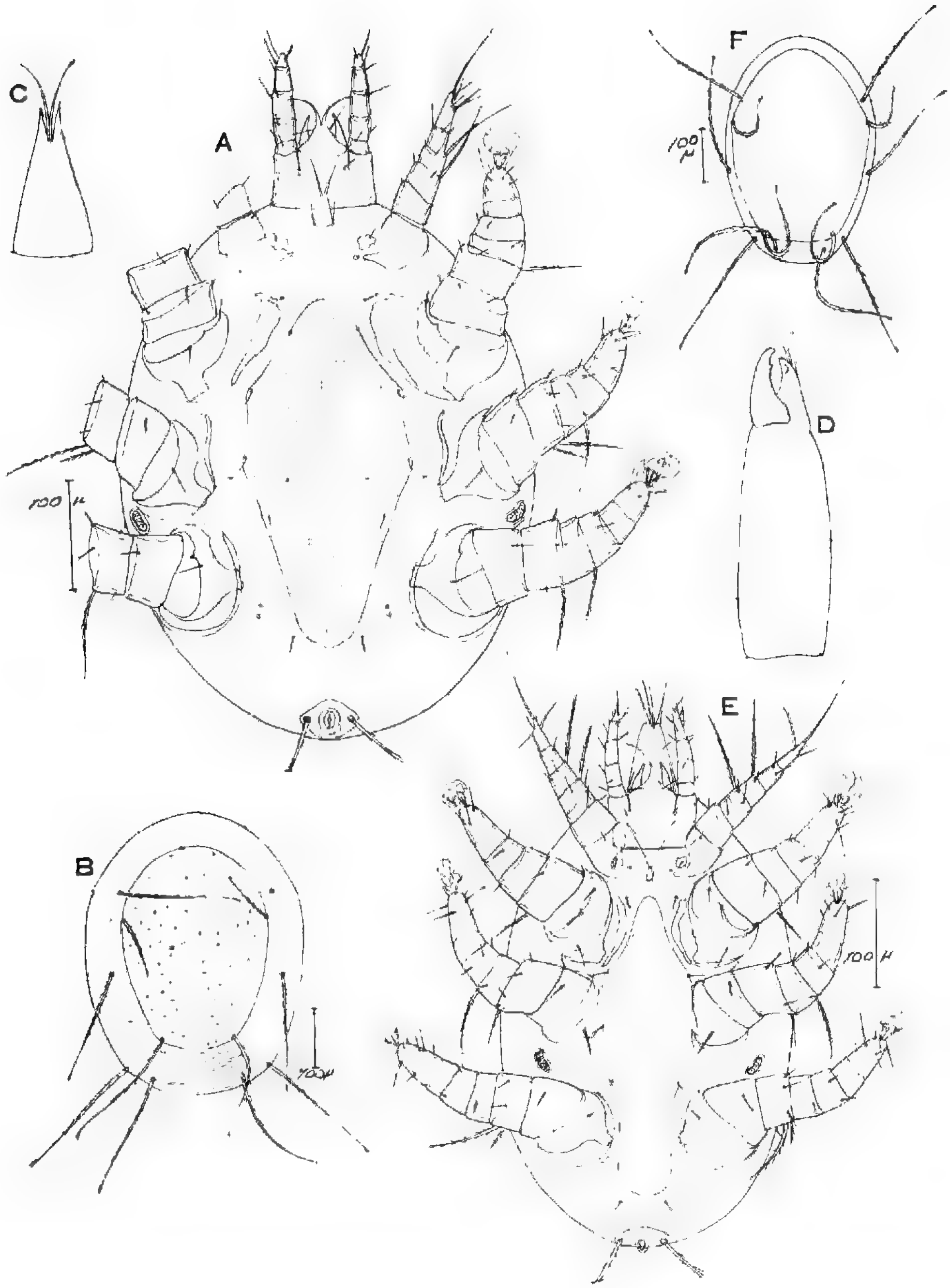

Fig. 4.—*Brachytremella trägårdhi* sp. nov., from Wondecla, Q. A, tritonymph in ventral view; B, tritonymph dorsum; C, tectum of tritonymph; D, mandibles of tritonymph; E, deutonymph in ventral; F, deutonymph dorsum.

Gnathosoma.—As in Fig. 3C and D; hypostome with only three pairs of setae of which the maxillary pair are fairly long, and the anterior pair are also long and situated marginally on the base of the long ciliated paired styli; the labial cornicles are fairly long, about 3 times as long as wide at base, slender salivary styli reach almost to the tip of the cornicles, dorsally the gnathosoma is covered by a distinct conical apically quadrifurcate tectum which ends in a pair of slightly outwardly curved arms from between which arises a pair of longer and more slender filaments; the palpi are 5-segmented as figured, dorsally the femur carries a very long ciliated tapering seta; the mandibles carry a pair of small chelate chelicerae, the movable digit having a minute tooth subapically, and the fixed digit with subapical excrescence.

Legs.—All short, I (Fig. 3E) the shortest and rather tapering, to 216μ long, femur and genu with one long ciliated seta each, tarsus bifid apically and with a long apical seta; legs II-IV stouter, tarsi without claws but with large ambulacral pad, femur of II with one long ciliated seta, femur of III with two and genu with one long seta, femur and genu of IV similar to III; the coxae of leg I are demarcated and fragmented as shown with the posterior seta situated on the larger of the separated portions.

Male.—Unknown.

Tritonymph (Fig. 3F).—Of the same form and texture as the female; length of idiosoma 526μ, width 397μ.

Dorsum (Fig. 4B).—Shield entire, 408μ long by 336μ wide, with six pairs of long setae as in the female, of which the second anterior pair is only 120μ long, the others to 240μ, the shield is supplied with many fine pores, but only takes in the second and fourth pairs of dorsal setae, the first and third pairs being on the surrounding cuticle as are the posterior two pairs.

Venter (Figs. 3F, 4A).—With only a single ventral shield as figured, with longitudinal striate markings, this shield is 317μ long by 125μ wide between coxae III, it is round and narrow apically, and tapers to a rounded end on a level with the posterior edge of acetabula IV, the first sternal setae are fairly long and off the shield, setae II, III and IV are on the shield marginally, but setae V are off, endopodal shields of coxae II-IV free and well sclerotised, those of II elongate, wide anteriorly, tapering to a point and curved posteriorly; the anal shield is diamond-shaped, 62μ long, with one pair of long ciliated apically knobbed setae to 312μ long; the peritreme and stigma are as in the female.

Gnathosoma (Fig. 4C, D).—As in the female.

Legs.—As in the female, I 192μ long; II and III 264μ, IV 288μ.

Deutonymph (Fig. 4E, F).—Length of idiosoma 432μ, width 269μ.

Dorsum.—Shield as in female and tritonymph but 360μ long by 254μ; dorsal setae as in tritonymph with setae II 105μ long, rest 225μ long.

Venter.—As figured, ventral shield as in tritonymph 288μ long by 77μ wide but more slender and extending rather further back from coxae IV; endopodal shields of coxae II distinct. Peritreme small, 19μ long.

Gnathosoma as in female and tritonymph.

Legs.—As in other stages, I 175μ long, II 206μ, III and IV 220μ.

Remarks.—This species differs from all other known species in the second pair of dorsal setae being only about half the length of the rest. In *D. quercus*, which also has only six pairs of long dorsal setae, they are all of about equal length in both adult and tritonymphal stages, and all longer than the anal setae, whereas in *B. trägårdhi* the anal setae are longer than the dorsal setae.

Brachytremella bornemisszai sp. nov.

Text Fig. 5A-C.

Types.—Two tritonymphs, one holotype and one paratype, in the South Australian Museum collection.

Localities and Hosts.—The holotype from the Passalid *Aulacocyclus edentulus* McL. from Wilson's Downfall, New South Wales, 8/10/56 (coll. G. F. Bornemissza), the paratype from the same host, Hinchinbrook Is., N. Queensland, 8/9/56 (coll. G.F.B.).

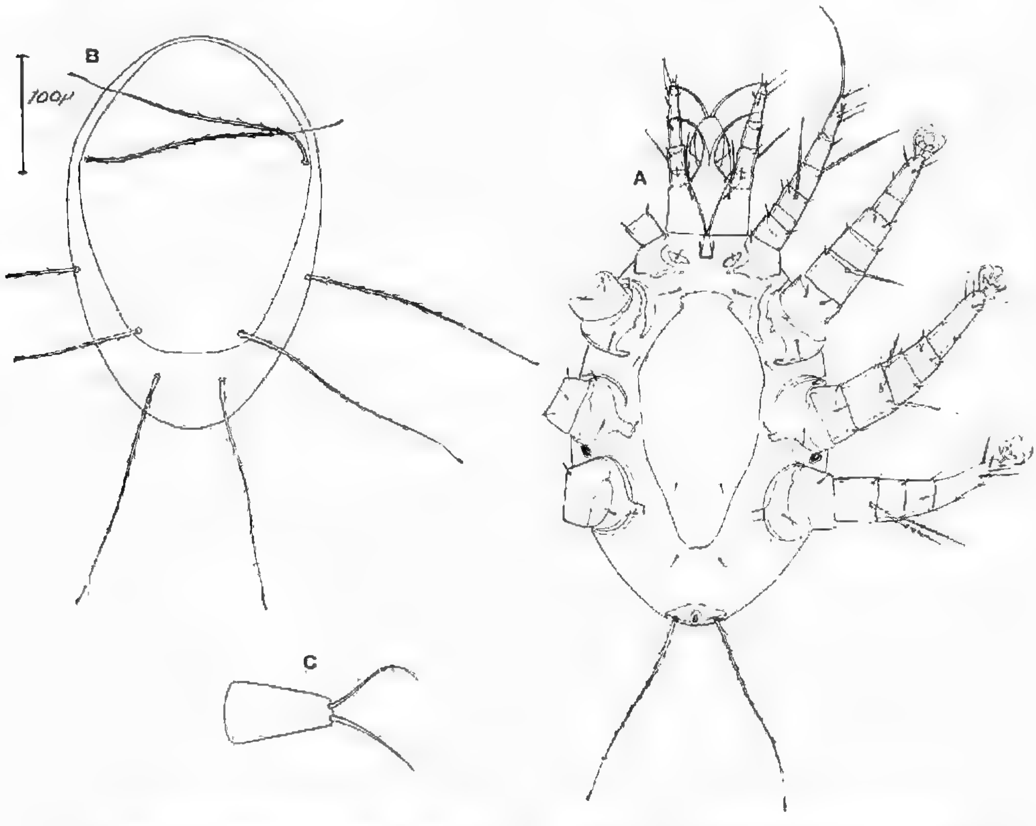

Fig. 5.—*Brachytremella bornemisszai* sp. nov. Nymph—A, ventral view; B, dorsum; C, tectum.

Description.—Tritonymph. A flattish, lightly chitinised, oval species. Idiosoma 334μ long, 225μ wide.

Dorsum (Fig. 5B).—Shield entire, not completely covering body as figured, furnished with only two pairs of long slender ciliated capitate setae, one pair of which are marginal on the shoulders, the other on the posterior margin, there are also two other pairs of such setae off the shield, one pair on the body edge and midway between the two pairs on the shield, the other pair are on the cuticle posterior of the dorsal shield, these setae are to 240μ long.

Venter (Fig. 5A).—Ventral shield as figured, 216μ long by 106μ wide, widest in a line between coxae II and III, the anterior margin is only lightly convex and 48μ wide, the sides almost immediately narrow to 38μ then expand to the maximum width between coxae II and III and then converge to the

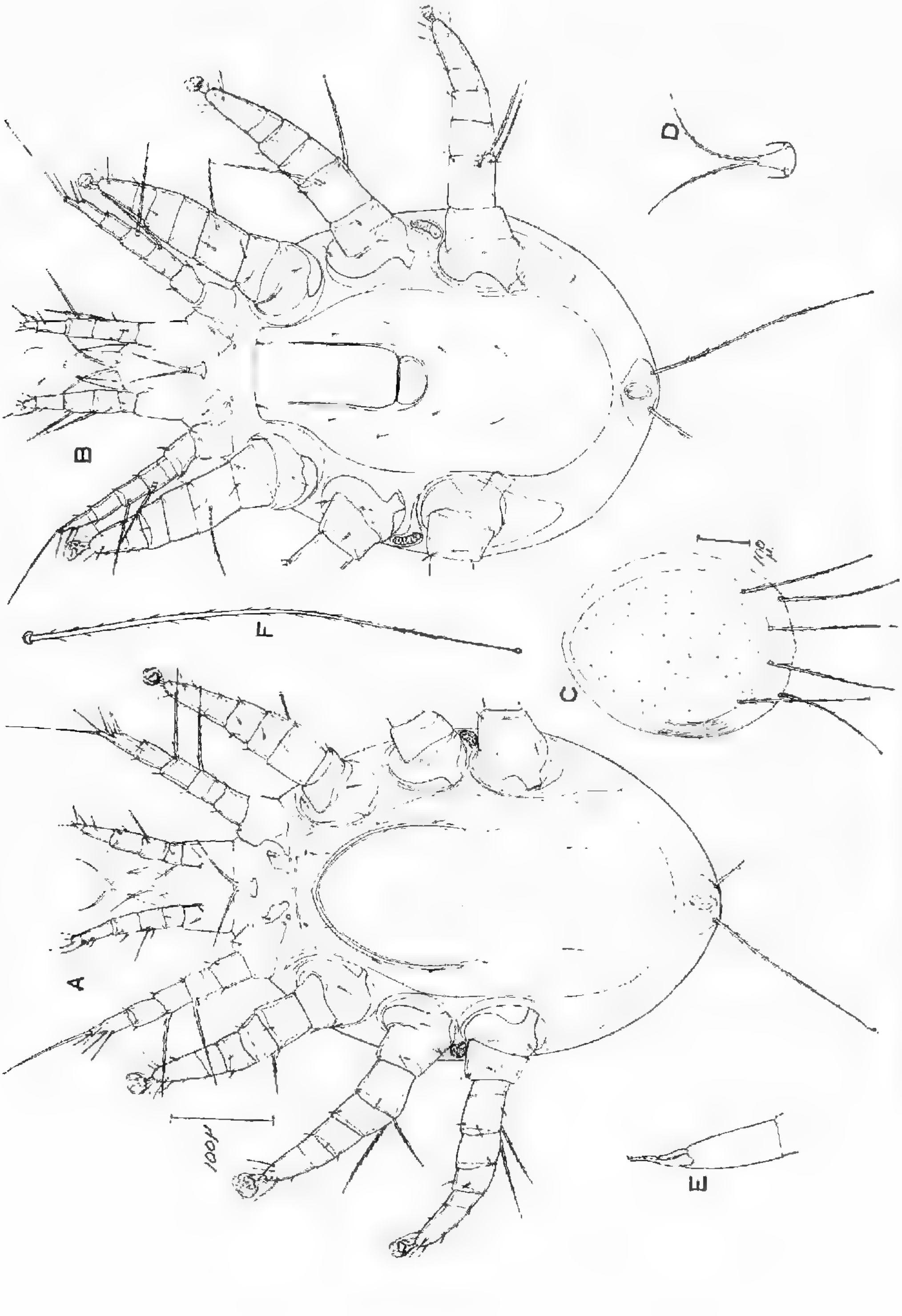

Fig. 6.—*Lombardiniella lombardinii* g. et sp. nov. A, female in ventral view; B, male in ventral view; C, dorsum of female; D, female tritosternum; E, mandible of female; F, dorsal seta.

rounded end slightly beyond posterior margin of acetabula IV, only the fourth pair of setae are actually on the shield and these are well inside the margin, of the other four pairs of setae, I are longer than the others; the endopodal shields of coxae II-IV are well developed especially those of II which are more curved and moon-shaped than in other species; the anal shield is transversely diamond-

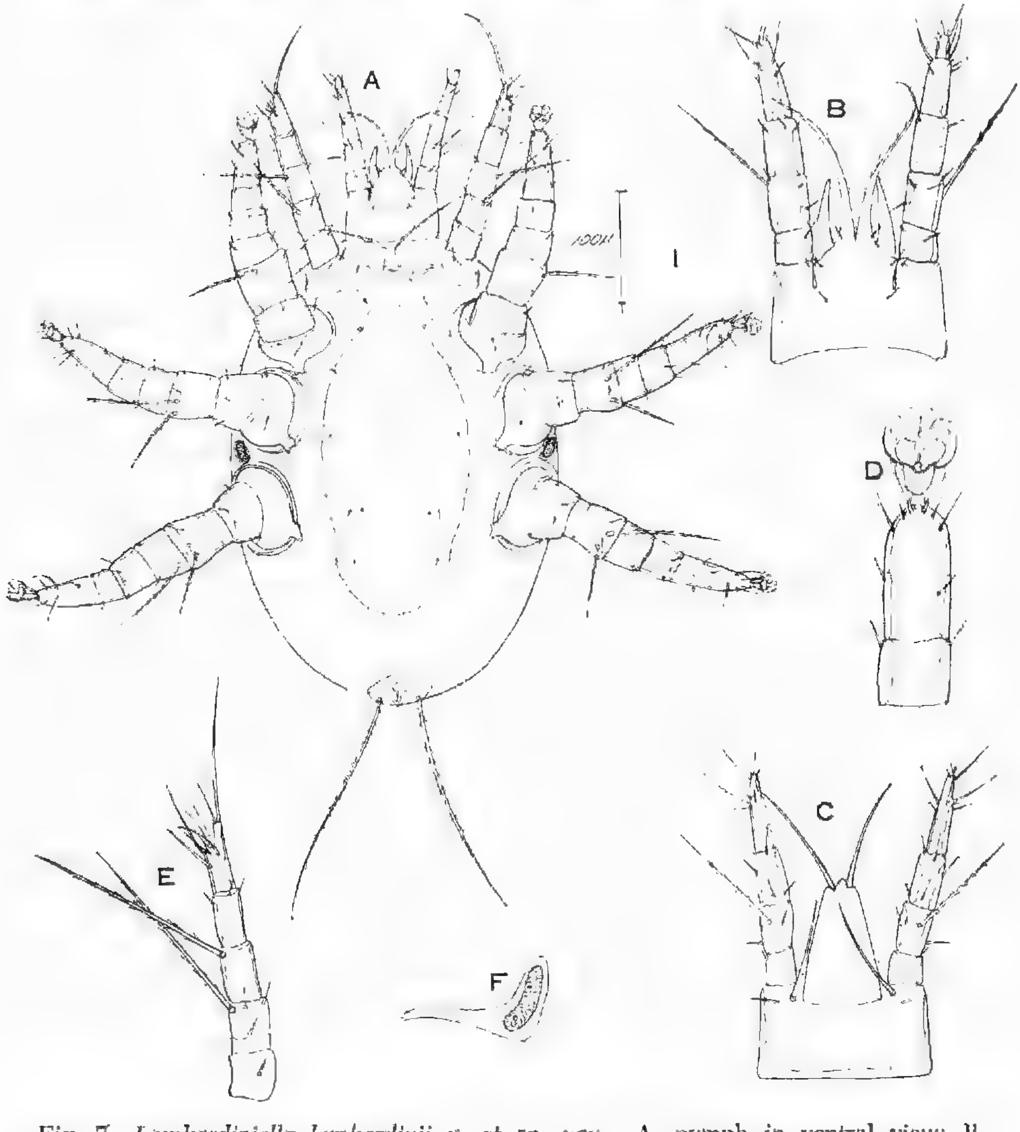

Fig. 7.—*Lombardiniella lombardinii* g. et sp. nov. A, nymph in ventral view; B, gnathosoma of female from below; C, gnathosoma and tectum of female from above; D, tarsus of leg II from below; E, leg I; F, stigma and peritreme.

shaped, 48μ wide with one pair of long ciliated capitate setae to 180μ; the stigma lies between coxae III and IV with hardly a distinct peritreme.

Gnathosoma as figured and as described for *B. spinosa;* tectum (Fig. 5C), however, apparently with only two apical filamentous branches as figured.

Legs as in other species, I 173μ long, with fragmented coxae, II, III and IV 240μ long and stouter than I.

Remarks.—This species differs from *B. spinosa* Träg. and *B. trägårdhi* sp. n. in the number and arrangement of the long dorsal setae. In the absence of the female, however, it is only tentatively referred here to the genus *Brachytremella*.

Gen. LOMBARDINIELLA nov.

Allied to *Brachytremella* but with the metapodal shields separated from the sterno-ventral shield and extending posteriad of coxae IV as a triangle; tectum an elongate cone with one pair of long apical laciniae.

Type *Lombardiniella lombardinii* sp. nov.

Lombardiniella lombardinii sp. nov.

Figs. 6A-F, 7A-F.

Types. Holotype female, allotype male, 8 paratype females, one paratype male and 6 paratype nymphs in the South Australian Museum.

Localities.—The paratype male from under the elytra of a Passalid beetle *Aulacocyclus edentulus* McL. from a rotting eucalypt log, Hampton, Queensland, 3rd Oct., 1956 (coll. G. F. Bornemissza), all the others from the same host and habitat from Wilson's Downfall, New South Wales, 8th Oct., 1956 (coll. G.F.B.).

Description.—Female (Fig. 6A). A lightly sclerotised oval species. Length of idiosoma to 490μ (average of 8 specimens 481μ); width to 360μ (average 342μ).

Dorsum (Fig. 6C).—Dorsal shield entire, not completely covering dorsum but surrounded by a fairly wide strip of striated cuticle, dorsally with only 3 pairs of long, ciliated and apically knobbed setae to 210μ long (Fig. 6F), of these setae two pairs are situated on the posterior margin of the shield, the other pair is on the cuticle and on the posterior margin of the dorsum.

Venter (Fig. 6A).—Tritosternum (Fig. 6D) with not very long conical base, flanked on each side by a short seta, and apically with a pair of shortly ciliated laciniae; sternal, metasternal, and ventral shields coalesced to form a single shield reaching posteriorly almost to anterior margin of anal shield, antero-medially the shield surrounds with an oval chitinous rim the large tongue-shaped genital shield, close to the rim it carries three pairs of small setae, the sternal II and III and the metasternal setae; anterior of the genital shield is a pair of longer setae, sternal setae I, and posterior on the shield beyond coxae IV is another longer pair of setae probably the genital pair in other groups, the whole shield is wide and the margins confluent with the inner edges of the coxae as figured, the length of the whole shield is 370μ by 206μ wide with a slight constriction between coxae IV to 197μ; the genital shield 211μ long by 149μ wide, is without setae and is not hinged to the ventral shield although there is a faint subcuticular transverse line between the third and fourth pair of sternal setae which may indicate a weakness allowing the genital shield to lift up and open from the anterior; the anal shield is small, transversely lozenge-shaped and is furnished with only two setae which are similar to and as long as the dorsal setae; large metapodal shields extend backwards from coxae IV as fairly large triangles, anteriorly as wide as the coxae and tapering to a rounded blunt apex at about halfway from the coxae to the apex of the ventral shield; peritremal shields small with the stigma (Fig. 7F) between coxae III and IV and the peritreme short, 29μ and curved.

Gnathosoma as figured (Fig. 7B), with apparently four pairs of short hypostomal setae, hypostome with a pair of long curved, shortly ciliated styli; corniculi moderately long; in the dorsal view (Fig. 7C) the maxillary part has two pairs of setae near the base of the palpi of which the inner pair are long, the outer short, between the bases of the palpi is an elongate cone-shaped bifurcate tectum carrying apically a pair of equally long laciniae, the base of the tectum is demarcated by a transverse line; palpi as figured 5-segmented, the femur dorsally has a strong straight ciliated seta and there also are some fairly long setae on the tibia and tarsus; the chelicerae (Fig. 6E) are small, apparently edentate, and the movable finger has a subapical excrescence.

Legs.—All relatively short, I (Fig. 7E) thinner than II-IV and antennaeform, with the tarsus apically bifid with some long tactile setae, femur and genu dorsally with a long straight outstanding ciliated seta, coxae with two small setae and fragmented, legs II-IV moderately thick all tarsi with pad-like ambulacrum (Fig. 7D) but no claws, femur of II with one long seta, of III and IV with two such setae; length of I 206μ, II 269μ, III 298μ, IV 298μ, all legs directed forwards.

Male (Fig. 6B).—With the facies of the female, length of idiosoma 475μ and 440μ, width 350μ and 312μ (allotype and paratype respectively).

Dorsum as in the female, shield 408μ by 302μ, setae 220μ.

Venter (Fig. 6B).—Generally as in the female but the genital organ consists of a two-segmented shield as figured lying in a longitudinal groove in the sterno-ventral shield; the shield is 134μ long by 58μ wide; the stigma and peritreme are similar to the female, but the peritremal shield is peculiar in that posteriorly it runs inwards between coxae III and IV (see Fig. 7F) and is more distinct: the sterno-ventral shield is 345μ long by 182μ wide (173μ between coxae IV).

Nymph (Fig. 7A).—General facies as in female. Length of idiosoma to 432μ (aver. of 6 specimens 407μ), width to 293μ (aver. 275μ).

Dorsum.—Similar to that of female, dorsal shield 336μ by 240μ.

Venter.—With a single elongate sternal shield, 260μ long by 130μ wide as figured, extending posteriorly to half-way between coxae IV and the anterior margin of anal shield, the first sternal setae are lateral and anterior of the apex of the shield, setae II are also off the shield, but closely adjacent to the margin, setae III-V are distinctly on the shield, while just off the shield and between setae I and II is a pair of pores and there is another pair of pores between setae IV situated near to the setae. Anal shield as in female. Peritreme 19μ long.

Gnathosoma as in female.

Legs as in female, I 192μ long, II 240μ, III 260μ, IV 260μ.

Genus Brachytremelloides nov.

Body form elongate. Dorsum without long setae. Genital shield in female coalesced posteriorly with ventral which expands immediately behind coxae IV, then tapers posteriad to a short straight posterior margin confluent with the anterior margin of the anal shield. In male genital shield relatively short. Legs II similar to III and IV in both sexes. Tectum bifurcate. Coxae I coalesced to form a single transverse shield.

Type *B. striata* sp. nov.

Brachytremelloides striata g. et sp. nov.

Text fig. 8A-H.

Types.—Holotype female, allotype male, 10 female and 8 male paratypes in the South Australian Museum.

Localities.—Holotype female, allotype male, 4 paratype females and 1 paratype male from a Passalid, *Aulacocyclus edentulus* McL. from a eucalypt log at Wilson's Downfall, near Tenterfield, New South Wales, 8/10/56 (coll. G.F.B.). Other specimens: 4 females and 2 males from Hinchinbrook Is., Nth. Queensland, 9/9/56 (G.F.B.); 4 males and 1 female from a Passalid, 8 miles east of Wondecla, Queensland, 20/10/45 (R. V. Southcott); one female from *A. edentulus* McL. from Bell, Blue Mountains, New South Wales, 27/11/56 (G.F.B.); and one male from *A. edentulus* McL., Hampton, Queensland, 2/10/56 (G.F.B.).

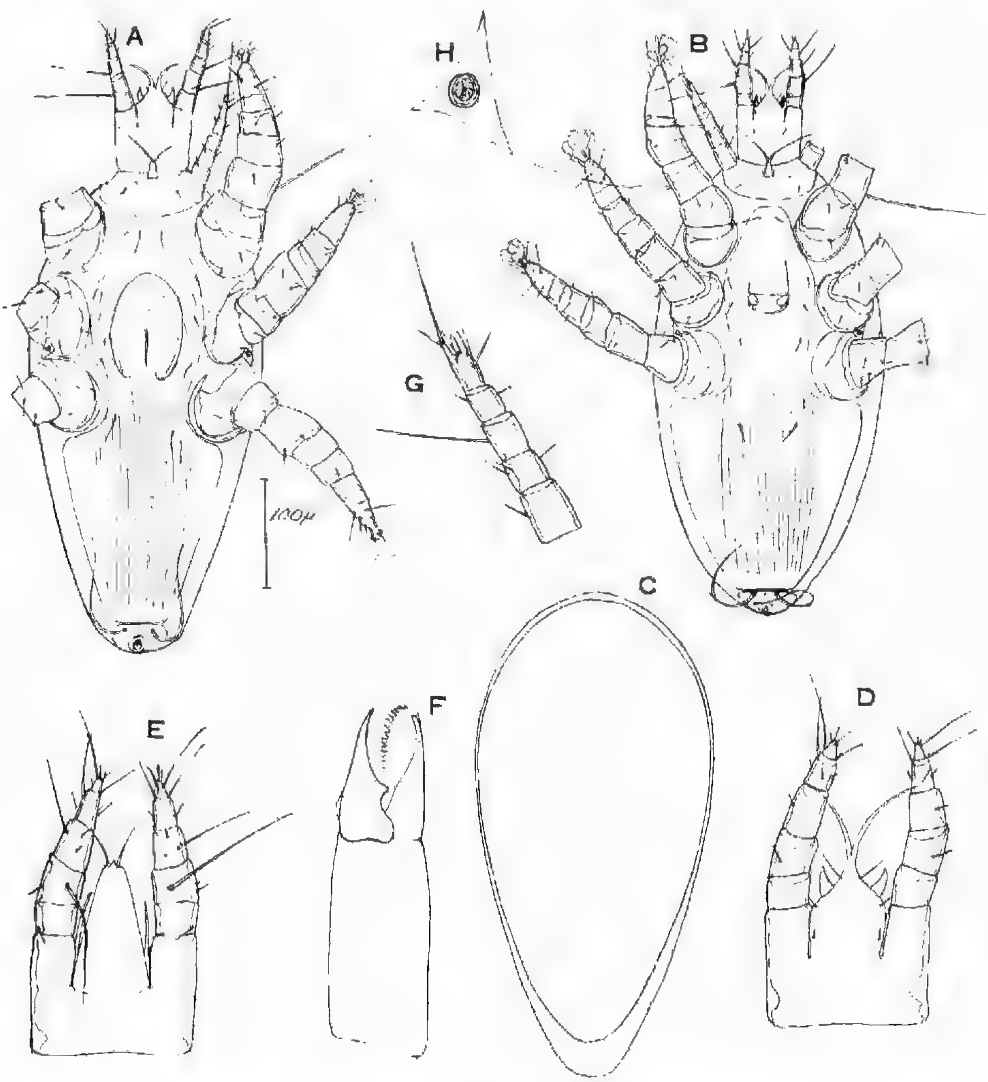

Fig. 8.—*Brachytremeloides striata* g. et sp. nov. A, female in ventral view; B, male in ventral view; C, dorsum; D, gnathosoma from below; E, gnathosoma and tectum from above; F, mandible; G, leg I; H, stigma.

Description.—*Female* (Fig. 8A, C-H). An elongate oval species. Idiosoma 432μ long, 206μ wide. Fairly well sclerotised.

Dorsum (Fig. 8C).—Shield entire, almost completely covering dorsum except posteriorly as figured, smooth and without any long setae, 413μ long by 201μ wide.

Venter (Fig. 8A).—As figured; sternal, metasternal and ventral shields coalesced, the combined shield rounded anteriorly between coxae II, widening to 100μ between coxae III then contracting between coxae IV to 72μ, then contouring acetabula IV to a width of 144μ after which the sides converge to a width of 53μ in a flattened apex almost touching the anterior margin of the separate anal shield, the intercoxal portion of the shield is provided with 5 pairs of setae of which the anterior and longest pair are between coxae II, the second and third pairs are short and on a level with coxae III, the fourth pair between coxae III and IV, and the fifth on a level with the posterior margin of acetabula IV, the ventral portion of the shield is longitudinally striate medially with about seven lines on each side of the mid-line; anal shield transversely trapezoidal 53μ wide by 24μ deep, and furnished with two long, nude and slender, forwardly curved setae to 120μ, these arise anteriorly of the anal opening; the genital orifice is long, oval and lies between the posterior edge of coxae II and the posterior edge of coxae IV, the genital shield is 86μ long and 62μ wide and contours the inner edge of the orifice, posteriorly it is coalesced with the ventral shield and not clearly hinged, below its surface can be seen a Y-shaped apodemal structure; the stigma lies between coxae III and IV and is on a small triangular peritremal shield but no distinct peritreme is present.

Gnathosoma as figured; hypostome (Fig. 8D) with three pairs of setae of which only the anterior pair on the base of the paired outwardly curved hypostomal styli are long, labial cornicles short; palpi 5-segmented with the long dorsal setae on femur and genu nude; tectum (Fig. 8E) a long cone but apically with only a single pair of short laciniae; chelicerae edentate (Fig. 8F), fixed digit with a thick hyaline apparently fringed excrescence.

Legs.—I short 110μ and tapering (Fig. 8C), tarsus apically bifid, without ambulacrum, coxae ill-defined, not fragmented and coalesced to form a transverse shield 96μ across, II-IV longer and much stouter, II 204μ, III 216μ, IV 220μ, tarsi with pad-like ambulacra but no claws, long dorsal seta present only on femur of I and this seta nude.

Male.—Of the same shape and general facies as in the female. Length of idiosoma 412μ, width 206μ.

Dorsum.—As in the female. Length of shield 384μ, width 206μ. No long setae.

Venter (Fig. 8B).—The sterno-metasterno-ventral shield as in female, length 345μ by 82μ wide between coxae III, narrowing to 72μ between coxae IV then contouring acetabula to a width of 168μ, afterwards the sides converge to almost touch anterior margin of anal shield with a posterior width of 48μ. Anal shield as in female, width 43μ, depth 28μ, setae simple to 144μ long. Peritreme and stigma as in female.

Gnathosoma with palpi, chelicerae and tectum as in female.

Legs.—As in female, I 113μ long, the coxae ill-defined, not fragmented, coalesced to form a transverse shield 96μ across, II stout and somewhat stouter than III and IV, 230μ long, II and IV stout but less so than II. II 230μ long, IV 240μ.

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TRÄGARDH, I., 1946. Diarthrophallina, a new group of Mesostigmata found on Passalid beetles. Ent. Medd., 24 (6), pp. 369-394.

ON THE FAMILY DIARTHROPHLLIDAE (ACAHNAMESOSTIGMATAMONOGYNASPIDA) WITH PARTICULAR REFERENCE TO THE GENUS PASSALOBIA LOMBARDINI 1926.

BY H. WOMERSLEY

Summary

The family Diarthrophallidae Tragardh 1946 is discussed and all known genera and species belonging to it considered. Two subfamilies, the Diarthrophallinae comprising the genera *Diarthrophallus Trag., Brachytremella* Trag., *Lombardiniella* Worn. 1960 and *Brachytremelloidcs* Wom. 196O, and the Passalobiinae containing the genera *Passulolia* Lomb. 1926 and *Passalana* g. nov. are erected. The gentus *Passalobia* Lomb. is redefined and the species *P. duodecimpilosa* Lomb. is removed therefrom as a synonym of *Diurtl~rophullus sirnilis*
Trag. 1946. *A* new genus *Passalana* is erected for *Passalobia peritrematica* Lomb. 1951. The subfamilies, genera and a11 known species are keyed.

ON THE FAMILY DIARTHROPHALLIDAE (ACARINA-MESOSTIGMATA-MONOGYNASPIDA) WITH PARTICULAR REFERENCE TO THE GENUS *PASSALOBIA* LOMBARDINI 1926.

H. WOMERSLEY*

[Read 12 May 1960]

SUMMARY

The family Diarthrophallidae Trägårdh 1946 is discussed and all known genera and species belonging to it considered. Two subfamilies, the Diarthrophallinae comprising the genera *Diarthrophallus* Träg., *Brachytremella* Träg., *Lombardiniella* Wom. 1960 and *Brachytremelloides* Wom. 1960, and the Passalobiinae containing the genera *Passalobia* Lomb. 1926 and *Passalana* g. nov. are erected. The genus *Passalobia* Lomb. is redefined and the species *P. duodecimpilosa* Lomb. is removed therefrom as a synonym of *Diarthrophallus similis* Träg. 1946. A new genus *Passalana* is erected for *Passalobia peritrematica* Lomb. 1951.

The subfamilies, genera and all known species are keyed.

The family Diarthrophallidae was erected in 1946 by Trägårdh in his very important paper, "Diarthrophallina, a new group of Mesostigmata, found on Passalid beetles", published in the Ent. Medd., 24 (6), pp. 369-394, 1936.

It was founded upon a study of the curious mite found under the elytra of *Passalus cornutus*, in North Carolina and described by Pearse *et al.* as *Uroseius quercus* n. sp. in Ecol. Monog. 6, pp. 478-479, figs. 31-34.

For the species Trägårdh erected the genus *Diarthrophallus*. The family he placed in a new cohort, the Diarthrophallina, within his subdivision, the Eugynaspida of the Mesostigmata, in which the epigynial shield (sterno-gynial of Camin and Gorirossi, 1955) is developed or if absent then secondarily so. He stressed the relationship of his cohort to the Uropodina and defined the cohort and family as follows:

> "Body flat, shield-shaped. Legs very short; legs I without ambulacres, legs II-IV with large ambulacres but no claws. Tritosternum flanked by two praesternal hairs. Mandibles short, chelate. Palpi without bi- or trifurcate bristle on the base of the terminal joint. Peritreme very short. Female epigynial shield large, tongue-shaped, without hairs, not articulated at the base. Metasternal shields fused with the other sternal shields and the ventral shield forming a rim round the genital aperture. Male genital armature consisting of a large, biarticulated penis fitted into a groove and directed backwards.
>
> Typical genus *Diarthrophallus* nov. gen."

In 1955, Drs. Camin and Gorirossi reduced the Diarthrophallina to the rank of a superfamily, the Diarthrophalloidea, and together with the Trachytoidea and Uropodoidea placed it in the cohort Uropodina.

They diagnosed the superfamily thus:

> "Epigynial shield elongate, tongue-like, fused or hinged to ventral shield. Metasternal shields fused with sternal shield. Sternal shield independent or fused with ventral to form perigenital ring; enlarged jugulars in some. Base of tritosternum moderate to broad, unconcealed; flanked by a

* South Australian Museum.

pair of 'praesternal' setae. Stigmata between coxae III and IV. One or two dorsal shields without marginal shields. No camerostome or 'foveahe pedales'."

Besides the genotype of *Diarthrophallus*, Trägårdh (loc. cit.) described a second species of the genus, *D. similis* from Mexico, and erected a new genus, *Brachytremella* for a new species *B. spinosa* from New Guinea. He also in the same paper referred to his family the little known genus *Passalobia* Lombardini, 1926.

Through the great kindness of the authorities of the Stockholm Museum and the assistance of Dr. K. H. Forsslund of the Swedish Forest Research Station, Stockholm, I have been able to examine the material of *D. quercus* which was sent to Trägårdh by Dr. Pearse for study. In addition, I have received from Dr. D. E. Johnston of the Inst. of Acarology, Univ. of Maryland, U.S.A., a number of slides labelled and identified by him as *D. quercus*. Actually not all of these are this species but as will be shown later some are to be assigned to *D. duodecimpilosa* (Lomb.), which is the same as *D. similis* Träg. I have also a single male and nymph of *D. quercus* which I collected from a Passalid in a rotting log at a saw mill in Annapolis, Maryland, U.S.A., in June 1947.

Inquiries of my friend, Dr. S. L. Tuxen, as to the present existence of the unique female of *Brachytremella spinosa* Träg. from New Guinea have failed to locate it. It seems therefore to be now lost. However, on Passalids which I collected at Bulolo, New Guinea, in 1954, I was fortunate to find a single specimen of each sex and two nymphs which agree with Trägårdh's description. The species is therefore redescribed in this paper.

The third genus which Trägårdh referred to the Diarthrophallidae is the little known *Passalobia* Lomb., 1929. This genus was erected for *P. quadricaudata* from a Passalid from Brazil.

Later Lombardini described three other species as belonging to his genus, namely, *P. duodecimpilosa* 1938, *P. major* 1938, and *P. peritrematica* 1951

Hitherto, no one but Lombardini has seen material of this genus or even re-examined his material. It is therefore a very great privilege that I have been permitted by Dr. Lombardini to examine what is extant of his *Passalobia* spp. and with his permission to remount them. Unfortunately, the war resulted in the loss of much of his collection and the whole lot still existing and sent to me comprises 1 slide of *P. quadricaudata*, ♂, 1 ditto larva, 2 slides of *major*, nymphs, 1 slide of *duodecimpilosa*, ♀, and 1 slide of *peritrematica*, nymph. Of these species *duodecimpilosa* is considered to be a synonym of and to have priority over *similis* Träg. and not to be a true *Passalobia* but probably a *Diarthrophallus*. For the very curious *P. peritrematica*, a new genus *Passalana* is created. I have therefore been able to study all the described species of Diarthrophallidae while in a concurrent paper to this I have described two new species of *Brachytremella* from Australia, as well as erected the genera *Lombardiniella* and *Brachytremelloides* for two other new species also from Australia.

Family DIARTHROPHALLIDAE Trägårdh.

Trägårdh, I., 1946 Diarthrophallina, a new group of Mesostigmata found on Passalid beetles. Ent. Medd., **24** (6), pp. 369-394.

New Diagnosis.—Body form flat, broadly oval to elongate, sometimes constricted medially. Dorsum with a single shield, generally surrounded by a narrow band of cuticle, with or without a number of long ciliated capitate setae. All legs short, I thin and antennaeform without ambulacra, tarsus apically bifurcate, II-IV much stouter with large ambulacra but no claws; coxae I coalesced medially to form a single transverse praesternal shield or well differentiated and fragmented. Tritosternum at base flanked by a pair of setae. Sternal, metasternal and ventral shields coalesced, forming a perigenital oval ring between the coxae; sterno-gynial shield in female tongue-shaped fitting the genital orifice and fused posteriorly with the ventral shield, in the male fused anteriorly with the sternal shield and the sterno-gynial shield directed posteriad. Anal shield small, with one pair of long adanal setae. Metapodal shields present or absent. Hypostome with 3 pairs of setae. Tectum bi- or quadrifurcate or helmet-shaped with apical spike. Chelicerae with excrescence on fixed digit. Stigma between coxae II and IV, rarely between II and III, peritreme short or absent and directed anteriorly, or long, free and directed backwards.

Typical genus *Diarthrophallus* Träg.

Subfamily Diarthrophallinae Trägårdh, 1946

Tectum bi- or trifurcate. Body broadly oval to elongate oval, not medially constricted, dorsally with long ciliated capitate setae or entirely without setae.

Typical genus *Diarthrophallus* Träg.

Genus Diarthrophallus Träg.

Trägårdh, I., 1946. Ent. Medd., **24** (6), p. 371. Type *Uroscius quercus* Pearse *et al.*, 1936.

Body broadly oval, with long dorsal ciliated capitate setae. Perigenital ring in female closed behind by a well-defined semicircular suture. Tectum a rather elongate cone, apically quadrifurcate with the outer styli simple and strongly bent outwards, the inner styli directed straight forwards closely adjacent and basally with long ciliations. Leg II in male similar to female. . . . .

Genotype *Diarthrophallus quercus* (Pearse *et al.*).

This genus so far contains only two species and seems to be confined to North America. Besides the type Trägårdh, 1946, described a second species *D. similis* from a single nymph found on a specimen of the Passalid *Proculus goryi* from Mexico, in the Hope Museum, Oxford. As is shown later, *similis* is a synonym of Lombardini's *Passalobia duodecimpilosa* 1938 which trivial name has priority.

Diarthrophallus quercus (Pearse *et al.*).

Text figs. 1A-F, 2A-B.

Uroscius quercus Pearse *et al.*, 1936. Ecol. Monog., **6**, p. 478, figs. 31-34.
Diarthrophallus quercus Trägårdh, 1946. Ent. Medd., **24** (6), pp. 371-380, figs. 1-2, 4-5.

Female, Fig. 1A.—A broadly oval, brownish species. Length of idiosoma 526μ, width 409μ.

Dorsum.—Almost entirely covered by dorsal shield, only a narrow band of cuticle surrounding shield, length of shield 468μ, width 398μ, with 6 pairs of long ciliated capitate setae to 440μ long, second and fourth pairs of setae marginal on shield, first, third, fifth and sixth pairs on the cuticle, shield with a pair of pores in line with coxae III and a number of fine pores or setae (not shown in Fig. 1B).

Venter, Fig. 1A.—As figured; tritosternum with a moderately long conical base flanked by a pair of setae; sternal, endopodal, metasternal and ventral shields coalesced to form a single shield 394μ long, 120μ wide anteriorly, expanding to 216μ between coxae II and coxae III, then contracting to 130μ between coxae IV to expand again to 149μ before rounding off a short distance from anal shield; in the intercoxal portion is the large oval perigenital ring in which lies the close-fitting oval tongue-shaped sternogynial shield, the margin of the orifice is thickened to 134μ from the anterior and across at this point is

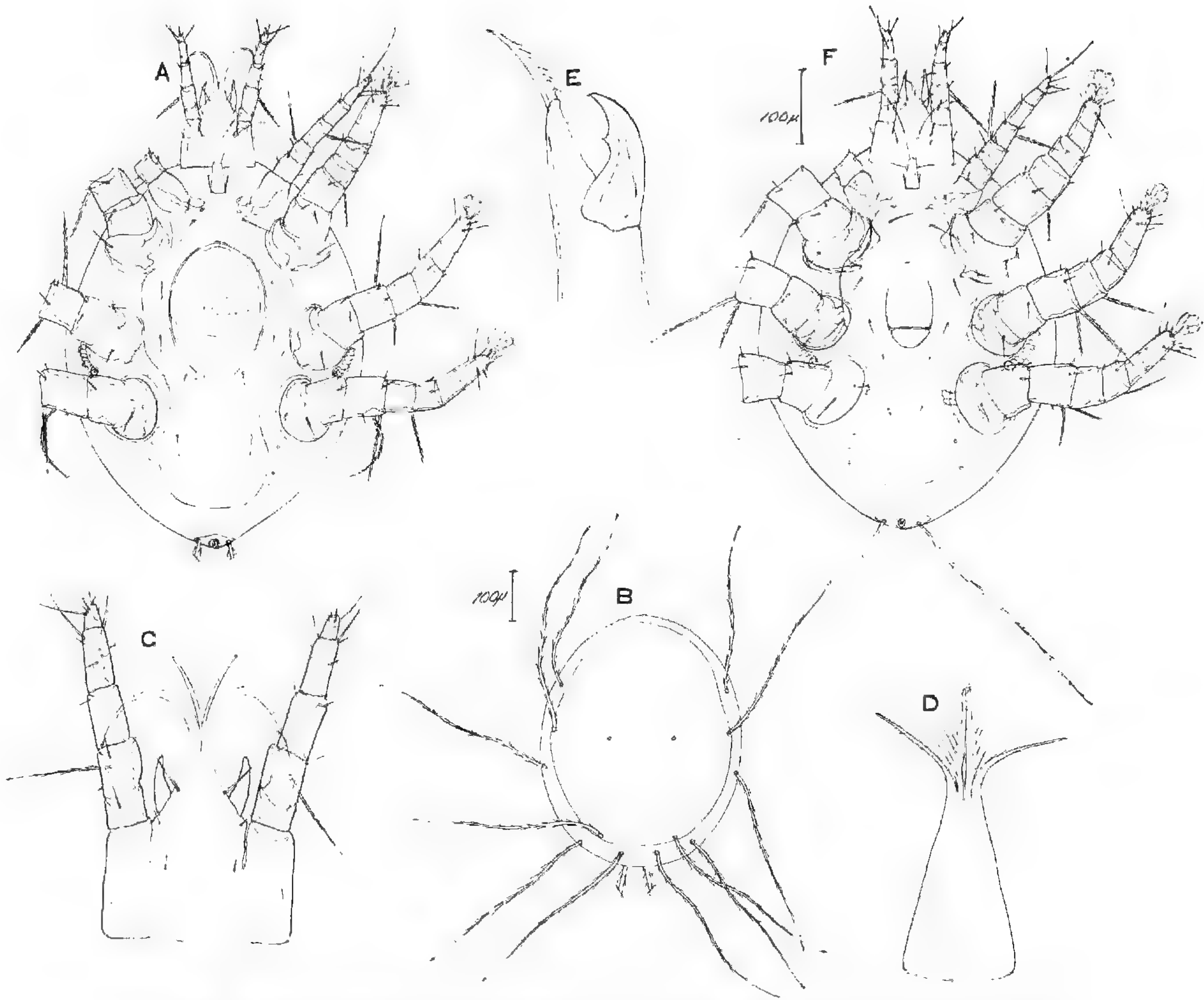

Fig. 1.—*Diarthrophallus quercus* (Pearse *et al.*). A, female in ventral view; B, dorsal view

a faint sub-cuticular transverse line, the orifice is posteriorly closed by a semi-circular suture, the anterior pair of sternal setae are long, 48μ, the second to fourth pairs 14μ and the fifth pair in line with posterior margin of coxae IV 24μ; anal shield transversely diamond-shaped, 58μ wide by 20μ, with a pair of long ciliated capitate setae to 440μ; there are no metapodal shields; on each side of the ventral portion of the sterno-ventral shield are 2 or 3 small shieldlets; stigma between coxae III and IV with a short curved forwardly directed peritreme 48μ long.

Gnathosoma, Fig. 1C.—As figured, with 3 pairs of hypostomal setae of which the anterior pair is the longest, with a pair of strong outwardly curved hypostomal styli and a pair of long salivary styli; dorsally with a long conical tectum,

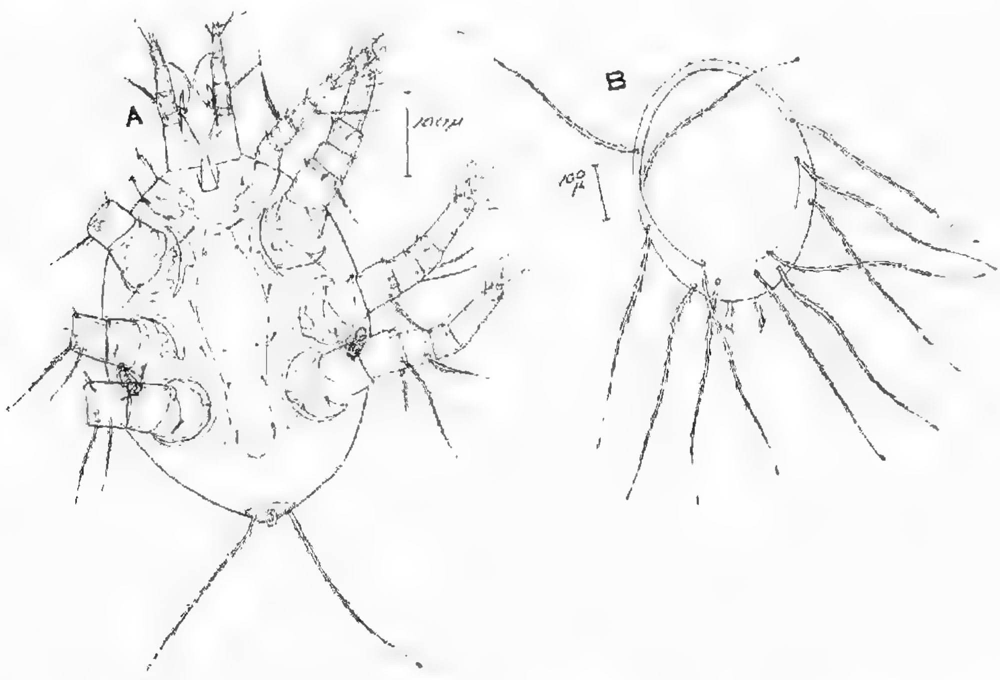

Fig. 2.—*Diarthrophallus quercus* (Pearse et al.). Nymph. A, venter; B, dorsum.

Fig. 1D, with 4 apical branches, the outer ones bent rather sharply outwards and nude, the inner ones about the same length, closely adjacent and directed straight forwards with long ciliations basally. *Palpi* 5-segmented (Fig. 1C), femur with straight long-ciliated seta dorsally. *Chelicerae* (Fig. 1E), fixed digit without teeth but with a subapical excrescence, movable digit with a small median inner tooth.

Legs.—All 6-segmented and shorter than body, I slender and tapering to 216μ, tarsus without ambulacra but apically bifid with a long seta, with a long straight and ciliated seta on femur and on genu, II-IV much stouter and the tarsi furnished with large ambulacra but without claws, II 312μ long with two long ciliated setae on femur and one on genu, III 336μ with similar setae on femur and genu, IV 360μ and similar.

Male, Fig. 1F.—Of the same size and facies as in the female.

Dorsum as in the female.

Venter, Fig. 1F, as in the female but the coalesced sternal, endopodal, metasternal and ventral shield somewhat narrower, length 374μ, anterior width 120μ, expanding between coxae II and between coxae III to 178μ, contracting to 101μ between coxae IV and then widening to 120μ before rounding off, the setae are as in the female, between the coxae is the oval perigenital ring which is not as large as in the female, 110μ long by 72μ wide, within it lies the elongate backwardly directed and two-segmented sternogynial shield, 82μ long by 62μ wide, with the apical segment 24μ long, coalesced anteriorly with the sternal shield; the stigma is between coxae III and IV with peritreme 58μ long.

Gnathosoma and *Legs* as in female; leg I 226μ long, II 326μ, III 360μ, IV 384μ.

Tritonymph, Fig. 2A-B.—Of the same general shape as in the female. Length of idiosoma 433μ, width 304μ.

Dorsum, Fig. 2B.—Dorsal shield with 2 pairs of long, 409μ, ciliated capitate setae and surrounding cuticle with 4 pairs of such arranged as in the female.

Venter, Fig. 2A.—With a single shield 283μ long by 82μ wide between coxae II and III, rounded anteriorly and tapering from coxae III to just past the posterior of acetabula IV, between coxae IV it is 53μ wide, of the 5 pairs of sternal setae only IV and V are on the shield, sternal setae I are longer than the others; endopodal shields of coxae I are free and well demarcated, rather moon-shaped as shown; stigma between coxae III and IV with peritreme 29μ long; anal shield as in female, 53μ wide by 19μ long, with adanal pair of long ciliated setae to 336μ.

Gnathosoma as in female.

Legs as in female, I 206μ long, II 288μ, III 298μ, IV 312μ.

Remarks.—The above descriptions and figures are from preparations sent by Dr. D. E. Johnston of specimens from Oakland Co., Michigan, U.S.A., 14/4/57. The female was from slide I-241-1, the male from slide I-241-3 and the nymph from slide I-241-4.

Diarthrophallus duodecimpilosus (Lomb., 1938) new comb.

Fig. 3A-G.

Passalobia duodecimpilosa Lomb., 1938. Mem. Soc. ent. ital. XVII, fasc. 1, p. 46, Figs. V and VI.

Diarthrophallus similis Träg., 1946. Ent. Medd., 24 (6), pp. 380-384, Figs. 6 and 7.

Lombardini described this species from a single specimen taken from under the elytra of a Passalid from Brazil. He ascribed it to his genus *Passalobia* and regarded it as a male. Actually his figures show clearly that it is a nymph and this is confirmed from an examination of the specimen itself which Prof. Lombardini has very kindly loaned to me and permitted me to remount for critical study.

D. similis was described by Trägårdh also from a single nymph from a Passalid, *Proculus goryi* from Mexico in the Hope Museum at Oxford. Unfortunately, it has not been possible to trace Trägårdh's slide of this specimen, either in the Trägårdh material in the Stockholm Museum, or in the Hope Museum, to which it was supposed to have been returned. It must therefore be presumed to have been lost.

However, in addition to being able to examine Lombardini's type, I possess a single nymph collected by myself from a Passalid, at Annapolis, Maryland, U.S.A., in 1949, and amongst a number of slides of *Diarthrophallus quercus* (Pearse *et al.*) sent to me by Dr. D. E. Johnston of the University of Maryland, was one of nymphs, all of which agree with Trägårdh's and Lombardini's species thus establishing the synonymy of *similis* with *duodecimpilosa*. In his descrip-

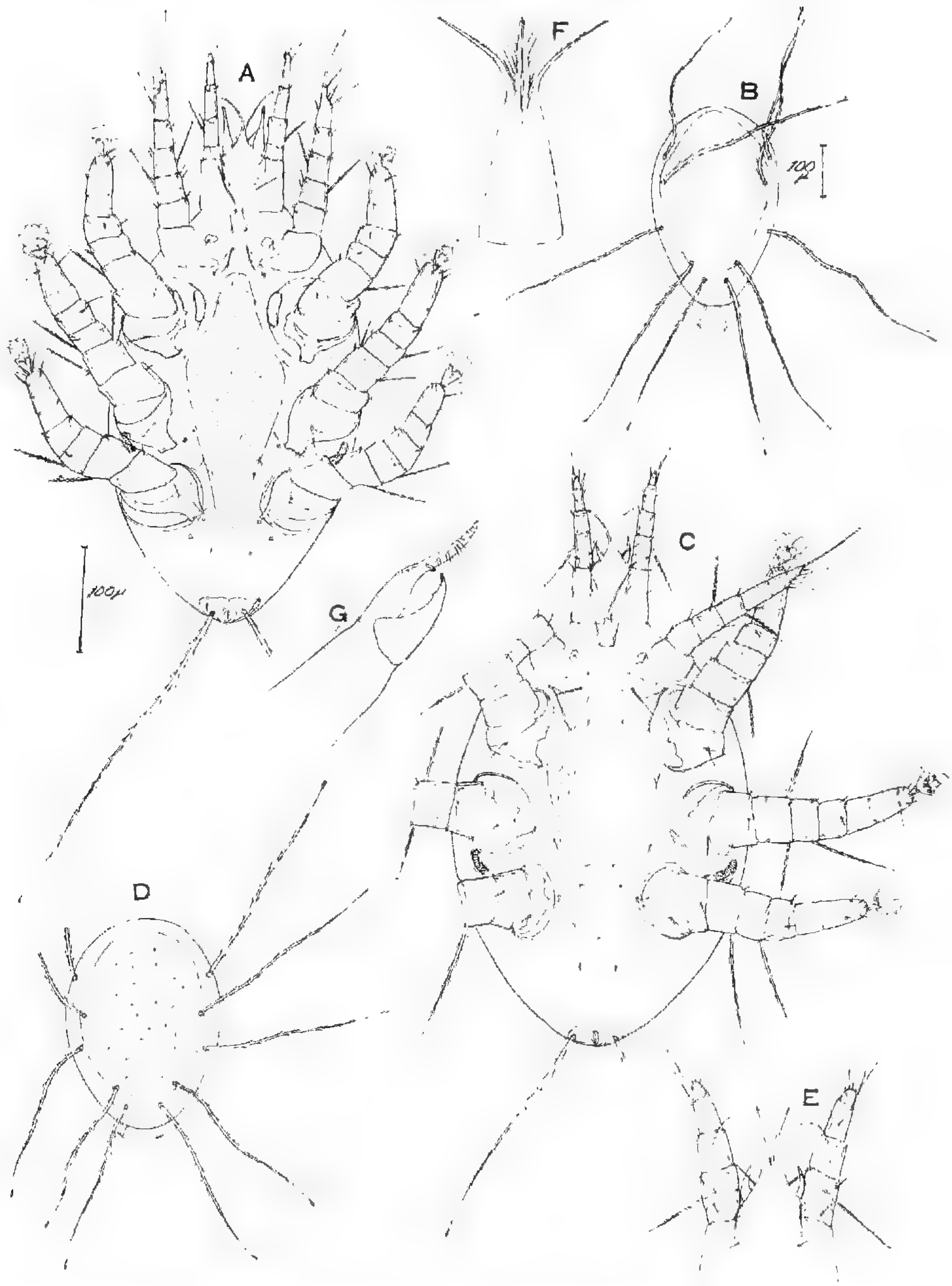

Fig. 3.–*Diarthrophallus duodecimpilosa* (Lomb., 1938). Nymph: A, venter; B, dorsum (A-B from Lombardini's type); C, venter; D, dorsum; E, gnathosoma from below; F, tectum; G, chelicerae (C-G from specimen 1-241-6, from Michigan, U.S.A.).

tion Trägårdh described the tectum (*sic* epistome) as having a triangular mucro with a very fine fringe and figures it so (Fig. 7C). In this Trägårdh was mistaken, for in all three specimens before me the tectum is conical with a quadrifurcate apex as in most species of Diarthrophallinae; the outer members are strong and angled, and the inner straight, but with long basal ciliations. It is these ciliations which Trägårdh saw and interpreted as the fringe of a triangular tectum.

The species is principally characterised by having only 5 pairs of long dorsal setae, but whether it should be strictly placed in *Diarthrophallus* or the allied genus *Brachytremella* Trägårdh, must await the discovery of the adult female. For the present it is as well to retain Trägårdh's placing.

Redescription of Holotype. Fig. 3A-B.

Nymph.—Length of idiosoma 384μ, width 240μ. Shape broadly oval.

Dorsum.—With entire dorsal shield not completely covering dorsum as figured; with five pairs of long ciliated slender capitate setae of approximately equal length from 336μ to 408μ; shield 312μ long by 230μ wide.

Venter as figured, with the median shield 254μ long by 96μ, widest between coxae II and III, the shield is furnished with short broken elongate markings and carries a pair of marginal pores in line with front of coxae II and another pair in line with anterior of coxae IV, of the 5 pairs of ventral setae only the fourth pair are on the shield and marginal; only the endopodal shields of coxae II and IV are well sclerotised, those of II being somewhat kidney-shaped as shown, 38μ long by 14μ wide and do not tend to contour the coxae as in other species, those of coxae IV contour the coxae normally; the anal shield is roughly triangular and furnished with a pair of long setae, 336μ, similar to the dorsal setae; peritreme small, 29μ long.

Gnathosoma similar to that of other species as are also the palpi. *Chelicerae* as figured, movable digit with a small median tooth, fixed digit with subapical excrescence; tectum as figured, quadrifurcate, the outer members strongly angled outwards, the inner straight, closely adjacent.

Legs as in *D. quercus* (Pearse *et al.*), the coxae of leg I not conjoined medially, but distinct and fragmented. I 182μ long, II-IV 240μ.

Remarks.—The accompanying figures of this specimen are drawn after remounting. For comparison figures and details of a specimen from Michigan (one of three) are given as well as measurements of the specimen collected by myself at Annapolis.

Specimen from Oaklands Co., Michigan, U.S.A. (one of three labelled *Diarthrophallus quercus*) coll. D. E. Johnston, 24th April, 1957. No. I-241-6. Length of idiosoma 359μ, width 307μ. Dorsal shield 317μ long by 245μ wide. Dorsal setae 5 pairs to 384μ long. Ventral shield 245μ long, maximum width 96μ; endopodal shields of coxae I 48μ by 14μ; peritreme 24μ long. Anal setae 264μ long.

Specimen from Annapolis, Maryland, U.S.A., June, 1947 (coll. H.W.). Length of idiosoma 442μ, width 350μ. Dorsal shield 336μ long by 230μ wide. Dorsal setae, 5 pairs to 384μ long. Ventral shield 254μ by 100μ maximum width; endopodal shields of coxae I 48μ by 14μ; peritreme 29μ long. Anal setae?

Genus BRACHYTREMELLA Trägårdh, 1946.

Trägårdh, I., 1946. Ent. Medd., 24 (6), p. 386.

This genus was erected by Trägårdh for a single female obtained from a Passalid *Protomocerus* sp. from New Guinea. He distinguished the genus on the fact that the perigenital ring was open posteriorly with the sterno-gynial shield completely coalesced with the ventral and not closed by a semicircular suture as in *Diarthrophallus*. The genus has been redefined and the genotype redescribed from freshly discovered material in the concurrent paper.[1]

Besides the above difference from *Diarthrophallus* there is a significant one in the form of the tectum. In the two known species of *Diarthrophallus* the tectum is apically quadrifurcate with the outer elements bent angularly outwards and simple, the inner elements but little shorter directed straight forwards, closely adjacent to each other and with long ciliations basally; in *Brachytremella* the tectum is quadrifurcate in *B. spinosa* Träg. and *B. trägårdhi* Wom., 1960 (this Journal, p. 11), with the outer elements shorter and stouter than the inner and slightly curved outwards, the inner elements arise well within the basal junction of the outer ones, are much longer, simple and divergent. In *B. bornemisszai* Wom., 1960 (this Journal, p. 20), the tectum is only bifurcate apically with two long slender simple elements.

The above three species placed in the genus are separated as in the following key to subfamilies, genera and species of Diarthrophallidae.

Brachytremella spinosa Träg.

Trägårdh, I., 1946. Ent. Medd., 24 (6), p. 385, fig. 8.

Womersley, H., 1960. Some Acarina from Australia and New Guinea, paraphagic upon millipedes and cockroaches and on beetles of the family Passalidae. Pt. 4. The family Diarthrophallidae. This Journal, p. 13, figs. 1 and 2.

The type specimen of this species described from New Guinea from *Protomocerus* sp. has apparently been lost. The species was redescribed (Womersley, this Journal, p. ??) in the concurrent paper from fresh material of both sexes and the tritonymph, from a Passalid from Bulolo, New Guinea, Aug., 1954 (coll. H.W.).

Brachytremella trägårdhi Wom.

Womersley, H., 1960. *Ibid.*, this Journal, p. 16, figs. 3 and 4.

This species was described from the female, tritonymph and deutonymph from specimens from Passalids (*Mastochilus* sp.), from Mt. Lamington, Queensland, collected in December, 1948 (H.W.).

Brachytremella bornemisszai Wom.

Womersley, H., 1960. *Ibid.*, this Journal, p. 20, fig. 5.

Only the tritonymph of this species is known. It was described from two specimens found on *Aulacocyclus edentulus* McL., Hinchinbrook Is., North Queensland, 9/9/56 (coll. G.F.B.), and on the same host from Wilson's Downfall, near Tenterfield, New South Wales, 8/10/56 (coll. G.F.B.).

Genus Passalobia Lombardini

Lombardini, G., 1926. Duo novo genera acarorum. Boll. Soc. entom. ital., 63 (9-10), p. 158, figs. 1-2.

Lombardini erected this genus for a new species *Passalobia quadricaudata* found under the elytra of a Passalid beetle from Brazil. His generic diagnosis was very brief and inadequate and merely stated that it belonged to the Laelaptidae, that the sexes differed in some secondary characters and that the tarsi of leg I lacked ambulacra.

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[1] Some Acarina from Australia and New Guinea paraphagic upon millipedes and cockroaches and on beetles of the family Passalidae. Pt. 4. The family Diarthrophallidae. Womersley, H., 1960. This Journal, p. 11.

Since his original diagnosis of the genus and description of the type species Lombardini has described three other species which he assigned to his genus. These were *duodecimpilosa* 1938, Mem. Soc. ent. ital., 17 (1), p. 44, figs. V and VI; *major*, 1938, *ibid.*, pp. 118-120, fig. II, *peritrematica*, 1951, Redia 36: 245-7, fig. 1.

In his original description of *quadricaudata* he figures the female and what he then considered to be the male, but in 1943, in l'Agricoltura Coloniale, 37 (3), pp. 3-6, figs. 1 and 2, he described a true male which he ascribed to *quadricaudata* and concluded that his original figure and description of the male were those of the nymph. In the same paper he described and figured a larva as of this species.

Apart from the above species, no others have been described or met with, nor has further material been reported by other workers. The first reference to the genus, however, by other workers appears to be that of Trägårdh, 1946, in his important paper on the Diarthrophallidae, when he placed *Passalobia* in association with his genera *Diarthrophallus* and *Brachytremella*, mainly on the structure of the genital shield of the female in that family. Trägårdh himself came to the conclusion that Lombardini's male of 1926 was a nymph, but as he apparently had only Lombardini's 1926 paper before him, he was unaware that Lombardini himself had earlier corrected this while at the same time describing a true male. Trägårdh, 1946: 394, in a key to the genera of the Diarthrophallidae, separates *Passalobia* from *Diarthrophallus* and *Brachytremella* on the presence of a constriction of the body posterior of coxae IV. This feature apparently was not considered as generic by Lombardini, but it is one of several mentioned in the original description of *quadricaudata* which may be so regarded.

Owing to the uncertainty of the status of *Passalobia* the writer requested the loan of Lombardini's original material, and I have been privileged to be able to study what is now extant of this, for which I am truly grateful to my colleague. I have received from Prof. Lombardini 6 slides, (1) the unique male and the larva of *quadricaudata* described by him in 1951, (2) the unique specimen of *duodecimpilosa*, (3) two nymphs of *major*, one of which agrees with his figure, and (4) one of the two recorded specimens of *peritrematica*. These are all the material which now exists, the remainder including the original female and nymph of *quadricaudata* having, I am informed, been lost in the war.

With Prof. Lombardini's permission I have been able to remount these specimens and they are redescribed and figured in this paper.

Of these, it is now shown that except in *duodecimpilosa* and *peritrematica*, the constriction behind coxae IV is present in both the female, male and nymph of *quadricaudata* and in the nymph (the only stage known) of *major*. *P. duodecimpilosa* is shown to be synonymous with and to have priority over *Brachytremella similis* Trag., 1946. Thus it must be removed from *Passalobia*. Lombardini's *peritrematica* is a most interesting form and a new genus, *Passalana*, is erected for it. Thus the only two species to remain in *Passalobia* are the genotype *quadricaudata* and *major*. Of all these four species, except *duodecimpilosa*, however, there is one character by which they differ from the other genera of the Diarthrophallidae, namely, the tectum is a short conical helmet shape with an apical spine, it does not terminate in four or two branches. The original female and nymph of *quadricaudata* are now presumably lost. The male attributed by Lombardini to *quadricaudata* is here redescribed. If the correlation is correct, and at present I see no reason to disagree, then the characteristic enlarged and armoured second leg in this sex can be considered as generic for *Passalobia*. There is, however, one very remarkable feature by which it differs from all other species of Diarthrophallidae so far known. The stigmatic opening instead of lying between coxae III and IV is placed between coxae II and III as figured and is apparently more dorso-lateral than ventro-lateral. Although Lombardini does not mention the stigmata in his description, the position between coxae II and III is clearly indicated in his figure.

The slide containing the larvae described by Lombardini, showed that his figure was probably correct, although when received the specimen was in poor condition. Unfortunately, however, this specimen was lost in remounting. It is clear, however, from what was seen of the specimen before it was lost, and from Lombardini's figure 3, that it is not the larva of a Diarthrophallid. The

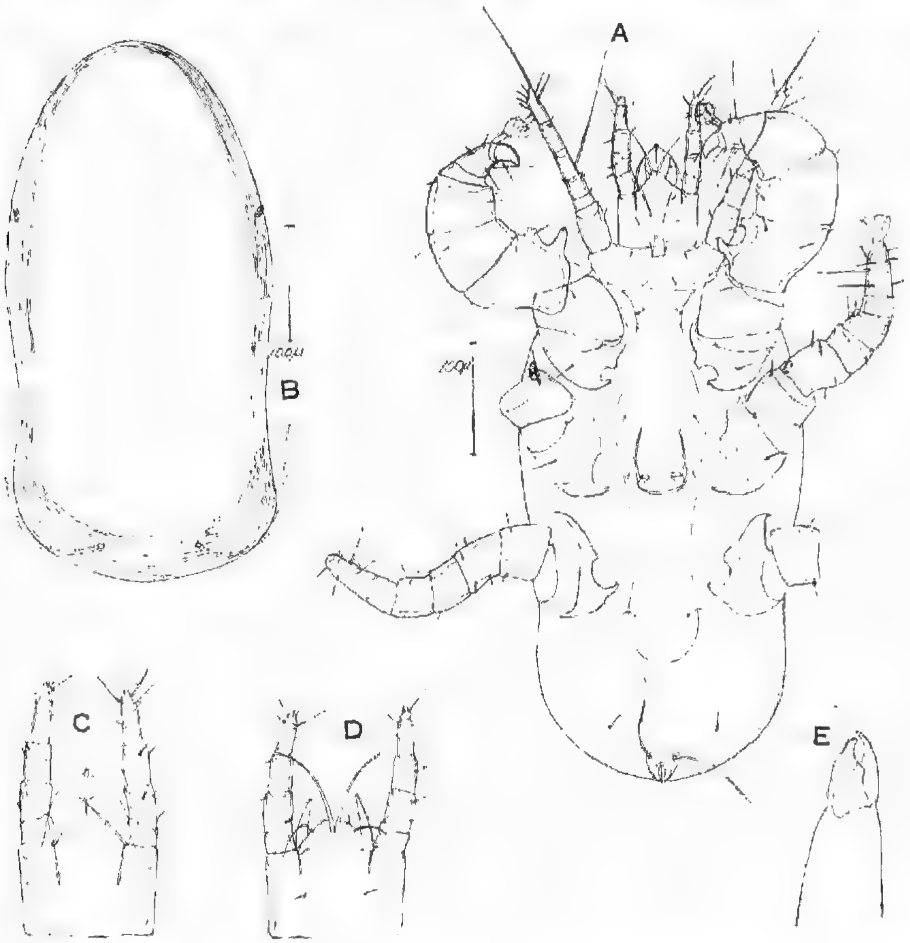

Fig. 4.—*Passalobia quadricaudata* Lomb. Male: A, venter; B, dorsum; C, gnathosoma from above showing tectum; D, gnathosoma from below; E, chelicerae.

number of dorsal setae, the formation of the gnathosoma and the legs, especially the tarsi with the ambulacra bearing two claws on all legs clearly separate it. At present, however, I would not venture to place it.

Passalobia major agrees with all the characters of generic value shown in the nymph of *quadricaudata* as figured and described by Lombardini and although only known from the nymph is probably a good and valid species.

Passalobia peritrematica, however, is a very striking creature. The body is not constricted behind coxae IV as in *P. quadricaudata* and *P. major* but tapers posteriad of coxae IV to a rounded end and thus is somewhat obovate in shape. The most striking feature is that while the stigmal opening although small is between coxae III and IV, the peritremes are long, rather wide lobe-like structures with indistinct chambers and are directed posteriorly and free of the body. As Lombardini remarks, this is a unique feature in the Acarina. In the tectum the species agree with *Passalobia*. A new genus *Passalana* is created for it.

On the structure of the tectum the two genera *Passalobia* Lomb. (genotype *P. quadricaudata* Lomb.) and *Passalana* g. nov. (genotype *P. peritrematica* (Lomb.)) are placed in a separate and new subfamily of the Diarthrophallidae, the Passalobiinae.

The genus *Passalobia* may now be more adequately diagnosed as follows:

> Diarthrophallidae, with the body and dorsal shield, more or less, constricted medially posterior of coxae IV and furnished with only one pair of long anteriorly curved simple setae subposteriorly; tectum a short rounded cone with apical spike, helmet-like; stigma between coxae III and IV (♀) or between coxae II and III (♂), coxae I coalesced to form a transverse shield; ventral shield in nymph extending well past coxae IV. In the male, leg II is very much stouter than III or IV and armed with strong apophyses on femur and a strong claw-like spur ventrally and subapically on tarsus.
>
> Type *P. quadricaudata* Lomb., 1926.

Passalobia quadricaudata Lomb.

Fig. 4A-E.

Passalobia quadricaudata Lombardini, 1926, Bull. Soc. entom. ital., 63 (9-10), p. 158, figs. 1-2 (nymph and ♀); 1943, l'Agricoltura Coloniale, No. 3, pp. 3-5, figs. 1-2 (♂).

Passalobia tetracaudata Lomb., 1938, Mem. Soc. entom. ital., 17 (1), p. 46 (a *lapsus calami* for *quadricaudata*); 1938, *ibid.*, 17 (1), p. 120 (a similar *lapsus calami*).

Passalobia quadricaudata, Trüg., 1946, Ent. Medd., 24 (6), p. 38. (N.B.—Legend under fig. 9 copied from Lombardini, 1926, reads "*quadricornuta*" in error.)

No material of the female and nymph now being available the following redescriptions of these stages is drawn up from a careful consideration of Lombardini's descriptions and his excellent figures of 1926. For the male I have been able to study the unique specimen.

Female.—Body form bilobed with a distinct constriction just behind coxae IV; approximate length 500μ, width 250μ.

Dorsum with a single dorsal shield which anteriorly completely covers dorsum, with one pair of long simple forwardly curved setae subposteriorly.

Venter.—Tritosternum with basal cone flanked by a pair of setae, with a pair of long laciniae; sternal, endopodal, metasternal and ventral shields coalesced, expanding widely behind coxae IV to occupy almost all the ventral surface with rounded margin, with 5 pairs of setae, the anterior pair, sternal setae I, not much if at all longer than II, setae II-IV between the second and third pairs of coxae, V subposterior on the ventral portion of shield; in the intercoxal portion is the large oval perigenital ring which is open posteriorly, its anterior is in line with the middle of coxae II and the sides extend to beyond coxae IV, at its open posterior end the sternogynial shield which is the same shape and occupies the whole of the perigenital ring is fused with the ventral shield; the stigma is small and placed between coxae III and IV and has no peritreme.

Gnathosoma.—No hypostomal setae are shown on Lombardini's figure, but doubtless there are the usual 3 pairs; tectum a short cone with rounded sides and an apical spike, helmet-like; *palpi* 5-segmented, tapering.

Legs as in other Diarthrophallids, generally directed forwards, shorter than body, I tapering, tarsi without ambulacra and apically bifid, with a long apical seta (shown in Lombardini's fig. 11 as arising from the tibia), II-IV stouter and somewhat longer than I, tarsi with large pad-like ambulacra but no claws, leg setae minute and sparse, without any long setae on femur or genu and only a few moderately long setae subapically on tarsi.

Male lectotype, Fig. 4A-E.—Of rather elongate shape with slight constriction posterior of coxae IV. Length of idiosoma 480μ, width 240μ.

Dorsum.—With single dorsal shield 442μ long by 220μ wide anteriorly, surrounded by a narrow band of striated cuticle (Fig. 4B), one pair of long 160μ setae posterior of the shield.

Venter, Fig. 4A, as figured; tritosternum with conical base flanked by a pair of setae and with paired laciniae; sternal, endopodal, metasternal and ventral shields coalesced to an elongated shield extending well beyond coxae IV but still widely separated from anal shield, with 4 pairs of short setae, the anterior pair somewhat behind anterior margin, the shield is 336μ long and 120μ wide between coxae III and 110μ wide posterior of coxae IV, in the intercoxal portion lies the perigenital ring 67μ long and 43μ wide, containing the backwardly directed, double-segmented sternogynial shield 63μ long by 38μ wide with the anterior part 48μ long, the sternogynial shield is fused anteriorly with the sternal portion; between the ventral shield and the anal is a pair of short wider spaced setae; anal shield small, triangular, 28μ wide by 28μ long with adanal setae 96μ long; stigma situated between coxae II and III and apparently more dorsal than ventral, without peritreme.

Gnathosoma, Fig. 4C, D; with 3 pairs of hypostomal setae, the anterior pair much longer than the others, and with paired styli; dorsally with helmet-shaped tectum, labial cornicles moderately long; *palpi* 5-segmented, without any long setae on femur or genu; *chelicerae*, Fig. 4E, with short edentate chelae, the fixed digit with subapical hyaline excrescence.

Legs.—Six-segmented, I slender and much shorter than the rest, 192μ, without ambulacra or claws, tapering, genu with a very long simple seta, tarsus apically bifid with a long terminal seta, coxae coalesced to form a single transverse shield, II very stout, much more so than III or IV and armed on femur with a strong inner process and a smaller one subapically, tarsus with ambulacra of a large pad but no claws, subapically with a strong claw-like spur, length of leg 336μ, width of femur 72μ; III and IV thicker than I, 288μ long, without any long setae except on tarsi when they are only of medium length, tarsi with large ambulacra but no claws.

Remarks.—The male is a remarkable creature and should the correlation of it with the female described earlier by Lombardini be correct, then the character of the enlarged and armoured leg II can be considered a generic character. Another remarkable feature is that the stigma, normally between coxae III and IV in the female, is in the male placed between coxae II and III as is clearly indicated in Lombardini's original figure. The rediscovery of the species in both sexes is badly needed to verify the above features and check the correlation.

In his 1943 paper Lombardini also described and figured (Fig. 3) what he regarded as the larva of *quadricaudata*. Amongst the slides sent to me by Dr. Lombardini was that of this specimen. Although in bad condition, it could be seen that Lombardini's figure was a reasonably good one. Very regrettably, however, in an attempt to remount this specimen it became lost.

From what was seen of the specimen and from Lombardini's figure and description, it seems pretty conclusive that on the structure of the ambulacra which consisted of a longish caruncle with only a small pad and paired claws on all tarsi, as well as the body setae, it is not a Diarthrophallid and probably does not belong to the Uropodina. Until rediscovered little more can be said.

Passalobia major Lomb., 1938.

Fig. 5.

Lombardini, G., 1938. Mem. Soc. entom. ital., 17 (1), p. 120, fig. II.

This species was described from the nymph only, from under the elytra of Passalids from Brazil. Amongst the slides sent to me by Dr. Lombardini were two nymphs of this species, one of which in good condition appears to be

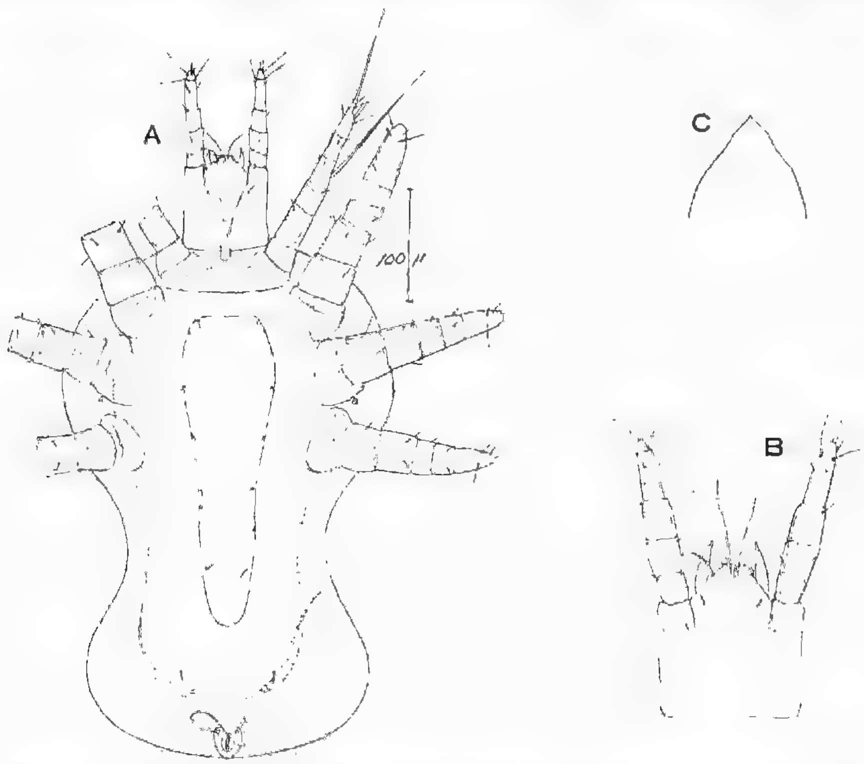

Fig. 5.—*Passalobia major* Lomb., 1938. Nymph: A, venter; B, gnathosoma from below; C, tectum.

that figured by Lombardini. It differs slightly, however, in the shape of the ventral shield and is refigured and redescribed as follows:

Tritonymph.—Body of elongate bilobed form with a strong constriction behind coxae IV, length of idiosoma 480μ, anterior portion 298μ wide, posterior portion 187μ wide and across the constriction 115μ.

Dorsum, Fig. 5A.—Dorsal shield entire, roughly contouring the body shape 360μ long by 206μ wide, posteriorly with a pair of submarginal long setae 67μ apart and 115μ long and directed forwards.

Venter, Fig. 5A.—Tritosternum with paired laciniae and flanked by a pair of setae; with a single elongated shield 240μ long and 94μ at the widest part between coxae III, extending well past coxae IV but not nearly reaching anal shield, with 5 pairs of small setae; endopodal shields not marked; anal shield small, triangular, 24μ wide by 24μ long with a pair of forwardly directed setae 57μ long.

Gnathosoma, Fig. 5B, with three pairs of hypostomal setae, the anterior pair much the longest, with long salivary styli, dorsally with helmet-shaped tectum, Fig. 5C; *palpi* 5-segmented, without long setae on femur or genu Fig. 5B; *chelicerae* not clearly seen.

Legs.—I the shortest and slender, 192μ long with a long seta on genu, tarsus apically bifid with a long terminal seta but without ambulacram, coxae coalesced to form a single transverse shield; II-IV stouter, 216μ long, without any long setae, tarsi with pad-like ambulacra but no claws.

Remarks.—This would seem to be a valid species, differing from the nymph of *quadricaudata* Lomb. figured as a male by him (1926), in the shorter ventral shield and in the shorter dorsal and anal setae.

Genus Passalana nov.

This genus is erected for the very curious species described in 1951 by Lombardini under the name of *Passalobia peritrematica*. The genus may be diagnosed as follows:

Diarthrophallidae in that legs I are antennaeform without ambulacra or claws and with the tarsus apically bifid with long terminal seta; legs II-IV stouter than I with large ambulacra but no claws; body shape obovate with a single dorsal shield, with only one pair of long dorsal setae sub-posteriorly on cuticle between dorsal shield and end of body; sternal shield extending only slightly beyond coxae IV and into the angles between coxae II and III, and between coxae III and IV; ventri-anal shield large with a pair of small sub-anterior setae and a pair of long adanal setae; stigma between coxae III and IV with long tubular blunt-ended peritreme with a number of indistinct chambers and extending backwards and free of the body almost to the end of it; coxae of leg I coalesced; tectum helmet-shaped. Type *Passalobia peritrematica* Lomb.

The unique specimen is redescribed thus:

Passalana peritrematica (Lomb.).

Lombardini, G., 1951. Redia 36, 2nd ser., pp. 245-247, fig. 1.

Of this species Lombardini states that he had found only two females from under the elytra of Passalid beetles from Brazil.

It is clear from his figure, however, as well as from the single specimen now extant and amongst the slides he sent me, that the specimens are not adult in that there is no sign of the genital organs. True there is a peculiar large ring with crenulate margin lying between the third and fourth coxae which might suggest on superficial examination an ovum in situ; that it is not so, is evident from the absence of genitalia and the fact that it appears to be on the dorsal surface. Until fresh material can be examined the precise nature of this feature is problematical, but it is possibly a dorsal protuberance which in mounting has been depressed to give the ring-like appearance; the marginal crenulations do to some extent extend on to the surface from the margin inwards.

Nymph, Fig. 6A-C.—Shape of body obovate, idiosoma 328μ long by 199μ wide, widest part in line of coxae III.

Dorsum, Fig. 6B; with a single dorsal shield as shown, which is only separated from the margin of the body anteriorly and ends about midway between coxae IV and the anus, with only one pair of long simple setae marginally, which are 82μ apart, 53μ from the anus and 72μ long.

Venter, Fig. 6A.—Tritosternum with short conical base flanked by a pair of setae and with paired laciniae; with the sternal and endopodal shields coalesced, with almost straight anterior margin, 120μ, and strongly convex

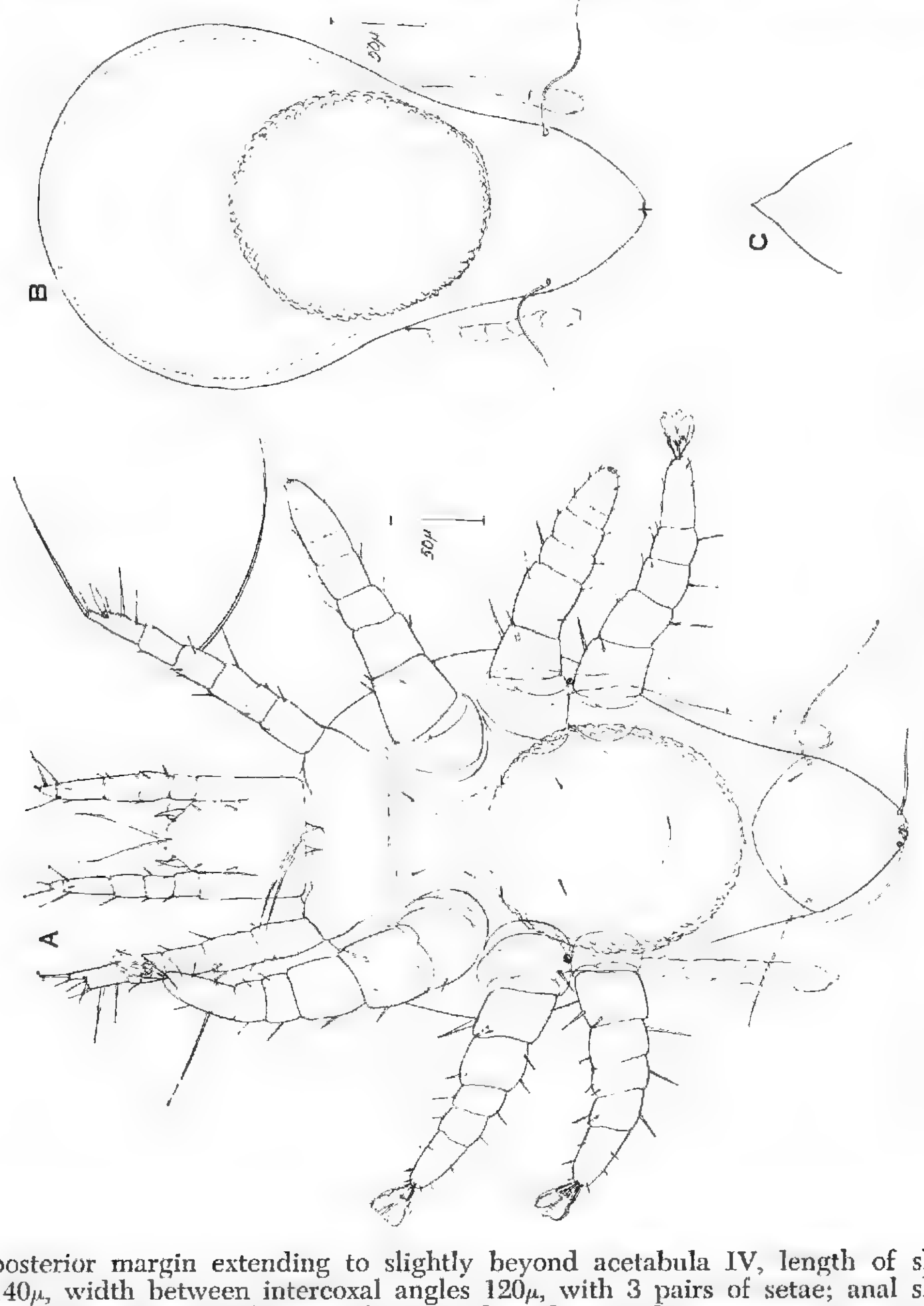

Fig. 6.—*Passalobia peritrematica* (Lomb., 1951). Nymph: A, venter; B, dorsum; C, tectum.

posterior margin extending to slightly beyond acetabula IV, length of shield 140μ, width between intercoxal angles 120μ, with 3 pairs of setae; anal shield large, apparently embracing the ventral, with strongly convex anterior margin and sides contouring the body margin, 72μ long, 82μ wide, with the anus and adanal setae posterior, adanal setae simple and 96μ long, sub-anteriorly and about 50μ apart is a pair of short setae; stigma small and situated between coxae III and IV with a long, sausage-like chambered peritreme, 150μ long and ca. 12μ wide which lies free from the body and is directed backwards.

Gnathosoma with 3 pairs of hypostomal setae, the anterior pair much the longest, with a pair of long hypostomal styli; tectum helmet-like (Fig. 6C); *palpi* 5-segmented, without any very long setae; *chelicerae* not clearly seen.

Legs.—All 6-segmented, I the longest, 158μ, but not so stout as II-IV, antennaeform, without ambulacra or claws, tarsi apically bifid with a long apical seta, a very long nude seta on genu; legs II-IV stouter, with large ambulacra but no claws, without any long setae on any segments, II 216μ, III 178μ, IV 178μ; coxae of leg I coalesced to form a transverse shield.

Remarks.—The curious ring structure noticed above is 110μ in diameter.

Key to the Subfamilies, Genera and Species of the *Diarthrophallidae*.

1. Tectum bi- or quadrifurcate; dorsum generally with some long ciliated capitate setae 2

Subfam. *Diarthrophallinae* Träg.

Tectum helmet-like with apical spike, not bi- or quadrifurcate; dorsum with only one pair of sub-posterior long simple setae. 5

Subfam. *Passalobiinae* nov.

2. Of broadly oval body form, with some long ciliated capitate dorsal setae. 3

Of elongate form, without any dorsal long setae. Ventral shield reaching to the anal; with longitudinal lines. Tectum bifurcate.

Gen. *Brachytremelloides* nov.

B. striata Wom., 1960.

3. Genital orifice of female closed behind by a semicircular suture; coxae of leg I not coalesced, fragmented. Tectum quadrifurcate, with inner elements ciliated basally.

Gen. *Diarthrophallus* Träg., 1946.

(a) With 6 pairs of long dorsal setae.

D. quercus (Pearse *et al.*, 1936).

(b) With 5 pairs of long dorsal setae.

D. duodecimpilosa (Lomb., 1938).
= *similis* Träg., 1946.

Genital orifice open behind, genital shield coalesced with ventral. 4

4. Metapodal shields present, large and not coalesced with ventral. Tectum bifurcate. Dorsum with only 3 pairs of long setae posteriorly.

Gen. *Lombardiniella* nov.

L. lombardinii Wom., 1960.

Metapodal shields absent or fused with ventral. Tectum bi- or quadrifurcate. Dorsum with more than 3 pairs of long setae, not confined to the posterior.

Gen. *Brachytremella* Träg., 1946.

(a) With 6 pairs of long dorsal setae of which the second pair from the front are only half the length of the others. Tectum quadrifurcate with the inner elements the longest.

B. trägårdhi Wom., 1960.

With all the dorsal setae equally long (b)

(b) With 5 pairs of long dorsal setae. Tectum quadrifurcate with the inner elements the longest.

B. spinosa Träg., 1946.

With 4 pairs of long dorsal setae. Tectum bifurcate.

B. bornemisszai Wom., 1960.

5. Body constricted more or less behind coxae IV then widening.
Gen. *Passalobia* Lomb., 1926.
   (a) In nymph with ventral shield although surpassing coxae IV not nearly reaching anal; adanal setae much shorter than dorsal.
   P. major Lomb., 1938.
   (b) In nymph with ventral shield nearly reaching anal; adanal setae as long as dorsal setae. In male leg II with femoral apophyses and subapical tarsal spur, and stigma between coxae II and III.
   P. quadricaudata Lomb., 1926.

Body form obovate, tapering from coxae IV; with backwardly directed long and free, chambered peritremes. Tectum bifurcate. (Only known from nymph.)
Gen. *Passalana* nov.
P. peritrematica (Lomb., 1951).

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ON THL3 DIET AND FEEDING HABITS OF *HEMIDACTYLUS FRENATUS* (DUMERIL AND BIBRON) (REPTILIA: GEKKONIDAE) AT RANGOON, BURMA

BY MICHAEL J. TYLER

Summary

Twenty-one specimens of *Hemidactylus frenatus* (Dumeril and Bibron) were examined at Rangoon, Burma; the stomach contents were listed and observations were made on the feeding habits of several communities. Consideration of these observations and records of geckos ingesting prey normally regarded as aposematic, led to the conclusion at insufficient evidence exists for it to be possible to establish whether H. *frenatus* is a discriminate feeder, although it has been previously believed to be so.

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[Read 12 May 1960]

SUMMARY.

Twenty-one specimens of *Hemidactylus frenatus* (Duméril and Bibron) were examined at Rangoon, Burma; the stomach contents were listed and observations were made on the feeding habits of several communities. Consideration of these observations and records of geckos ingesting prey normally regarded as aposematic, led to the conclusion that insufficient evidence exists for it to be possible to establish whether *H. frenatus* is a discriminate feeder, although it has been previously believed to be so.

INTRODUCTION

Numerous references to studies of *Hemidactylus* spp. may be found in bibliographies of zoological literature, and *H. frenatus* is probably one of the better known species.

Several papers list food items which were accepted, or examined, but rejected, by the geckos. Of these the most comprehensive is probably that by Sevastopulo (1936) in India, whilst a note by Lamborn (1921) of an observation in Malaya on a species which was possibly *H. frenatus*, is also of interest. More recently Nagtegaal (1954) in a paper describing his successful method of breeding specimens of *H. frenatus* and *H. platyurus* (Schneider) from eggs exported from Indonesia to Holland, mentioned the food items accepted or rejected in captivity.

The present investigation, which is based on observations made at the Young Men's Christian Association, Llanmadaw Branch Hostel at Rangoon, Burma, during the period 13th-28th December, 1958, was carried out to determine the range of prey ingested. Close attention was paid to observations of feeding habits to determine whether this species is a selective feeder.

METHODS

In the majority of cases the specimens were collected by hand but, when not within reach, capture was quite simply effected by means of a large butterfly net.

After the geckos had been killed with carbon tetrachloride vapour, the following data was recorded prior to dissection: the length of the body, including the tail, measured dorsally from the external nares to the extremity of the tail; the length of the body, excluding the tail, measured ventrally from the anterior extremity of the lower jaw to the vent; the tail was examined for the presence of scars revealing previous loss and subsequent regeneration of that appendage. The stomach was then removed and the contents examined and listed.

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HABITAT

During the hours of daylight *H. frenatus* lives in crevices in walls within houses, restaurants, shops, etc., but at an hour or two before dusk the geckos emerge, and at night are to be found congregating near electric lights in search of insects.

In Calcutta geckos were seen clinging to the plate glass windows of shops below neon lights, whilst the outer surface of warehouse walls on the dockside at Surabaja, Java, provided a hunting ground for several hundred specimens.

The specimens examined at Rangoon Y.M.C.A. were captured on the walls of the dormitories, staircase, showers and lavatories, and on the walls of a small cafeteria situated adjacent to the Y.M.C.A.

The status of *H. frenatus* in private dwellings in Burma is a rather unusual one. There is no doubt that its presence is beneficial to the occupants, for the control of household insect pests, a fact noticed also in the Philippines by Taylor (1922). However, since many of these Burmese people are Buddhists, and the beliefs of some of these followers restrain them from harming even an insect, it is probable that geckos would be tolerated in houses even if such a symbiotic relationship did not exist. Furthermore, a widely accepted superstition exists which states that if a person is bitten by a gecko, he or she must immediately drink water for, if the gecko does so before the victim, the victim will die. It is claimed by others that this myth applies only to the Tokay (*Gecko gecko*) but, whatever the origin, there appears to be a distinct reluctance amongst some Burmese to handle these creatures. The bite of both can be most painful and that of the Tokay severe, but it is worthwhile reflecting here that only two species of venomous lizard exist in the world, one in North America and the other in Borneo. The result is that the geckos in Burma are respected, tolerated and therefore permitted to propagate their kind unmolested in the habitations of man.

SIZES OF SPECIMENS CAPTURED

The Gekkonidae are well known for their rapid rate of growth, and Cagle (1946) records one species (*H. garnoti* Duméril and Bibron) completing development in 30-40 days of hatching from the egg. Nagtegaal's captive specimens of *H. frenatus*, however, took considerably longer, and a specimen which measured 35-40 mm. total length when hatched on 31.8.53, had only reached a length of 70 mm. six weeks later. His specimens had been reared in a terrarium at a temperature of 25° C., and it is probable that the optimum temperature, based on that experienced during the season when the eggs are laid, is several degrees higher than this figure.

The histogram in Fig. 1 compiled from the body lengths (measured ventrally from the vent to the snout) of the twenty-one Burmese specimens, reveals a distinct bimodality representing juvenile and adult specimens. In view of the small number of individuals involved, it is not possible to determine here whether the adult specimens (55-70 mm. body length) represent one or more generations.

FEEDING HABITS

The method of approach of *H. frenatus* to an insect is initially a rapid movement followed by one of great stealth, until the gecko is within a few inches of its prey when it mades a sudden rush at the object. The tongue plays little or no part in the capture which is accomplished by a rapid movement of the jaws. The writer's observations support those of Sevastopulo who considered that this last rush is provoked by some slight movement on the part of the prey.

At the Rangoon Y.M.C.A. fierce competition for food items was observed amongst the geckos, well illustrated by the following example. Two mature specimens simultaneously approached the same food item, a dragonfly, and the larger upon noticing that a competitor existed, turned from the prey and attacked the other gecko. Despite the fact that the commotion disturbed the dragonfly, which hurriedly escaped, the larger gecko, which already lacked one eye, grasped the smaller by the lower jaw and clung there for several minutes.

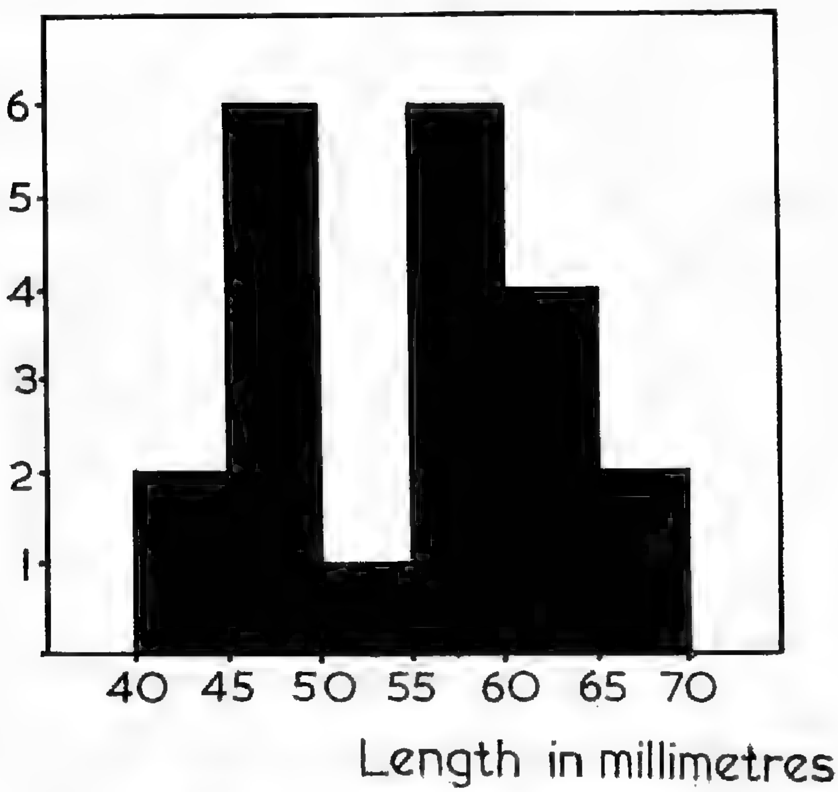

Fig. 1.—Histogram of body lengths of specimens examined. Horizontal scale: body lengths in millimetres; vertical scale: frequency.

Each lizard in turn made violent spasmodic sideways movements with its head, with the result that in a few minutes both were bleeding profusely and at the end their issue remained apparently undecided.

Whether this attack by the larger upon the smaller was, as it appeared, to be induced solely as competition for the same food item or whether a distinct territorialism also exists as a contributory factor could not be determined.

STOMACH CONTENTS

A total of eighty-three food items were recovered from the twenty-one stomachs examined, and is tabulated in the form of a point frequency diagram in Fig. 2. Facilities for the detailed identification of the stomach contents were not available at the time that the observations were made. The food items were therefore only classified to the order, and occasionally to the family.

Three stomachs each contained single specimens of Hymenoptera of which one was an aphid (Family: Aphididae), another an ant (Family: Formicidae), whilst the remaining specimen was in such an advanced state of digestion that identification was impossible. Of eight specimens of Coleoptera recovered from four stomachs, digestion was advanced in seven cases, but the eighth was a member of the Curculionidae Family.

The seventeen Lepidoptera found in a total of eleven stomachs consisted of ten adult microlepidoptera and seven adult macrolepidoptera. Of the latter, the bulk of the food item was frequently large in comparison with the size of

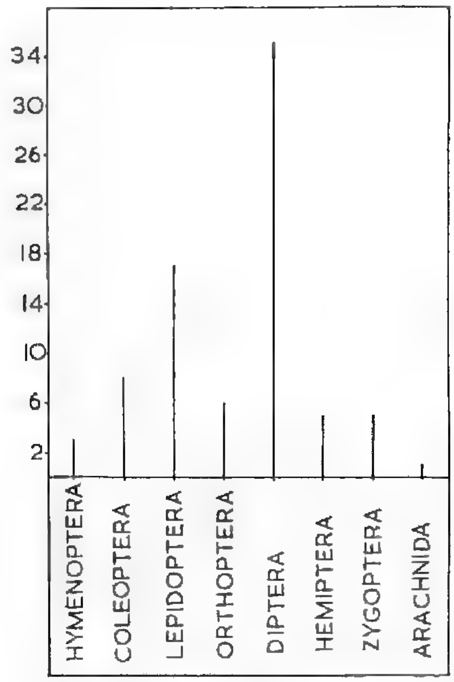

Fig. 2.—Point frequency diagram of stomach contents. Horizontal scale: types of prey; vertical scale: number of specimens recovered from stomachs.

the predator. The wing span measurements of the three largest prey were 33 mm., 28 mm., and 21 mm. from predators with body lengths of 65 mm., 55 mm., and 48 mm. respectively.

Three stomachs each contained two nymph crickets (Orthoptera: Family Gryllidae).

Diptera were the prey most frequently ingested and a total of thirty-five specimens (of which fourteen were mosquitoes, Family Culicidae), were recovered from thirteen stomachs.

The remainder of the food items consisted of five small Hemiptera, one dragonfly: Zygoptera, and five spiders (Arachnida: Family Araneae).

DISCUSSION

As has been revealed by the observational data, the habit of large numbers of geckos to congregate together results in fierce competition between them for any potential food item. It is therefore most interesting to note instances where none of the geckos in a group would attempt to capture a particular type of insect. Such a case is described in a note by Lamborn (1921), who observed three geckos separately examine a specimen of *Hypsa* (= *Asota*) *alciphron* Cram. which had settled upon the ceiling of a room in his house at Kuala Lumpur. He noted that although geckos captured, or attempted to capture, other species they ignored the *H. alciphron*. Cott (1955) concluded that this was an example of selective feeding but, since Lamborn stated that the moth did not move at all during the period that it was examined by the geckos, and thus did not provoke attack as was found to be necessary by Sevastopulo and the writer, it would not appear to be quite as convincing an example as Cott believed.

A much better example of geckos avoiding a type of prey is that mentioned by Sevastopulo, who observed geckos approaching the bee, *Apis mellifera indica*, and then retreating from it. Since the bee would be regarded as distinctly aposematic this reaction is perfectly normal if the predator is a discriminate feeder. It is therefore indeed quite remarkable when the same author found that the brilliantly coloured larva of *Paraspa lepida* Cr., which, covered with urticating bristles, must be considered distinctly aposematic although procryptic in its natural surroundings, was devoured by the geckos promptly.

The present Burmese data reveal that a wide variety of prey is ingested in the probable proportion in which they occurred in the hostel. Mosquitoes and other Diptera were undoubtedly the insects most frequently occurring there, and it is therefore not surprising that these insects were found with equal frequency in the stomachs examined. None of the items could be regarded as aposematic.

Since many of the prey are to be regarded as household pests, it is established that the presence of *H. frenatus* is beneficial to the occupants.

Although examples of feeding which are clearly selective do occur, the converse cases are just as frequently recorded, and it is therefore concluded that there is insufficient evidence to date to assume that *H. frenatus* is a discriminate feeder, if discrimination of prey is determined by the visual senses.

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SUBSURFACE STRATIGRAPHY OF THE MARALINGA AREA, SOUTH AUSTRALIA

BY N. H. LUDBROOK

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by N. H. Ludbrook*

[Read 9 June 1960]

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Eighteen bores in a previously unknown locality at Maralinga in the west of South Australia established a sequence of about 1,000 feet of Proterozoic (Marinoan) shales and sandstones resting on diorite. These are overlain by a thin series of kaolinized grits of either Permian fluvio-glacial origin or of Mesozoic age with reworked Permian glacigenes. They are followed by thin paralic Eocene silts and limestone with a relatively thick cover of Tertiary to Recent terrestrial sands.

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INTRODUCTION

During 1954 and 1955 a survey was conducted by the South Australian Department of Mines to locate supplies of underground water for the Long Range Weapons Establishment project at Maralinga. Eighteen percussion bores were drilled in an area extending from 15 miles north of Watson on the Trans-continental Railway through Maralinga and Tietken's Plains to Marcoo, 45 miles north of Watson.

Maralinga is located near the north-eastern margin of the Eucla Basin. Prior to the investigation the subsurface stratigraphy and geological structure of the terrain immediately to the north of the Eucla Basin were unknown. When the first (Numbers 1 to 5) bores drilled at Tietken's Plains in 1954 established the presence of older Tertiary sediments it was thought that there might be an extension of the Eucla Basin to the north beyond the margin as it is at present delimited by the Nullarbor Limestone. Subsequent drilling showed this not to be the case, although Eocene seas gained access to the overdeepened shallow basin at Tietken's Plains.

STRATIGRAPHY

Stratigraphic units intersected by the wells are as follows:

	Approximate depth related to sea level (feet)	Approximate thickness (feet)
Tertiary to Recent non-marine sediments ...	+ 900 to + 500	48 to 500
Upper Eocene bryozoal calcarenite (Wilson Bluff Limestone) ...	− 460 to + 360	100
Eocene paralic silts and sands with lignite	+ 430 to + 330	100
?Permian kaolinitic grits and sandstone ...	+ 410 to + 270	120
Upper Proterozoic chocolate and blue shales and brown sandstone ...	+ 380 to − 751	1,126
?Archaean diorite ...	− 751	

* Palaeontologist, Geological Survey of South Australia. Published with the permission of the Director of Mines.

The sequence differs from that of the Eucla Basin. No marine Cretaceous was intersected in any of the bores, and the possible connection of the Eucla Basin with the Great Artesian Basin during the Lower Cretaceous was not established. In view of the thinness of the Cretaceous at Lake Phillipson and Mabel

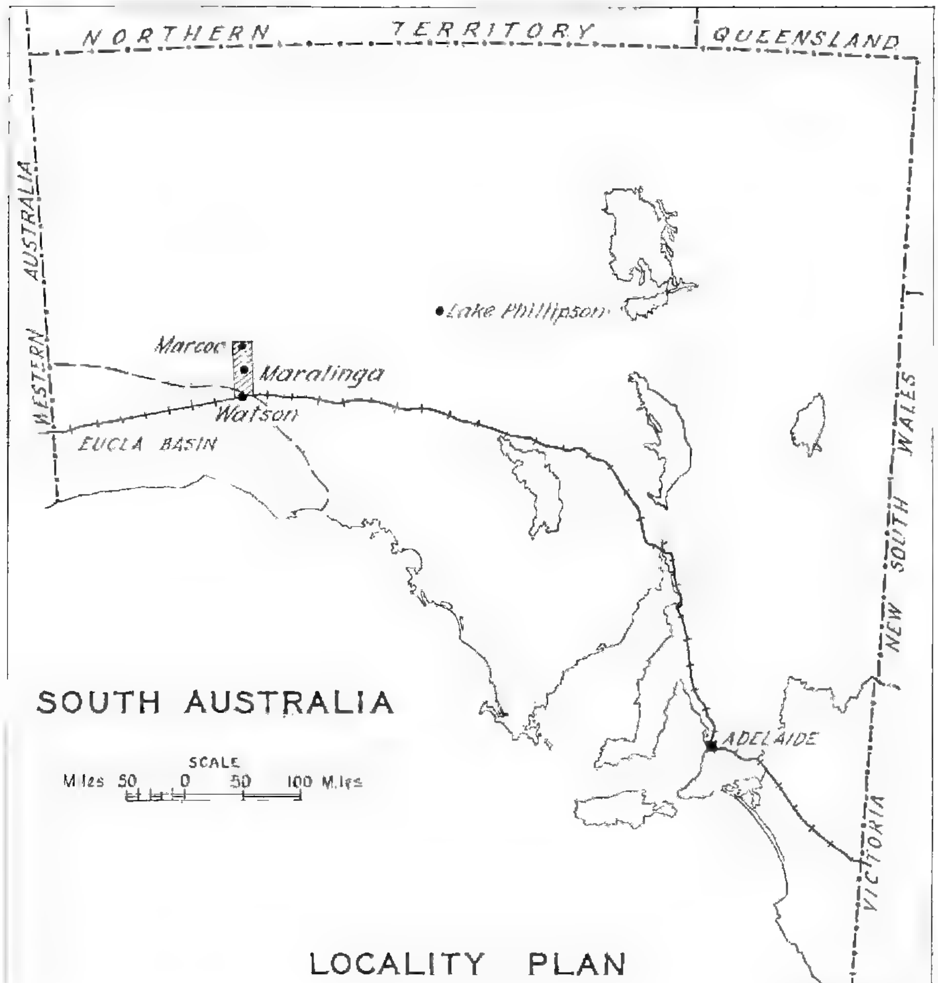


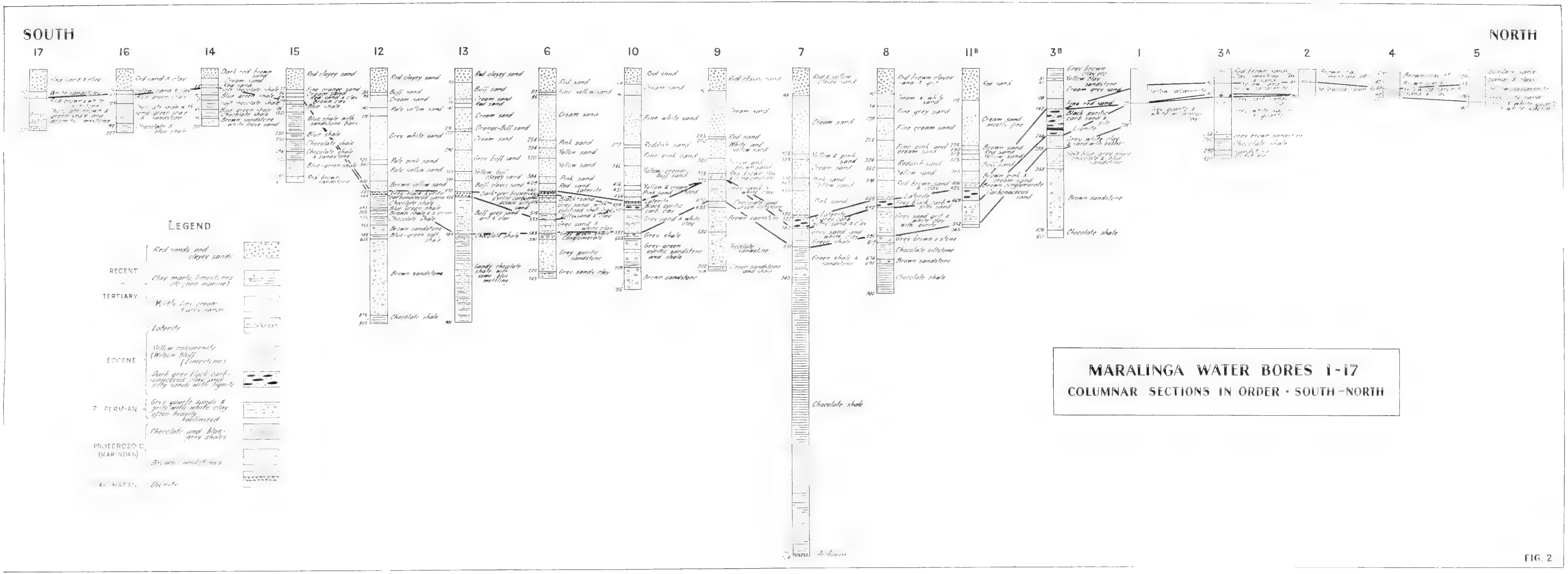
FIGURE 1

Creek it is likely that any marine sediments deposited during the Cretaceous have been removed by erosion.

The Nullarbor Limestone of Miocene age was not proved to extend any further north than Lake Yarle.

? ARCHAEAN BASEMENT

At 1,720 feet Bore 7 entered fine-grained diorite presumed to belong to the basement complex, though intrusive diorites are known to occur in the Upper Proterozoic (B. P. Webb, personal communication).



MARALINGA WATER BORES 1-17

COLUMNAR SECTIONS IN ORDER · SOUTH – NORTH

FIG. 2

UPPER PROTEROZOIC SEDIMENTS OF THE MARINOAN SERIES

With the exception of the most northerly bores 1, 2, 4, 5, all bores entered at depths not greater than 631 feet a series of chocolate siltstones and shales, blue-green siltstones and brown sandstones. No organic remains were detected in any of the cuttings. Lithologically, the formation consists of soft either chocolate siltstone or pale green-blue pyritic siltstone passing downwards into fine to medium grey-brown sandstone or shale inter-bedded with sandstone and then into chocolate shale. There is considerable mottling of the green-blue and chocolate shale. The sandstone is generally soft, and may be loose and unconsolidated. Siderite content is high. Dolomite or dolomitic limestone was intersected in Bore 17 between 122 and 170 feet. This lithology is consistent with the Upper Proterozoic (Marinoan) and the sediments are correlated with the Tent Hill Formation, which is currently placed in the Upper Proterozoic.

The formation was completely penetrated in Bore 7 to a total thickness of 1,090 feet between depths of 631 feet and 1,721 feet. In this bore the following sequence occurred below 631 feet:

		Thickness
631- 740 feet	Green siltstone with sandstone bars	109 feet
740-1,220 feet	Chocolate siltstone interbedded with red brown sandstone	480 feet
1,220-1,360 feet	Red-brown siltstone and sandstone	140 feet
1,360-1,370 feet	Red-brown sandstone and shale	10 feet
1,370-1,690 feet	Chocolate shale with thin sandstone bars	320 feet
1,690-1,696 feet	Chocolate shale and sandstone	6 feet
1,696-1,708 feet	Chocolate shale	12 feet
1,708-1,721 feet	Dark red sandstone	13 feet

The formation appears to be flat-lying, the sandstones in particular giving very little evidence of disturbance since their deposition, which is believed to have taken place under non-marine conditions.

GREY-WHITE PYRITIC GRITTY AND SANDY CLAYS

A maximum of 127 feet of grey-white highly kaolinized gritty clays was intersected in bores north of Bore 12, although they were absent in Bore 12 itself. They are characterized by a high kaolin content and the presence of muscovite, pyrite, and grey opalescent quartz grains to grit size. The grains are usually subangular but the degree of roundness varies from angular to rounded. Muscovite flakes are fine and abundant, pyrite is also abundant and may be present as large aggregates or nodules. Facetted pebbles occur near the base of the formation.

The age of the sediments is uncertain. On the western margin of the Artesian Basin south-west of Mount Eba and northwards from Lake Phillipson surface exposures have been mapped as ?Jurassic. It has now been shown (Bahne, 1957) that a thickness of at least 1,800 and possibly 3,000 feet of Permian tillites, clays and sandstones passing upwards into carbonaceous shales is present in Lake Phillipson Bore, overlain by some 80 feet of Lower Cretaceous siltstones.

The kaolinized grits and gritty clays in the Maralinga area may therefore be fluvio-glacial sediments of Permian age or Permian glacigenes redeposited during the Mesozoic, probably the Lower Cretaceous. The sediments differ from most Permian glacigenes in South Australia in that the pebbles and grits consist almost entirely of quartz, generally blue-grey or opalescent, and are not heterogeneous. This would tend to favour a younger age for the sediments with re-sorting of the material. However, they cannot be correlated litho-

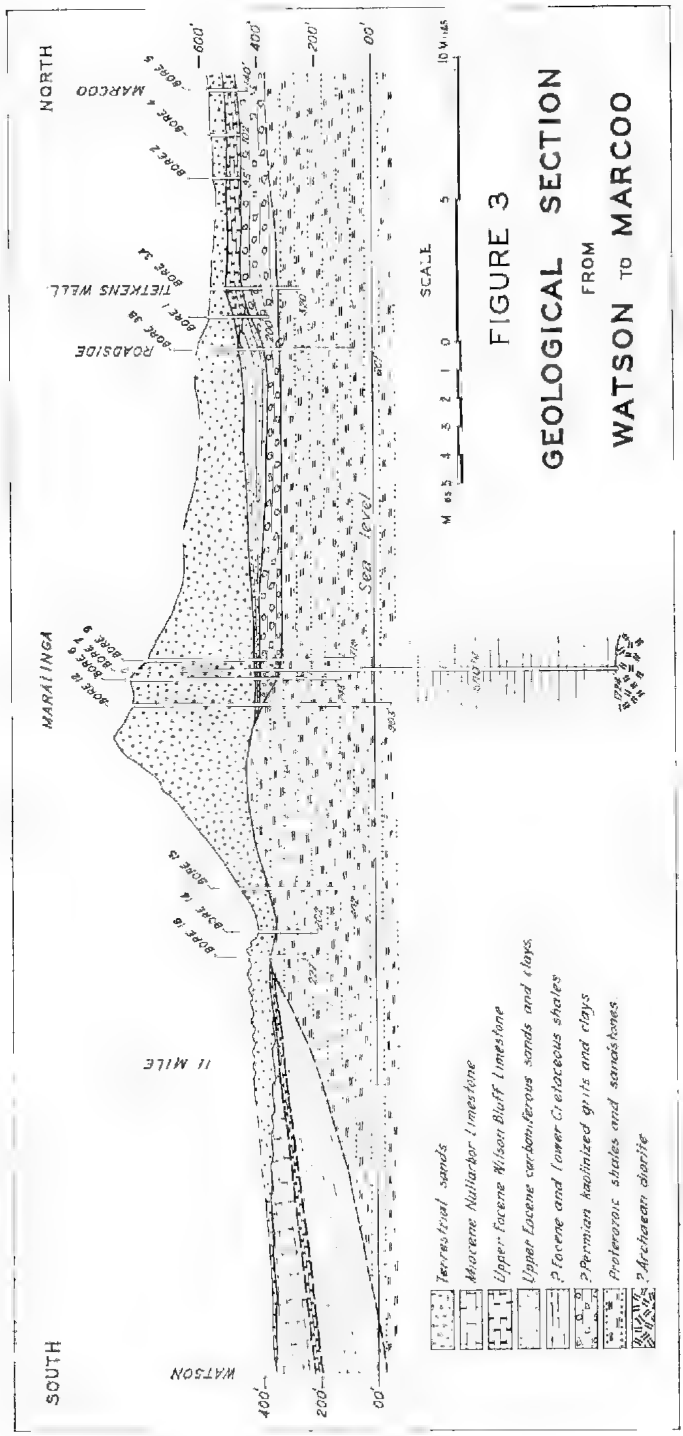


FIGURE 3
GEOLOGICAL SECTION
FROM
WATSON TO MARCOO
NORTH
SOUTH
MARCOO
BORE 5
BORE 4
BORE 2
BORE 34
TIETKENS WELL
BORE 1
BORE 38
ROADSIDE
MARALINGA
BORE 9
BORE 7
BORE 6
BORE 12
BORE 13
BORE 14
BORE 16
11 MILE
WATSON
Sea level
600'
400'
200'
00'
SCALE
Miles 5 4 3 2 1 0 5 10 Miles
Terrestrial sands
Miocene Nullarbor Limestone
Upper Eocene Wilson Bluff Limestone
Upper Eocene carboniferous sands and clays
?Eocene and lower Cretaceous shales
?Permian kaolinized grits and clays
Proterozoic shales and sandstones
?Archaean diorite

logically with the Upper Jurassic-Lower Cretaceous Blythesdale Group of the Great Artesian Basin.

The slight overdeepening of the area north of Bore 12 may well be related to Permian glaciation.

EOCENE CARBONACEOUS SANDS AND SILTS

Overlying the kaolinized grits and clays are paralic dark grey-brown silty sands up to 100 feet thick with lignite in Bores 11 and 3B. These are of Eocene age. Weathering and lateritization have destroyed most of the organic remains. No foraminifera were recovered but pyritized shell fragments are not uncommon. These include "*Turritella aldingae*", *Dentalium* sp., *Nuculana* sp., and *Liotina*, all of which commonly occur in Upper Eocene sediments of this type elsewhere in South Australia.

The carbonaceous silts occur between Bore 12 and Bore 3A and are to be correlated with the lignitic clays outcropping at Pidinga.

EOCENE MARINE SEDIMENTS

North of Bore 3B bryozoal calcarenite and calcareous sands either overlying or partially equivalent to the paralic silts were intersected in all bores. These appear to be a marginal remnant of the Wilson Bluff Limestone (Eocene) of the Eucla Basin. In the sandhills area between Watson and Tietken's Plains the formation was either cut off in Eocene times by bedrock highs or subsequently removed by erosion and formation of the high dunes.

The calcarenite contains fairly abundant, if not very well preserved, small foraminifera including *Sherbornina atkinsoni* (juveniles), *Anomalina perthensis*, *Globigerina linaperta*, *Cibicides umbonifer*, *Cibicides pseudoconvexus*, *Heronallenia pusilla*, *Planorbulina* sp., and other small forms.

POST-EOCENE SANDS

The northern margin of the Eucla Basin is marked by a series of great dunes, which attain a maximum thickness of about 500 feet in the neighbourhood of Bores 12 to 11B. The base of the sands is generally marked by a laterite and the carbonaceous silts between Bores 6 and 11 show evidence of lateritization. The sands are generally pink, red, or yellow in colour near the base and are rich in iron minerals. For the most part they consist of up to 200 feet of fine cream sand with some coarse rounded grey quartz grains.

On Tietken's Plains Bores 1 to 5 passed through lake marls and sands with fresh water oolitic limestone containing ostracodes.

DESCRIPTION OF THE BORES

Bore 1.

0-120 feet Existing well with bryozoal calcarenite occurring somewhere in the interval, the exact thickness being indeterminable. Sample F 10/54, collected from spoil consists of a fine-grained yellow calcarenite with abundant bryozoa and the following foraminifera: *Textularia* sp., *Dentalina* sp., *Pseudoglandulina clarkei* Parr, *Lagena* spp., *Fissurina* sp., *Vaginulina* cf. *patens* Brady, *Vaginulina* sp., *Marginulina* sp., *Guttulina irregularis* d'Orbigny, *Guttulina* sp., *Guttulina problema* d'Orbigny, *Angulogerina* spp., *Trifarina bradyi* Cushman, *Bolivina* spp., *Cassidulina* spp., *Gyroidina* sp., *Alabamina* sp., *Cibicides vortex* Dorreen, *Cibicides pseudoconvexus* Parr, *Cibicides umbonifer* Parr, *Anomalina perthensis* Parr, *Globigerina linaperta* Finlay, *Planorbulina* sp., *Astrononion* sp., *Nonion* sp., *Elphidium* spp., *Heronallenia pusilla* Parr, *Notorotalia* sp. nov., *Sherbornina atkinsoni* (juveniles). The assemblage is of Upper Eocene age.

121-137 feet	F 15/54 to F 16/54. White pyritic quartzose kaolinized clay with abundant muscovite. Quartz grains mostly clear, angular to subrounded with etched surface.
137-145 feet	F 17/54 to F 18/54. Fine to coarse micaceous quartz sand into clay, pyrite and limonite.
145-180 feet	F 19/54 to F 20/54. White sandy micaceous clay with quartz pebbles.
180-200 feet	Quartz sandstone with pyrite, muscovite and siderite. From 121-200 feet the boring is in the kaolinized ?Permian grits.

Bore 2.

0- 12 feet	Samples F 22/54 to F 24/54. Brown soil and clay subsoil.
12- 39 feet	F 25/54 to F 27/54. Brown buff and pink calcareous clay or marl and argillaceous limestone of lacustrine origin with probable ostracodes.
39- 48 feet	F 28/54. Brown argillaceous sand with large rounded quartz grains and small angular to subangular grains.
48- 60 feet	F 29/54. Yellow calcareous quartz sandstone.
60- 75 feet	F 30/54. Yellow fossiliferous calcareous sandstone with a microfauna similar to that of Bore 1, F 10/54, including *Lagena* spp., *Vaginulina* cf. *patens*, *Guttulina* sp., *Angulogerina* spp., *Trifarina* sp., *Bolivina* spp., *Cassidulina* sp., *Gyroidina* sp., *Alabamina* sp., *Cibicides umbonifer*, *Cibicides* spp., *Anomalina perthensis*, *Sherbornina atkinsoni*.
75- 95 feet	F 31/54 to F 33/54. Yellow calcareous sandstone with a few microfossils including *Cibicides umbonifer*, *Reussella* sp., *Notorotalia* sp. Sediments from 48-95 feet are of Upper Eocene age.

Bore 3.

0- 50 feet	F 34/54 to F 38/54. Red brown surface soil, grey-brown clay and sandstone.
50- 82 feet	F 39/54 to F 41/54. Yellow coarse fossiliferous calcareous sandstone passing into limestone. *Cibicides umbonifer* occurs throughout, and from 71-82 feet is associated with species of *Vaginulina*, *Spirillina*, *Cibicides* and *Elphidium*.
82- 91 feet	F 42/54. Yellow fossiliferous crystalline limestone with echinoderm spines, ostracodes and small foraminifera including *Lagena* spp., *Angulogerina* sp., *Gyroidina* sp., *Cibicides umbonifer*, *C. pseudoungerianus*, *C. cortex*, *C. lobatulus*, *C.* spp., *Rotorbinella* sp., *Planorbulina* sp., *Elphidium* sp., *Sherbornina* sp.
91- 98 feet	F 43/54. Dark grey carbonaceous sandy clay with pyrite and a few foraminifera, including *Reussella* sp., *Cibicides umbonifer*, *Cibicides* sp., and *Elphidium* sp. From 48-98 feet the boring passed through Eocene sediments.
98-207 feet	F 44/54 to F 47/54. F 140/54 to F 143/54. Grey white gritty kaolin and sandy clay with massive kaolin at 190-207 feet.
207-225 feet	F 144/54 to F 145/54. Grey mostly coarse clayey quartz sand. Below 98 feet the formation is the kaolinitic grits of ?Permian age.

Bore 4.

0- 68 feet	F 147/54 to F 154/54. Red brown surface soil, calcareous clays, freshwater oolitic limestone and brown sand.
68- 90 feet	F 155/54 to F 157/54. Yellow calcareous sandstone with a few foraminifera including *Cibicides umbonifer*.
90- 92 feet	F 158/54. Ferruginous sandy clay with an assemblage of small foraminifera, including *Bolivinopsis crespinae*, *Angulogerina* spp., *Trifarina bradyi*, *Reussella* sp., *Cibicides umbonifer*, *Cibicides* cf. *refulgens*, *Cibicides* spp., *Stomatorbina concentrica*, *Patellina* cf. *corrugata*, *Globigerina* sp., *Gümbelina* sp., *Elphidium* sp., *Nonion* sp.
92- 95 feet	F 159/54. Dark grey gritty carbonaceous clay with dark grey nodules, carbonaceous matter, pyrite, limonite and a small foraminiferal assemblage with *Angulogerina* sp., *Reussella* sp., *Cibicides umbonifer*, *Cibicides* spp., *Globigerina* sp., *Gümbelina* sp., *Alabamina* sp. Eocene sediments occur between 68 and 95 feet.
95-102 feet	F 160/54. Grey gritty clay with angular quartz grains, limonite and pyrite. ?Permian.

Bore 5.

0- 43 feet F 120/54 to F 127/54. Red brown surface sand and clay, passing downwards into fine light brown and pale yellow sand.

43- 62 feet F 128/54 to F 129/54. Fine yellow calcareous micaceous sand with broken echinoderm spines and *Nuculana* from 53-62 feet.

62- 78 feet Yellow fossiliferous calcarenite with bryozoal fragments, echinoderm spines and *Cibicides* spp.

78- 87 feet F 131/54 to F 133/54. Yellow sandy fossiliferous calcarenite with an assemblage of small foraminifera including *Lagena* spp., *Vaginulina* cf. *patens*, *Guttulina* sp., *Trifarina* sp., *Angulogerina* sp., *Cibicides vortex*, *Cibicides umbonifer*, *Cibicides* spp., *Alabamina* sp., *Planorbulina* sp., *Gyroidina* sp., *Astrononion* sp., *Sherbornina* sp., *Heronallenia pusilla*.

87- 96 feet F 134/54 to F 135/54. Dark grey gritty clay with dark grey aggregates described by the Petrology Section as being composed of quartz, cryptocrystalline calcium carbonate, alteration products of iron minerals, with pyrite, carbonaceous and clay material, mica in small amount. A small assemblage of foraminifera includes *Lagena* sp., *Angulogerina* spp., *Trifarina* sp., *Reussella* sp., *Cibicides vortex*, *Cibicides umbonifer*, *Cibicides* spp., *Alabamina* sp., *Nonion* spp.

96-119 feet F 136/54. Pale grey sand, with *Trifarina*, *Angulogerina*, *Cibicides umbonifer*, *Nonion* sp.

From 53 to 119 feet the boring passed through the Eocene.

119-140 feet F 137/54 to F 139/54. Grey-white micaceous kaolinitic sandstone with abundant muscovite flakes, pyrite and grey aggregates of carbonaceous matter in sand.

These are the kaolinitic grits of ?Permian age.

Bore 6.

This bore was examined in the Petrology Section and details of the heavy mineral assemblages and differentiation of the sediments are contained in Petrological Laboratory Report No. 59/54.

0-451 feet F 55/54 to F 92/54. Post-Eocene sands. Celestite was reported by the Petrology Section as characterizing the interval from 384-394 feet.

451-531 feet F 93/54 to F 100/54. Grey carbonaceous pyritic clay and silty sands with pyritized shell fragments including *Nuculana*.

These are of Eocene age.

531-583 feet Samples F 101/54 to F 106/54. Grey kaolinitic and pyritic sands, ?Permian.

583-743 feet F 107/54 to F 119/54. Grey partly indurated unfossiliferous sandstones with abundant pyrite and siderite.

Present information permits correlation of this formation with rocks of the Marinoan Series.

Bore 7.

0- 98 feet Red and yellow clayey sand.
98-303 feet Cream sand, mostly fine.
303-323 feet Yellow and pink fine sand.
323-390 feet Fine cream sand.
390-408 feet Pink medium sand.
408-435 feet Cream and yellow medium sand.
435-520 feet Fine pink sand.
520-527 feet Pink sand and ironstone—laterite.
527-540 feet Dark grey black pyritic and carbonaceous sand.
540-567 feet Fine, dark grey carbonaceous silty sand with fine, angular to subangular quartz grains, pyrite, biotite.
567-595 feet Grey-white kaolinized sandstone and clay (?Permian).
595-740 feet Green pyritic siltstone interbedded with sandstone and conglomerate.
740-1721 ft. Chocolate and brown siltstone and shale.

Below 959 feet the formation belongs to the Marinion Series.

1721-1724′6″ Diorite, believed to be basement.

Bore 8.

0- 90 feet Red-brown clayey sand and grit.
90-324 feet Fine cream, grey and pink sand.
324-398 feet Reddish and yellow sand.

398-419 feet	Red-brown sand and clay.
419-425 feet	Dark red silicified ferruginous sandstone—laterite.
425-465 feet	Red-brown and pink sand with ferruginous quartz pebbles ? from laterite.
465-492 feet	Dark grey black carbonaceous silty sand with pyritized shell fragments including *Nuculana* sp. and pyritized bryozoa including *Cellaria* sp., of Eocene age.
492-591 feet	Grey clayey quartz grit and kaolinized gritty silt with pebbles and flat boulders between 571-591 feet. (?Permian).
591-617 feet	Fine brown sandstone and siltstone.
617-674 feet	Chocolate siltstone.
674-691 feet	Brown sandstone.
691-800 feet	Chocolate shale.

Sediments below 591 feet are believed to be Upper Proterozoic (Marinoan).

Bore 9.

0- 80 feet	Red clayey sand.
80-373 feet	Fine cream sand with red sand at 245-250.
373-395 feet	Red-brown clay with conglomerate at base, probably lateritized. Eocene silts and sands.
395-470 feet	Grey kaolinized sandstone and gritty clay (?Permian).
470-493 feet	Chocolate and green siltstone.
493-580 feet	Grey-buff and brown silty sandstone.
580-700 feet	Chocolate shale or siltstone.

Bore 10.

0- 59 feet	Mainly red-brown sand and clayey sand.
59-273 feet	Fine white and cream sand.
273-454 feet	Yellow, white and pink sand.
454-484 feet	Red and pink sand, ferruginous sandstone (? laterite) at 476 feet.
484-505 feet	Dark grey carbonaceous pyritic silts and sand with numerous pyritized shell fragments, including "*Turritella aldingae*", *Dentalium* sp. and *Nuculana* sp.
505-587 feet	Grey pyritic kaolinitic sands and gravel with abundant muscovite. (?Permian.)
587-605 feet	Green gritty siltstone.
605-786 feet	Greenish grey silty sandstone and shale (Upper Proterozoic—Marinoan).
786-900 feet	Sandy chocolate shale.

Bore 11.

0-115 feet	Red clayey sand.
115-275 feet	Fine cream sand.
275-325 feet	Red and yellow sand.
325-406 feet	Buff and brown sand.
406-425 feet	Brown sandstone and conglomerate.
425-469 feet	Dark grey pyritic carbonaceous silts and silty sand with fine angular quartz grains, a few large subrounded grains and large irregular pyrite nodules. Lignified wood from 457-462 feet.
469-552 feet	Grey-white kaolinized grits and clay (?Permian).
552-565 feet	Grey-brown sandstone — Upper Proterozoic.

Bore 12.

0- 85 feet	Red clayey sand.
85-325 feet	Fine buff, cream and grey-white sand.
325-440 feet	Pink, yellow and brown sand. Laterite at 440 feet.
440-444 feet	Ferruginized grey sandy and carbonaceous silt, with rounded opalescent quartz and pyritized shell fragments of Eocene age.
444-493 feet	Chocolate siltstone with a little green siltstone and white sandstone bars.
493-605 feet	Chocolate and blue-green shale interbedded with brown sandstone.
605-875 feet	Brown sandstone.
875-903 feet	Chocolate shale.

No kaolinized grits were present in this bore, in which the paralic Eocene rests directly on Upper Proterozoic.

Bore 13.

0- 50 feet	Mostly brick red clayey sand and kunkar.
50-363 feet	Mostly fine cream passing to grey-buff sand with occasional bluish opalescent quartz grains.
363-438 feet	Pinkish-buff, yellow and red sand and clayey sand.
438-456 feet	Dark grey-brown carbonaceous clay and silty sand, with pyrite of Eocene age.
456-583 feet	Brown and light blue-grey clayey sand and grit to pebble size. Facetted pebbles at 550-556 feet (?fluvio-glacial Permian).
583-645 feet	Chocolate and blue shale and sandstone (Upper Proterozoic).
645-900 feet	Chocolate shale.

Bore 14.

0- 68 feet	Red brown sand and clayey sand.
68-202 feet	Chocolate and blue-grey siltstones and shales and brown sandstones (Upper Proterozoic).

Bore 15.

0-114 feet	Dark red sands and clayey sand.
114-126 feet	Yellowish-brown sticky gritty clay with quartz grains black carbonaceous and pyritic aggregates, shale fragments. The age is uncertain, but the black aggregates may represent weathering or reworking of the Eocene paralic clays.
126-402 feet	Greenish grey and chocolate siltstones and sandstones (Upper Proterozoic).

Bore 16.

0- 78 feet	Red and yellow terrestrial sands.
78- 87 feet	Yellow-brown clay of uncertain age.
87-227 feet	Blue and chocolate siltstones and sandstones.

Bore 17.

0- 80 feet	Red brown clayey sand and kunkar.
80-103 feet	White sandstone — age undetermined.
103-220 feet	Red brown and white siltstone, chocolate, brown and green shale and dolomite.

STRUCTURE

Drilling of the Maralinga area has firmly established the northern margin of the Eucla Basin. Between Bore 16 and Bore 12 Proterozoic bedrock comes to within 68 feet of the surface. To the south it falls away under the sediments of the Eucla Basin, and to the north it forms an apparently fairly even floor to the small basin filled with the ?Permian kaolinitic grits and Eocene carbonaceous sands and clays and sandy limestone.

So far as can be deduced from bore sludges, the rocks appear to be flat-lying and to have been virtually undisturbed since deposition.

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DETERMINATION OF THE CRUSTAL THICKNESS OF THE EARTH IN THE GENERAL REGION OF ADELAIDE, SOUTH AUSTRALIA

BY *I. A. MUMME*

Summary

From the average gravity value for a large number of absolute gravity stations located in the region of Adelaide, the average Bouguer anomaly obtained was - 11-2 milligals. From this value the crustal thickness of the earth in this region has been calculated to be ***33*** kilometres.

DETERMINATION OF THE CRUSTAL THICKNESS OF THE EARTH IN THE GENERAL REGION OF ADELAIDE, SOUTH AUSTRALIA

by I. A. Mumme

[Read 14 July 1960]

SUMMARY

From the average gravity value for a large number of absolute gravity stations located in the region of Adelaide, the Average Bouguer anomaly obtained was $-11 \cdot 2$ milligals. From this value the crustal thickness of the earth in this region has been calculated to be 33 kilometres.

World-wide geophysical investigations show that there is a regular relationship between the crustal structure, density, elevations of the continents, and the related gravity anomalies. Such equations were applied to the Adelaide region where the writer carried out both elevation and absolute gravity measurements.

Geophysical work has shown that the earth's crust floats on a vitreous substratum referred to as the mantle. The discontinuity between the outer crust and the mantle rocks is a zone of seismological discontinuities and is called the Mohorovicic Discontinuity. Seismological information suggests that the mantle (which is the zone beneath the Mohorovicic Discontinuity) has a constant density of $3 \cdot 32$ grammes per cc., and the mean crustal density increases from a minimum value below the ocean of $2 \cdot 86$ grammes per cc., to $3 \cdot 08$ grammes per cc. beneath the high plateaus and mountains.

In spite of the fact that geophysical work shows that the earth's outer crust is the region of the greatest density variations, nevertheless, regional isostatic balance occurs everywhere on the earth's surface, and consequently a regular relationship between crustal structure, density, elevations of continents and the related gravity anomalies occurs.

In obtaining an average Bouguer gravity Anomaly for the Adelaide Region, the writer determined an average gravity value for a large number of absolute gravity stations located in the region with a Carter gravimeter.

These absolute gravity values are based on an absolute gravity value of $979 \cdot 7237$ gals for the absolute gravity station located at the new Adelaide Observatory. The average Bouguer Anomaly value obtained was $-11 \cdot 2$ milligals.

Elevations for these stations were obtained by tieing the stations, read with the gravimeter, into railway bench-marks by optical and micro-barometric measurements. The average elevation was 320 metres.

The Bouguer gravity Anomalies were computed for the gravity stations by subtracting the theoretical gravity values for the gravity stations from the reduced observed gravity values by applying the 1930 International Gravity Formula.

Determination of the Crustal Thickness in the Area Investigated

(1) Applying Andreev's formula, $H = 0 \cdot 1 \triangle g + 30$, where H is the crustal thickness in Kilometres, and $\triangle g$ is the Bouguer Anomaly, we obtain a value of 29 kilometres.

(2) Applying Woolard's equation relating elevation and depth to the Mohorovicic Discontinuity, we obtain a value of 34 kilometres.

(3) Applying Woolard's equation relating gravity anomaly and depth to the Mohorovicic Discontinuity, we obtain a value of 32 kilometres. (From the relationship graphically represented in the journal of geophysical research, Vol. 64 (1959).)

(4) Applying equation relating elevation and crustal thickness used by the Russian and Chinese Seismologists, $H = 33 \tanh. (0 \cdot 38 \triangle h - 0 \cdot 18) + 38$, where H is the crustal thickness and $\triangle h$ is the elevation, we obtain a value of 35 kilometres.

(5) Applying equation relating gravity Anomaly and crustal thickness used by the Russian and Chinese Seismologists, $H = 35(1 + \tanh 0 \cdot 0037 \triangle g)$, where H is the crustal thickness and $\triangle g$ is the gravity anomaly, we obtain a value of 36 kilometres.

(6) Applying Heiskanen's and Vening Meinesz's formula, namely,

$$Tc = T + 4 \cdot 45h + h,$$

where Tc is the normal thickness of the earth's crust at the place of elevation h, T is the normal thickness of the earth's crust, and h is the elevation of the area where the crustal thickness is Tc, we obtain a value of 32 kilometres.

Summarising these results, we have:

Crustal Thickness		*Equation Applied.*
(1) 29 kilometres	-	Andreev's equation.
(2) 34 kilometres	-	Woolard's elevation method.
(3) 32 kilometres	-	Woolard's gravity method.
(4) 36 kilometres	-	Russian and Chinese gravity equation.
(5) 35 kilometres	-	Russian and Chinese elevation equation.
(6) 32 kilometres	-	Heiskanen and Vening Meinesz equation.
Average 33 *kilometres.*		

An average value of 33 kilometres for the crustal thickness in this area is accepted from an analysis of the above results.

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LARVAL TREMATODES FROM AUSTRALIAN FRESH-WATER MOLLUSCS

BY D. E. SYMON

Summary

Cercaria velesunionis, a gasterostome, is described from the fresh-water mussel, Velesunio ambiguus. (It is possible, but is not considered likely, that Aluthyria jacksoni can also serve as host.) It is not a common parasite, having been found in only 16 of 1818 mussels examined.
It has a different excretory formula, 2 { (2 + 2) 4- (2 + 2) 1, from gasterostome cercariae for which the excretory formula has been described. Since it cannot be compared fully with cercariae for which the excretory formula is not known, it is assigned to a new species. The cercaria has been found, experimentally, to encyst in the fish Gambusia affinis, Carassius auratus, Oryzias latipes and Galaxias sp. Adult gasterostomes have never been identified from fresh-water fish examined in this department. These are Maccullochella macquariensis, Plectroplites ambiguus, Pseudaphritis urvillii, Tandanus tandanus, Therapon bidyana, Fluvialosa richardsoni and Macquaria australasica. Immature gasterostomes, probably of the same species as Cercaria velesunionis, were found in four Percalates colonorum. Until the adult trematode is found, Cercaria velesunionis cannot be assigned to a genus.

LARVAL TREMATODES FROM AUSTRALIAN FRESH-WATER MOLLUSCS

Part XV

Cercaria velesunionis n. sp.

by L. Madeline Angel*

[Read 8 September 1960]

SUMMARY

Cercaria velesunionis, a gasterostome, is described from the fresh-water mussel, *Velesunio ambiguus*. (It is possible, but is not considered likely, that *Alathyria jacksoni* can also serve as host.) It is not a common parasite, having been found in only 16 of 1818 mussels examined.

It has a different excretory formula, $2\{(2+2)+(2+2)\}$, from gasterostome cercariae for which the excretory formula has been described. Since it cannot be compared fully with cercariae for which the excretory formula is not known, it is assigned to a new species.

The cercaria has been found, experimentally, to encyst in the fish *Gambusia affinis, Carassius auratus, Oryzias latipes* and *Galaxias* sp.

Adult gasterostomes have never been identified from fresh-water fish examined in this department. These are *Maccullochella macquariensis, Plectroplites ambiguus, Pseudaphritis urvillii, Tandanus tandanus, Therapon bidyana, Fluvialosa richardsoni* and *Macquaria australasica*.

Immature gasterostomes, probably of the same species as *Cercaria velesunionis*, were found in four *Percalates colonorum*.

Until the adult trematode is found, *Cercaria velesunionis* cannot be assigned to a genus.

Type material has been deposited in the South Australian Museum.

Fielder, in a paper read before the Field Naturalists' Club of Victoria on May 10th, 1896, recorded as "the most interesting find of the month", "curiously modified fluke embryos in the fresh-water mussel (*Unio australis*)". From Fielder's short description, without figures, these were obviously gasterostome cercariae, and it would seem likely that it is the first record of *Cercaria velesunionis*, which is described in this paper. I know of no other records of cercariae from fresh-water mussels in Australia. McMichael and Hiscock (1958) list *Unio australis* Lam., of Smith, 1881, as a synonym of *Velesunio ambiguus*; *Unio australis* Lamarck, 1819, they assign to the genus *Hyridella*, subgenus *Hyridella*.

In this paper is given a description of the sporocyst, cercaria, cyst and metacercaria of *C. velesunionis*. Only immature adults have been obtained, however. Mature adults could not be obtained with attempted infections of three *Carassius auratus*.

Since June, 1937, gasterostome cercariae have been identified in 16 of 1818 fresh-water mussels collected in the River Murray between Tailem Bend and Morgan. They have been found on only seven occasions, in 1 of 3, 2 of 6, 2 of 16, 5 of 31 and 2 of 106 mussels from Tailem Bend, in 3 of 25 from Morgan, and in 1 of 70 from Teal Flat.

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Mussels from the River Murray were always identified as *Hyridella australis* (Lamarck). However, in 1958, McMichael and Hiscock published a "Monograph of the fresh-water mussels (Mollusca : Pelecypoda) of the Australian region". According to this, there are two species of mussel in the Tailem Bend-Morgan stretch of the Murray, *Velesunio ambiguus* (Philippi) and *Alathyria jacksoni* Iredale. Of the sixteen infected mussels collected, ten are still available and are now identified as *Velesunio ambiguus*. My impression is that probably no *Alathyria jacksoni* (fully grown shells of which are bigger and heavier than those of *Velesunio ambiguus*) have been found infected. The matter, however, must remain in some doubt. In the most recent collection, of 70 mussels from Teal Flat, only about 15 were *V. ambiguus*, but it was from these that the single infection was found.

The cercariae tend to lie at the bottom of the dish in which the mussel is isolated. Here, as observed with a dissecting microscope, they contract and expand the body, and may extend the furcae to great lengths and then contract them to become quite short. (These movements are not necessarily synchronised.) If the water in a beaker containing the cercariae is disturbed slightly, they can just be seen hanging suspended in the water by the two outstretched furcae. The body occasionally contracts, and, not always at the same time, one or both furcae contract also, but the cercariae do not change their position in the water by this means, and have never been seen to swim.

The following measurements were made on 20 cercariae which had been fixed by adding an equal volume of boiling 10 p.c. formalin to the water containing them. Body length 142-222 μ (average 175 μ); greatest width of body 55-97 μ (average 70 μ); length of anterior organ 37-71 μ (average 50 μ); breadth of anterior organ 25-43 μ (average 31 μ); width of tail stem (i.e. transverse diameter) 84-116 μ (average 100 μ); depth of tail stem (vertical measurement) 41-70 μ (average 45 μ). The furcae are too coiled in formalinised specimens to permit of measurement. In one living specimen the furcae were drawn out in a straight line by a current of water, and at their greatest length measured 2·4 mm.

The preceding measurements were taken from cercariae collected in late 1959 and early 1960. A collection made at Morgan in February 1956 from three mussels comprises cercariae noticeably larger. Measurements of 20 of these fixed in the same way as the later infections are: body length 175-350 μ (average 300 μ); greatest width of body 72-115 μ (average 91 μ); width of tail stem 58-130 μ (average 84 μ); depth of tail stem 44-65 μ (average 51 μ). Although the difference in size probably has no real significance, the description is based on cercariae from the 1959-1960 collections; in a few instances, information about the 1956 material has been included, but where this is so the date is stated.

The body of the cercaria is set with rows of fine spines which are quite prominent anteriorly but are very inconspicuous towards the posterior end of the animal. The anterior organ is quite well-developed; its cavity is comparatively small, elongated in the antero-posterior axis, and is lined with closely-set spines, which, though small, are much longer than those on the surface of the body. This region is more or less eversible, and when everted gives the appearance of a small spine-covered snout protruding anteriorly. In one favourable specimen five pairs of gland cells were seen in the anterior organ (Fig. 1). In arrangement these resembled those figured for *Cercaria scioti* by Woodhead (1936, plate LIX, fig. 1), with the exception that they did not rest on the basement membrane of the organ, but were situated more anteriorly. The ducts opened into the inverted part of the organ, which in this region appeared to be divided in two as in Woodhead's figure.

The mouth opens behind the middle of the body, nearly as far back as the level of the posterior third. There is a large muscular pharynx, an oesophagus, and a gut, which varies in shape from spherical to oval.

Gland cells scattered throughout the body show up after staining with neutral red. They do not appear to have any recognisable arrangement, but the ducts pass forward anteriorly.

The flame cell formula is $2\{(2+2)+(2+2)\}$. The most posterior pair of flame cells lies near the hind end of the body, and in much flattened specimens the last flame cell may appear to lie in the tail stem itself. The bladder is I-shaped; the anterior and posterior collecting tubes join the main excretory tube at the level of the mouth, and at the point of their union is a distinct dilatation of the tube (Fig. 1). The positions of the flame cells vary slightly in the cercariae examined, probably due to the relative compression of the various parts. The bladder opens at the posterior end of the body.

The base of the tail has the appearance of a cushion which consists of two regions. The upper segment is relatively clear and contains an extension of the bladder, which contracts at times so that the cavity disappears completely. The cytoplasm of the lower segment is filled with fatty globules. Some part of the base of the tail has a sticky secretion, for the animal can attach itself to a glass surface by this region. In one specimen, in which the body was quite free, the animal was attached by the base of the tail; it was impossible to dislodge it with currents of water directed from a fine pipette, and needles were required to free it. Dawes (1946, p. 456) stated that, according to Wunder (1924), the "rudimentary tail" of *Bucephalus polymorphus* secreted a viscid material which served to fasten the cercaria to the body of the fish intermediate host.

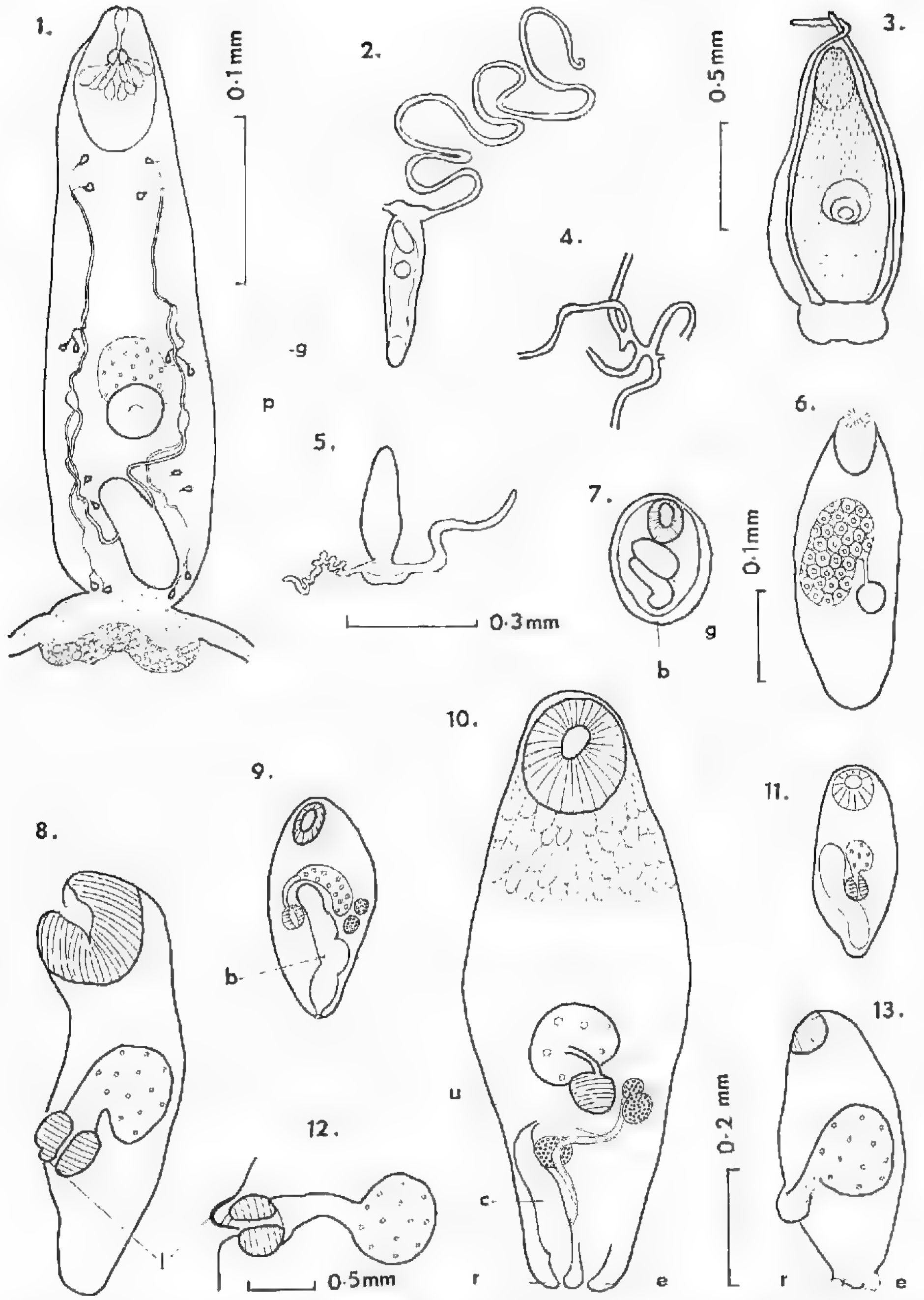
The furcae leave the outer margins of the upper segment of the base of the tail. They, too, are sticky; they become attached to fine needles used in handling the cercaria, and tend to break if pulled, rather than become detached. Even in formalinised cercariae, the furcae are sticky; it is difficult to clear them of any débris adhering and at the same time prevent them from breaking with any traction.

Woodhead (1936) made tests with live fish and stated that, with *Cercaria scioti*, *C. basi* and *C. argi*, the long furcae became entangled on the edge of a fin, and the tail stem functioned as a holding organ by becoming firmly attached, with the posterior portion in contact with the scales of the fish.

The furcae have extraordinary powers of extension. When contracted, they may be little more than the length of the body (Fig. 3), but when extended may be ten times as long. The contracted condition is not, apparently, the normal one; when the animal is suspended in water the furcae are elongated most of the time, and in formalinised material contracted furcae are not seen.

The Sporocyst

The sporocysts form a thick mass in the digestive gland, and are scattered through the region of the gonad and heart. They branch, apparently very freely, but it is difficult to obtain a sporocyst that one is sure is complete. Formalinised material is brittle and breaks easily, and it is hard to dissect out living sporocysts intact. Living sporocysts contain many cercariae, the furcae of which may protrude from the broken ends of the sporocyst to a great distance. No flame cells were seen in the sporocyst walls.



Figs. 1-3, 5, 6. *Cercaria velesunionis*; 1, compressed; 2, 3, 5, in different attitudes; 6, showing gut. Fig. 4. Sporocyst. Fig. 7. Cyst. Fig. 8. Young gasterostome from Murray Perch. Balsam mount. Figs. 9-13. Metacercaria of *C. velesunionis*; 9, 11, 13, different aspects; 10, compressed; 12, alimentary canal from lateral view, showing lip. Fig. 8 is to the same scale as Fig. 12. Figs. 2, 7, 11 are to the same scale as Fig. 5. Figs. 4, 9, 10 are sketches.

b, extretory bladder; c, cirrus sac; e, excretory pore; g, gut; l, lip; p, pharynx; u, uterus; r, reproductive aperture.

The Cyst

The cercariae have been found, experimentally, to encyst in the aquarium fish *Gambusia affinis*, *Carassius auratus*, *Oryzias latipes* and the native fish *Galaxias* sp. Gasterostome cysts were found as a natural infection in three *Carassius auratus* from Tailem Bend in 1937; these appear to be the same as the cysts obtained experimentally.

The cysts may be found in great abundance in the infected fish. In 1958, when detailed dissections were made, they were more numerous in the head region than elsewhere in the body. In one fish 103 cysts were recovered from the head region and only four in the rest of the body. In another there were 25 in the head region; 9 in the tail and 20 in the tissue between the fin rays of other fins. However, in heavily infected fish (1959-1960) there were literally hundreds of cysts in the tail region. (The rest of the body was not dissected, but was used in feeding experiments to try to find the adult stage.)

The cyst walls are thin and the metacercariae so active that the cysts continually change shape, from oval to circular, to pear-shaped, etc. The cyst wall breaks extremely readily, and excystment takes place spontaneously shortly after the tissues of the host are dissected apart. A few hours afterwards it is rare to find even one intact cyst. In order to collect sufficient cysts for measuring, it was found necessary to transfer them into formalin as soon as they were dissected out. (Table 1.)

The Metacercaria

Metacercariae dissected into 0·65 p.c. saline live for several days at 4° C., and up to twenty-four hours at room temperature.

Two fish, *Gambusia affinis*, were infected four and eight weeks respectively before they were killed; the metacercariae from these were accidentally mixed, but could be separated into two distinct ranges of size. The smaller size is presumed to comprise the younger metacercariae (see Table 1 for measurements of the two groups).

The body is spined all over; the spines are relatively large and obvious in the anterior half of the body, but become smaller and are very inconspicuous posteriorly. After staining with methylene blue, granular subcuticular cells of irregular shape can be seen (though they do not take up the stain) scattered throughout the body; no nuclei are visible. After neutral red a mass of gland cells shows up behind the anterior sucker. Individually, these cells are not very distinctly defined, but the area as a whole is very definite (Fig. 10). It extends behind the anterior sucker to a distance roughly equal to the length of the sucker.

The anterior organ has increased greatly in size and has much more the appearance of a normal sucker than was the case in the cercaria. It has no lobes or appendages.

The mouth opens into a muscular pharynx which is followed by a distinct oesophagus; this is quite contractile, and opens into the sac-like gut. From the lateral view, a definite lip on the anterior border of the mouth is seen (Fig. 12). The gut, which occupies, roughly, the middle of the body, is generally rounded, but sometimes elongated. It often shows as a conspicuous yellow mass because of its bright yellow contents, which consist of a somewhat viscous liquid in which are refractile globules of various sizes. The mass of the gut contents stains deeply with neutral red.

The flame cell formula is the same as in the cercaria. The excretory bladder is elongated; it extends anteriorly beyond the mouth, and posteriorly opens on the end of the body close to the excretory pore. Very often it lies diagonally

TABLE 1.

Metacercariae and young adults of *Cercaria velesuntonis.*

N.B. Numbers given in brackets below the measurements indicate the number of organs measured.

				Length		Breadth		Anterior organ				Pharynx			
								Length		Breadth		Length		Breadth	
		Age weeks	Number measured	Range mm.	Average mm.	Range mm.	Average mm.	Range mm.	Average mm.	Range mm.	Average mm.	Range mm.	Average mm.	Range mm.	Average mm.
Cyst (1959-1960)	In formalin	8	20	·217—·334	·280	·145—·232	·180								
Cyst (1956)	In formalin	up to 16	10	·235—·341	·313	·200—·247	·226								
Metacercaria	In formalin	4	20	·232—·319	·255	·131—·174	·152								
Metacercaria	In formalin	8	20	·334—·464	·390	·116—·203	·157								
Metacercaria	Living	?	10	·309—·463	·382	·130—·247	·189	·080—·114	·098	·074—·108	·090	·040—·059	·053	·037—·062	·049
Metacercaria	Living	6—7	10					·074—·108	·090	·080—·120	·098	·037—·062	·049	·040—·059	·052
Metacercaria (1956)	Lactophenol	?						·059—·093	·077 (10)	·049—·071	·062 (10)	·034—·037	·036 (5)	·028—·037	·033 (5)
Young adults from carp	Flattened: in cedar-wood oil		1		·263		·136		·068		·068		·034		·037
			1		·253		·127		·068		·068		·037		·034
Young gasterostomes from *Percalates colonorum*	In Canada balsam		17	·213—·367	·300	·083—·142	·101	·068—·099	·083 (8)	·068—·093	·083 (8)	·037—·046	·041 (4)		·046 (4)
	Flattened: in glycerine		1		·355		·142		·093		·093				
			1		·343		·142		·096		·083				

across the body (Fig. 11). In freshly dissected specimens it is filled with dark excretory granules, tiny to small in size, some of them compound. These are extruded readily through the excretory pore.

The anlagen of the reproductive organs are fairly well defined (Fig. 10). There are three small rounded masses of cells which are evidently ovary and testes. The ovary is smaller than the others, and lies slightly anterior to the anterior testis; from it a ribbon of cells which is presumably to become the uterus, winds backwards between the diagonally placed testes, and then runs alongside the cirrus sac, which is a large organ lying to the side of the bladder at the posterior end of the body. The genital pore opens at the posterior end of the body, close to the excretory pore. Vasa deferentia are not seen, nor is there any trace of vitellaria.

The Adult

A laboratory-raised carp, *Carassius auratus*, was fed over a period of five weeks with 15 *Gambusia affinis* and one small carp, all of which had been exposed to infection with *Cercaria velesunionis*. Some of these small fish were partly dissected before being fed to the carp, and it is estimated that it was probably given two or three thousand cysts. The carp was killed five days after the last small fish had been fed to it. Two young gasterostomes were recovered from its intestine. Although these had had at least five days (and could have had as much as five weeks) in the gut, they showed little difference from the metacercaria of *C. velesunionis*. (See Table 1 for measurements.) The guts of the two specimens measured ·068 x ·068 mm. and ·068 x ·056 mm. respectively.

Two more carp were fed with an unknown number of cysts; they were killed 18 and 27 days respectively after the latest feeding. Neither yielded gasterostomes on dissection. The failure to establish infections indicated that *Carassius auratus* is not a suitable host for the species.

Adult gasterostomes have not been found in any fresh-water fish examined in this department. These include 31 Murray cod (*Maccullochella macquariensis*), 96 callop (*Plectroplites ambiguus*), 33 congolli (*Pseudaphritis urvillii*), 52 catfish (*Tandanus tandanus*), 10 Murray bream (*Therapon bidyana*), 4 bony bream (*Fluvialosa richardsoni*) and 12 Macquarie perch (*Macquaria australasica*).

Immature gasterostomes, however, were found in four of seven Australian perch, *Percalates colonorum*, taken from the River Murray at Swan Reach in September 1937. (They have not been found in nine *P. colonorum* collected from the River Murray since that time.) In size and general appearance, and in the presence of a lip, these young flukes are very similar to the metacercariae of *Cercaria velesunionis*. They are regarded as belonging to this species.

DISCUSSION

Cercaria velesunionis is regarded as a new species. It cannot be identified with cercariae which have been described without details of the excretory system, and it differs from other gasterostome cercariae in which the excretory system has been described (*C. elegans* Woodhead, 1930; *C. papillosus* Woodhead, 1930; *C. scioti* Woodhead, 1936; *C. argi* Woodhead, 1936, and *C. basi* Woodhead, 1936) in having an excretory formula of 2{(2 + 2) + (2 + 2)}. Hopkins (1956) pointed out that in the taxonomy of Bucephalidae, the structure of the excretory system had not been given phylogenetic significance. The excretory formula, 2{(2 + 2) + (2 + 2)}, was found in species of three different genera, while four different formulae were found in one genus (*Rhipidocotyle*).

Hopkins was of the opinion (and many other workers must agree with him) that no natural classification can be made without taking the excretory system into consideration. The nature of the anterior attachment organ, however, has been regarded as of great taxonomic importance in the Bucephalidae. In 1954, Hopkins (p. 355) pointed out that the cercariae of *Bucephalus elegans* Woodhead, 1930, *Rhipidocotyle papillosum* Woodhead, 1929, and *R. septpapillata* Krull, 1934, the only bucephalids whose life cycles had been established by experiment, did not show any signs of the papillae or hoods which distinguished the adults from the forms which Nicoll (1914) assigned to *Bucephalopsis*. He stated that, so far, there was no way of telling which genus of the Bucephalidae a given cercaria belonged to, until the life cycle had been worked out by experimental infection. To my knowledge, no life histories have been described since Hopkins' statement.

Until the adult form is found, it is not possible to assign *Cercaria velesunionis* to a genus.

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I wish to acknowledge the help given by my nephew, Dr. R. H. Burnell, in collecting mussels, and by Mr. T. D. Scott, of the South Australian Museum, in identifying fish. I wish also to express my indebtedness to the late Professor T. Harvey Johnston for records of the parasites of fresh-water fish dissected in South Australia.

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THE SPECIES OF *OXALIS* ESTABLISHED IN SOUTH AUSTRALIA

BY D. E. SYMON

Summary

Eleven species of *Oxalis* established in South Australia are discussed and a key provided.

THE SPECIES OF *OXALIS* ESTABLISHED IN SOUTH AUSTRALIA

by D. E. SYMON*

[Read 8 September 1960]

SUMMARY

Eleven species of *Oxalis* established in South Australia are discussed and a key provided.

A recent attempt to identify plants of *Oxalis* growing in South Australia has shown that the treatment of the genus in the Flora of South Australia, Part 2: 484 (Black, 1948) is now inadequate.

The genus is a large one with possibly 800 species. There are two main centres of distribution each with large numbers of species, one in South Africa and one in South America. There are two species native to Australia, *O. lactea* Hook. in Victoria and Tasmania, and *O. corniculata* L. which is very variable and is almost cosmopolitan. All other species have been introduced, usually as garden plants, and some of these have later proven to be aggressive and have become weeds. An early catalogue of the plants grown in the Adelaide Botanic Garden (Schomburk, 1878) lists forty species and includes nearly all the species listed below. Similarly, the early catalogue of the plants in the Melbourne Botanic Gardens (Guilfoyle, 1883) lists twenty-nine species, but few species are grown in either Botanical Gardens today, nor are more than three or four species deliberately grown in domestic gardens.

The following species have been found in South Australia:

1. *O. articulata* Savigny.
2. *O. bowiei* Lindl.
3. *O. compressa* L.f.
4. *O. corniculata* L. – Yellow Wood Sorrel.
5. *O. corymbosa* DC. – Pink Shamrock.
6. *O. flava* L.
7. *O. hirta* L. – Hairy Wood Sorrel.
8. *O. incarnata* L.
9. *O. latifolia* Kunth. – Large Leaf Wood Sorrel.
10. *O. pes-caprae* L. – Soursob.
11. *O. purpurea* L. – One o'clock.

Vegetative reproduction is common in the genus, with the consequent establishment of numerous distinct clones to which specific names have been freely given. The selection and distribution of horticultural variants which have later become naturalized has also added to the difficulties of naming specimens correctly.

The phenomenon of trimorphism is also common in the genus and plants with short-, mid- or long-styled flowers may occur. As is usual in such plants, pollen from the appropriate anther level of another flower is needed for satisfactory seed setting. In South Australia, seed is produced freely only in the *O. corniculata* complex. Seeding does occur occasionally in *O. pes-caprae*, but all other species depend on bulbil formation for their distribution. Because

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vegetative propagation is so common, large populations may consist almost entirely of plants with a single style length, and within these populations seed production is negligible. The flowers of all species are sensitive to weather conditions, and only open widely under bright, mild conditions.

The species, *O. bowiei*, *O. flava* and *O. hirta*, all flower early in their seasonal development and the first two may flower whilst having only one or two leaves; after this initial flowering there is continued leaf production. The stem of *O. hirta* elongates and branches freely after flowering has finished.

Most species produce one or more tuberised roots below the bulb during the growing period. These roots vary greatly in size and may be from 1-40 cm. long and from 3-10 mm. thick according to the species. They collapse late in the growing season and at least in some species their shrinkage results in pulling a newly formed bulb along the channel formed in soil and so assists in distributing the bulbs.

Despite the size of the genus and the importance of some of the species as weeds, relatively few counts of chromosome numbers are available; of the eleven species discussed here only *O. hirta*, 2n = 30; *O. corniculata*, 2n = 24; and *O. pes-caprae* (as *cernua*), 2n = 35, are listed by Darlington and Wylie (1955). In view of the interesting situation in *O. pes-caprae* described by Oram (1956), further cytological studies on the aggressive weedy species would be interesting.

In the following account, where two measurements are given separated by the sign X, the first is to be understood as the length and the second the breadth.

Key to the Species of *Oxalis* Established in South Australia

1. No stem developed above or below ground, leaves radical and springing directly from the bulb. Flowers pale or bright pink.
    2. New bulbils sessile, leaflets with rounded lobes broadest below the apex, hirsute .... *O. corymbosa* 5
    2a. New bulbils on stolons ·5-2 cm. long, leaflets with prominent lobes widest at the apex and often having a "fishtail" appearance, almost glabrous, sometimes with a brown crescent *O. latifolia* 9

1a. Stem developed to ground level (when leaves basal) or above ground.
    3. Stem usually developed to ground level only, simple, the leaves crowded at its apex.
        4. Flowers solitary.
            5. Leaflets 3, flowers white, pale or deep pink ..... *O. purpurea* 11
            5a. Leaflets 2-7, flowers yellow .... *O. flava* 6
        4a. Flowers umbellate or cymose.
            6. Petioles flattened, narrowly winged, with a prominent fringe of hairs, leaves and petioles hairy, flowers yellow *O. compressa* 3
            6a. Petioles cylindrical.
                7. Stems woody, perennial, no bulbs formed ..... *O. articulata* 1
                7a. Stems succulent, annual, bulbs formed.
                    8. Flowers pink, leaflets often large, to 5 x 6 cm., finely glandular pubescent .... *O. bowiei* 2
                    8a. Flowers yellow, leaflets smaller, to 2 x 3 cm., almost glabrous .... *O. pes-caprae* 10

3a. Stem usually developed above ground, branched, with leaves along its length.

9. Flowers yellow, no bulbs formed, stems often prostrate on the ground and rooting at the nodes *O. corniculata* 4

9a. Flowers pale mauve or bright pink, bulbs formed, stems spreading or erect.

10. Petioles very short 1-2 mm., flowers bright pink, bulbs formed below ground only ..... *O. hirta* 7

10a. Petioles several cm. long, flowers pale mauve, bulbs formed in leaf axils above ground, and also underground ... ... *O. incarnata* 8

1. *O. articulata* Savigny, 1798, in Lamarck, Encyl. Method. Bot., 4, 686.

Perennial, no bulbs formed, rhizome thick, almost woody and covered with the scars of leaf bases, sparsely branched and marked by constrictions which divide the rhizome into segments of varying length.

Leaves crowded at the apex of the stem, leaflets three, obcordate, pubescent, up to 4 cm. broad, with many orange calli along the lower margin, and sometimes flushed purple below. Petioles 10-20 cm. long, pubescent with appressed hairs.

Peduncles longer than the leaves, flowers many, corolla to 15 mm., bright mauve pink or white in a contracted cyme with the appearance of an umbel or with the cyme branches up to 5 cm. long and variously developed in different clones. Flowering in spring and summer.

Occasionally grown as a garden plant and one colony has been reported established in the field at Mount Compass.

Native to temperate South America, the involved synonomy of this species is discussed by Young (1958).

2. *O. bowiei* Lindl, Bot. Reg. XIX (1833) t. 1585.

Bulb long ovoid, tapered, somewhat curved. 1-4 cm., tunic pale brown when young, dark brown when old, producing up to three stout contractile roots 5 x 1 cm. Stem thickened at the ground level, the leaves crowded at its apex.

Leaflets broadly obcordate, often large and up to 5 x 6 cm., glabrous above but densely pubescent below along the veins and leaf margins with short, erect, glandular hairs. Petioles terete, to 10 cm. finely and densely glandular pubescent.

Peduncles 12-25 cm., 3-10 flowered, bracts 1 cm., pedicels to 5 cm. Corolla bright pink 2·5 cm. Flowering in winter and spring.

A native of South Africa that has been long cultivated as a garden plant and it is still to be found occasionally in gardens. Now established over 40 acres near Gawler where it is reported to have spread rapidly in recent years. It has also been recorded at Laura, Angle Vale and Victor Harbour in addition to suburban gardens.

3. *O. compressa* L.f. Supp. 1781.

Bulb ovoid, pointed, 1-2 x 1 cm. with a brown tunic, the outer bulb scales somewhat woody and ribbed. During growth up to three tuberised contractile roots are produced from the original bulb. Stem slender, but thickened at ground level and not usually developed above ground.

Leaves numerous, crowded at the apex of the stem. Leaflets three, broadly cuneate obovate 1-2 x 1-3 cm., hirsute below, the base of each leaflet sometimes with brown markings. Petiole 3-20 cm. long, compressed and narrowly winged, villous, dilated below the articulation.

Peduncles several, 5-20 cm. long. Flowers 2-6 in an umbel, calyx 5-7 mm., corolla yellow 2 cm. long. Flowering June to October.

Established at Roseworthy and Pt. Lincoln, but possibly overlooked elsewhere due to its general similarity to *O. pes-caprae.*

4. *O. corniculata* L. Sp. Pl. I (1753) 435.

Perennial, taproot thickened and at times almost woody, no bulbs produced. Stems prostrate and rooting at the nodes or long slender and ascending, branched, herbaceous.

Leaflets three, obcordate, 3-16 mm., with a deep sinus, pubescent, stipules small.

Peduncles slender, axillary, flowers 1-5 in an umbel, corolla 4-10 mm., yellow, pedicels often reflexed in fruit. Capsule angular cylindrical, pubescent, beaked 5-25 mm. Seeds reddish brown, compressed, transversely rugose.

All over the State, almost cosmopolitan. An extremely variable plant with an involved synonymy of allied species and their varieties (Young, 1958). Plants believed to be indigenous do not appear to root freely at the nodes and the corolla may be relatively large up to 15 mm. Those found as weeds of gardens usually have smaller flowers and root at the nodes. In lawns extremely small plants may be found bearing solitary flowers. It is the only *Oxalis* which produces seed freely in South Australia. It is a nuisance at times as a weed of pot plants and lawns, but it is not important as a weed in fields. The plant grows actively whenever moisture is available and flowers throughout the year.

5. *O. corymbosa* DC., 1824, Prod., 1, 696. *O. martiana* Zucc.

Bulbs globose 2-20 mm., tunics brown, with slight vertical striations, the original bulb producing a large number of sessile bulbils during the growing season. Several short, thick, conical, contractile roots may be formed at the base of the parent bulb.

Plant stemless, the leaves arising directly from the bulb. Leaves numerous, petioles weak and thin below ground, to 15 cm., sparsely hirsute. Leaflets three, roundish with a deep narrow indentation at the apex of the rounded lobes, sparsely hairy below on the veins and leaf margin which bears small reddish calli.

Peduncles up to 30 cm. bearing flowers in a contracted cyme. Corolla purplish pink 15-20 mm. Flowering in spring and summer.

Native to South America. It is a troublesome weed in sub-tropical areas and in the eastern States of Australia. In South Australia it is restricted to suburban gardens. It is mainly summer growing but does retain some foliage during the winter. It is a prolific producer of bulbils, and one pot-grown bulb has produced 110 bulbils during one summer. These may be quite small and are virtually impossible to pick out of the soil, and the often ineffectual efforts at removal assist in spreading the plant.

Barossa intake Weir J. B. Cleland, Adelaide suburbs.

6. *O. flava* L. Sp. Pl. (1753) 433.

Bulb ovoid 1-3 cm. long with a thin light brown tunic, young bulbs with a pinkish brown tunic are almost globular. The tuberised contractile root is long, 40 cm., and slender 3-4 mm. Stem slender underground but thickened at ground level.

Leaves, 1-10, petioles 2-10 cm. long, dilated below the articulation, glabrous. Leaflets 4-7 sessile, spreading palmately, linear oblong 30 x 3-5 mm.

Peduncles one flowered, about the same length as the leaves, with two bracts below the calyx. Corolla yellow 2 cm. long and the flowers are short styled in our clone. Flowering in autumn.

Salter describes it as a variable group species with many forms, and the South Australian material belongs to his typical form.

Established in South Australia at Glen Osmond, Victor Harbour, Tooperang, Cambrai, Freeling, Middletown, Hartley, Pt. Lincoln, Tatiara. Although not yet classed as an important weed, a report from Pt. Lincoln describes it as spreading at a considerable rate and causing concern.

7. *O hirta* L. Sp. Pl. (1753) 434.

Bulb ovoid, pointed, 2-3 cm. x 2 cm. with a brown tunic. Stem to 30 cm., pubescent, at first erect, later sprawling, simple or branched especially after flowering, glabrous and scaly below ground.

Leaves with short flattened petioles 1-2 mm. long. Leaflets three, sessile, oblong cuneate, slightly emarginate, glabrous above pilose below, 5-10 x 3-4 mm.

Peduncles axillary 1 flowered, to 3 cm. with two bracts below the calyx. Corolla bright purplish pink 3 cm. Flowering in autumn and winter.

An extremely variable species in South Africa and Salter describes many varieties. The South Australian plants appear to be the typical form.

Established in the Meningie and Victor Harbour Cemeteries.

8. *O. incarnata* L. Sp. Pl. (1753) 433.

Bulb ovoid 1-1½ cm. with a brown tunic, smaller sessile bulbils develop in the leaf axils during growth and later drop off. Stem rather stiff, branching, to 20 cm., the internodes relatively long, 8 cm., and bare.

Leaves crowded at the nodes in clusters of 4-10 (false whorls), petioles 2-4 cm. Leaflets glabrous above sparsely pilose below, obcordate 5-10 x 10-17 mm. The foliage is sweetly scented under warm still conditions.

Peduncles one flowered, to 4 cm. long, and with two bracts above the middle and at an articulation, pedicel 2 cm., corolla 1·5 cm., pale lilac, long styled in our clones. Flowering in spring and summer.

Sparingly established in South Australia in moist or shady places at Mt. Barker, Mt. Lofty, Adelaide suburban gardens, and on the river embankments at Tailem Bend.

9. *O. latifolia* Kunth. 1882. Nov. Gen. et Spec. 237, t., 467.

Bulb globose 1·5 x 1·5 cm. tunics brown, outer scales ciliate and with 3-4 vertical ridges. Several short conical tuberised roots may be produced. The numerous new bulbils are produced from the old bulb on stolons up to 2 cm. long. Plant stemless, the leaves and flowers issuing directly from the bulb.

Leaves numerous, petioles to 20 cm. terete, almost glabrous. Leaflets three, almost glabrous, broader than long, obdeltoid with a wide shallow indentation with straight sides giving them a fishtail appearance. Other clones with more rounded lobes and with a brown crescent on the leaves also occur and are rather similar to *O. corymbosa* in appearance.

Peduncles to 25 cm. sparsely pubescent in the region of the bracts which subtend the umbel of 8-13 flowers. Sepals with prominent orange calli at the tip. Corolla bright or pale pink, 1·1-2 cm. Flowering in summer.

A native to Central and Tropical South America, it is now widely spread as a weed in many parts of the world. It is aggressive in the Eastern States of Australia, but in South Australia it is still restricted to suburban gardens in Adelaide and Mount Gambier. It is summer growing in contrast to the South African species growing here and it appears to be less tolerant of cold conditions than *O. corymbosa*. The production of new bulbils is considerable, one pot-grown plant producing over 80 new bulbils in a season.

10. *O. pes-caprae* L., Sp. Pl. 1753, 434.

O. cernua Thunb. 1781, De Oxalide.

Soursop, Soursob of Australia, Bermuda Buttercup of England and America.

Bulb ovoid, pointed 1-3 x 1 cm. with a brown tunic, producing a white tuberised contractile root during growth and a thin annual underground stem which may bear bulbils along its length. The stem is only developed above ground when the plants are crowded or shaded.

Leaves many, on terete petioles up to 15 cm. long which are jointed and broadened near the base and arise from the top of the underground stem at the soil surface. Leaflets obcordate 1-3 cm. broad, notched, sparsely hairy below and often with numerus purple flecks on the upper surface.

Peduncles to 30 cm. long bearing an umbel of 3-16 flowers which are bright yellow, sepals 5-7 mm., petals 20-25 mm. long. Flowering June-October.

Two chromosome races occur in South Australia (Oram, private communication, 1956). Small populations of tetraploids ($4x = 28$) have been found and include all three style lengths, as well as variations in leaf and calyx marking. Some seed production appears to occur amongst these plants. The largest populations are of short styled pentaploids ($5x = 35$) which occupy hundreds of acres of land on the Adelaide Plains and Lower North.

These plants are virtually sterile and are very uniform morphologically. It would appear from overseas descriptions that it is the sterile short styled plant that is weedy in North Africa, Israel and Great Britain. The plants are almost wholly weeds of arable land and they have not invaded undisturbed sites to any extent. Continued consumption by sheep causes chronic kidney damage and may result in death, particularly with sheep new to the plant (Watts, 1953). This species is an important weed, smothering young crops and pastures with its vigorous autumn growth. Field distribution in South Australia is mainly on the Adelaide Plain and is approximately delimited by the 600 ft. contour line and the 11-12 inch April-October rainfall isohyet (Michael, 1958). However, domestic gardens are infested in almost every township in South Australia.

11. *O. purpurea* L. Sp. Pl. 1753, 433. syn. *O. variabilis* Jacq. "One o'clock".

Bulb ovoid, 2 cm., with a firm gummy blackish brown tunic. Amongst the plants grown contractile roots were only produced on plants from the smaller bulbils. Stem thickened at ground level and the leaves crowded at its apex.

Leaves numerous, usually prostrate, petioles terete, 2-10 cm. long. Leaflets three, glabrous above, ciliate, broadly cuneate rhomboid up to 3½ x 3½ cm. but usually less.

Peduncles one flowered, as long as, or slightly longer than, the leaves, with two alternate linear bracts at or below the middle. Sepals ·5 cm., glabrous or villous, ciliate. Corolla 2 cm. long, white, pale or bright pink, or pale violet usually with a yellow throat. Flowering in autumn, winter and spring.

This species is widely spread in South Australia as a garden escape although it is rarely common or weedy. There is a variant with reddish purple tints to the stems and leaves which occurs as a weed of lawns. Under continued mowing its dimensions may be very reduced, the leaflets being only ·5 cm. in diameter with petioles 1 cm. long. Another variant with leaflets completely flushed with purple has been grown as a garden plant and is perhaps more aggressive. It differs from the typical plant in that the stem arises obliquely from the bulb and may emerge up to 6 inches distant from it, instead of almost directly above it. New bulbils are formed along the length of this stem and contractile roots were not produced.

At least five colour variants and all style lengths of the typical form occur in South Australia.

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DESCRIPTION OF THE FEMALE OF *TRICHONYSSUS* WOMERSLEYI DOMROW *(ACARINA, MACRONYSSIDAE*)

BY *H. WOMERSLEY*

Summary

The female of Trichonyssus ***womersleyi*** Domrow, 1958, a species hitherto known only from the male, is described.

DESCRIPTION OF THE FEMALE OF *TRICHONYSSUS WOMERSLEYI* DOMROW (*ACARINA, MACRONYSSIDAE*)

by H. WOMERSLEY*

[Read 8 September 1960]

SUMMARY

The female of *Trichonyssus womersleyi* Domrow, 1958, a species hitherto known only from the male, is described.

In 1958 my colleague, Mr. R. Domrow (Proc. Linn. Soc., N.S.W., 83 (3), p. 220) erected a new genus *Trichonyssus* for the species described by myself in 1956 as *Chiroptonyssus australicus* (J. Linn. Soc., London, Zool., 43 (288), p. 597) and collected from an unidentified bat from South Australia. The species was only tentatively assigned to *Chiroptonyssus.*

The genus *Trichonyssus* was differentiated from *Chiroptonyssus* by Domrow as follows: in the female by the metasternal setae being free on the cuticle and not on small platelets, and in the male by the complete holoventral shield, the absence of a strong process on the femur of leg IV and the presence of very long setae posteriorly on the opisthoma.

In addition to designating *Chiroptonyssus australicus* Wom. as the genotype of his new genus *Trichonyssus* Domrow (loc. cit.) erected a second species *Trichonyssus womersleyi* for the two specimens which I described in 1957 as the males of *Plesiolaelaps miniopterus* sp. nov. (Trans. Roy. Soc., S.A., 80-70) from a bat *Miniopterus schreibersii blepotis* (Temmink) from Joanna, S. Australia. He showed that these males were not truly correlated with the holotype female. The genus *Plesiolaelaps* he placed in synonymy with *Spinolaelaps* Radford.

The males of *womersleyi* were distinguished from those of *australicus* by the long posterior opisthosomal setae being in two groups of seven instead of a continuous circlet of many more. The female of *womersleyi* has hitherto been unknown.

Recently, however, from a bat, *Chalinolobus gouldi gouldi* Gray, found on board a vessel at Port Adelaide, South Australia, 26th Feb., 1960, were obtained three males which were found to be conspecific with the holotype of *womersleyi* and two females which showed distinct differences from the females of *australicus* and are now ascribed to *T. womersleyi* Domrow.

Trichonyssus womersleyi Domrow.

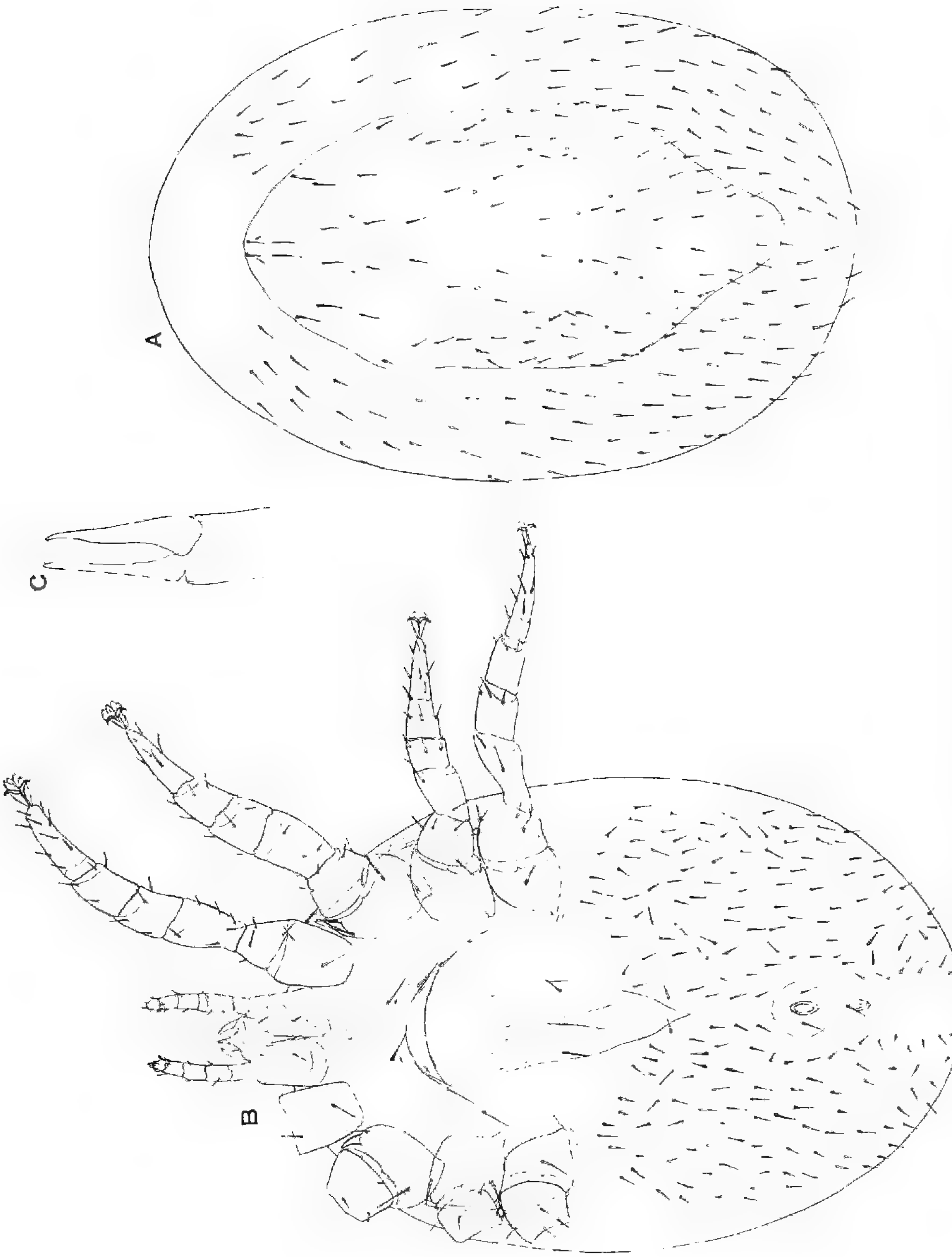
Domrow, R., 1958. Acarina from Australian Bats. Proc. Linn. Soc., N.S.W., 83 (3), p. 231.

Description of Allotype Female—A rather lightly sclerotised ovoid species. Length of idiosoma (gravid) 800μ, width 468μ.

Dorsum—With entire dorsal shield, not covering the whole body, 500μ long by 260μ wide, posteriorly becoming contracted to a rounded tip. Both shield and surrounding cuticle with numerous short pointed setae to 24μ long.

Venter—With only two pairs of setae on the sternal shield, the other pair being just, but only just, off the postero-lateral corners, the shield is 115μ wide between

* South Australian Museum.



Trichonyssus womersleyi Domrow, Female; A, dorsum; B, venter; C, chelicerae.

the third pair of setae and 43μ long in the median line, with strongly concave posterior margin and the posterior half more sclerotised and band-like; the metasternal setae are free on the cuticle; the genital shield tapers posteriorly to a very acute point, its length from the setae to the tip is 110μ and the setae are 67μ apart, anteriorly it is fimbriated; the anal shield is an elongate pear-shape, 105μ long by 52μ wide; ventral setae as on the dorsum and to 24μ long.

Legs—Normal, II the stoutest, I 608μ long, II 352μ long, III 327μ, IV 409μ; coxae II with a strongly antero-dorsal spur.

Remarks—Differs from the female of *australicus* Wom. in the shape of the dorsal and genital shields.

LABIDOSTOMMIDAE FROM AUSTRALIA (ACARINA, PROSTIGMATA) WITH THE DESCRIPTION OF A NEW SPECIES1

BY WARREN T. ATYEO AND D. A. CROSSLEY JR.

Summary

Current investigations on the labidostommid fauna of the Australian realm required the redescription of the type of the Australian species, Labidostomma adelaideae Womersley. Through the cooperation of the South Australian Museum, the type specimen plus unidentified specimens were loaned for study. Among the materials received, one new species was discovered which is described herein.

LABIDOSTOMMIDAE FROM AUSTRALIA (ACARINA, PROSTIGMATA) WITH THE DESCRIPTION OF A NEW SPECIES[1]

WARREN T. ATYEO[2] AND D. A. CROSSLEY, JR.[3]

(*Communicated by H. Womersley*)

[Read 8 September 1960]

Current investigations on the labidostommid fauna of the Australian realm required the redescription of the type of the Australian species, *Labidostomma adelaideae* Womersley. Through the cooperation of the South Australian Museum, the type specimen plus unidentified specimens were loaned for study. Among the materials received, one new species was discovered which is described herein.

Labidostomma adelaideae Womersley, 1935

Ann. Mag. Nat. Hist., 10th ser., **16** (9), pp. 152-153.

The dorsal integumental pattern of this species resembles those of *Labidostomma luteum* Kramer, *L. barbae* Greenberg, and *L. vejdosskyi* Storkán, but is easily distinguished from these species in that *adelaideae* lacks the large gland-like structures ("pustules" of Grandjean, 1942; "Seitenhoecker" of Thor, 1931) immediately behind each lateral eye.

Female.—Colour in life dark olive-green to greenish black. Length, including gnathosoma, 1004μ. *Gnathosoma.*—Chelicera (Fig. 1C): length, 189μ; height, 117μ; median surface with 2-3 short vertical rows of small spicules at bases of fixed digit. Fixed digit with 8-11 subequal teeth slightly larger than 10-13 subequal teeth of movable digit; longest cusp of fixed digit minutely dentate apically. Palpus, 144μ in length; gnathosomal base with 3 pairs of setae. *Dorsal idiosoma* (Fig. 1A). Length, 815μ; without anterolateral projections; without large gland-like organs on median lateral surfaces; sensilla minutely branched. *Ventral idiosoma.* Epimera with polygons except: epimeron III with small striated area near median line, epimeron IV with striated areas on medial and lateral thirds. Paragenital region with large striated area as in Fig. 1D. *Legs.* Measurements: tibia I, 185μ; tarsus I, 76μ; pretarsus I, 36μ; tibia IV, 158μ; tarsus IV, 143μ; total lengths of legs (excluding coxae and pretarsi): I, 654μ; II, 523μ; III, 468μ; IV, 611μ. Famulus with single dichotomy; solenidia short, extending to insertion of famulus (Fig. 1B).

Male.—Unknown.

Type.—Female, collected at Morialta Gorge, Adelaide, South Australia, September 2, 1934, by H. Womersley, among hepatics.

Location of Type.—The South Australian Museum, Adelaide.

Remarks.—A second female collected at Long Gully, Belair, South Australia, in August, 1938, by H. Womersley from moss, was available for study and was found not to deviate from the redescription of the type. All drawings are of the type specimen.

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Labidostomma womersleyi n. sp.

This new species is similar to *L. adelaideae,* but can be distinguished by the lack of striated areas surrounding the genital plates, tarsus IV being longer than tibia IV (rather than shorter), and being slightly smaller in size.

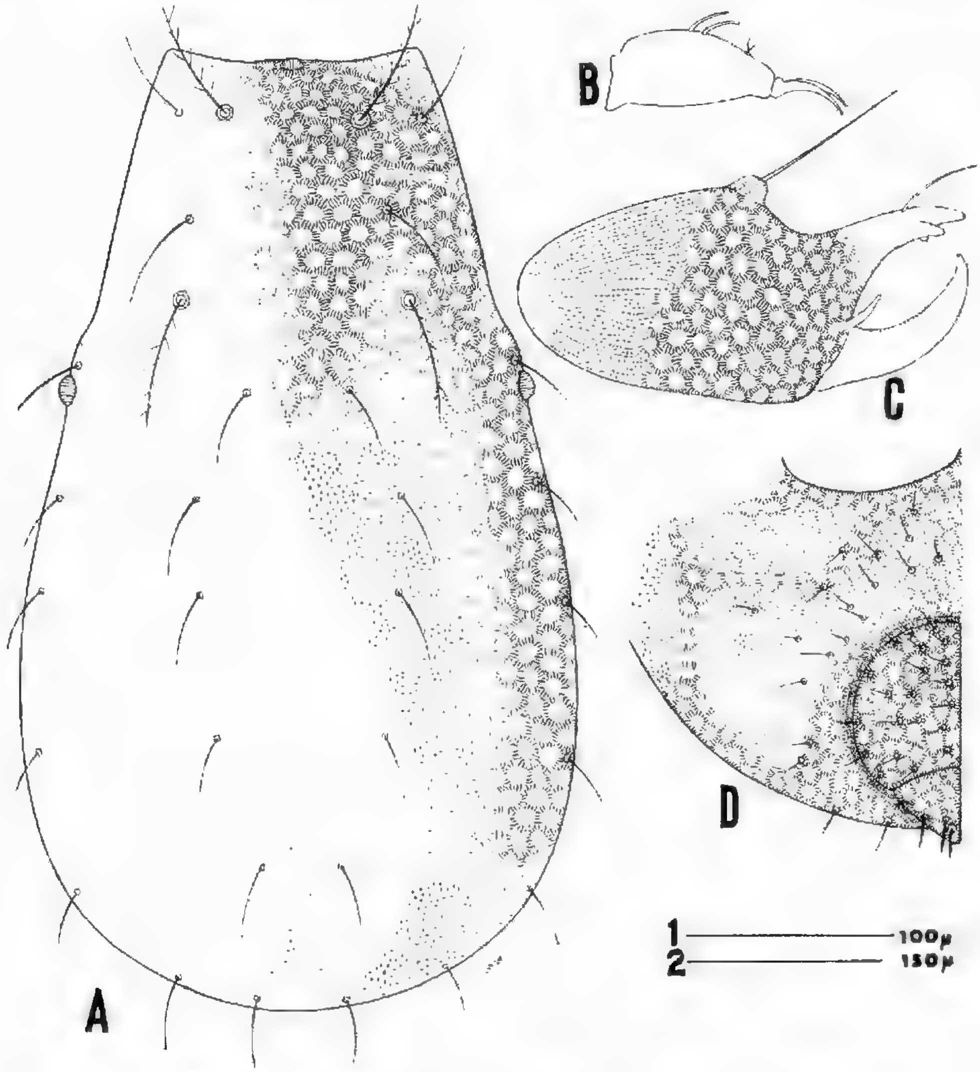

Fig. 1.—*Labidostomma adelaideae* Womersley, 1935, type female. Figs. A and D, scale 1; Figs. B and C, scale 2. A, dorsum of idiosoma; B, tarsus I showing two solenidia and branched famulus, C, lateral aspect of right chelicera; D, ventral aspect of opisthosoma showing paragenital, genital, and anal regions.

Female.—Colour in life deep yellow. Length, including gnathosoma, 780μ. *Gnathosoma.*—Chelicera (Fig. 2C): length, 170μ; height, 98μ; median surface without spicules. Fixed digit with minute serrations on inner face, much smaller than dentations of movable digit; both cusps of fixed digit minutely dentate apically. Palpus, 102μ in length; gnathosomal base with 3 pairs of setae. *Dorsal* *idiosoma* (Fig. 2A).–Length, 610μ; without anterolateral projections; without large gland-like organs behind lateral eyes; sensilla minutely branched. *Ventral idiosoma.*–Epimera with polygons except for striated outer third of epimeron IV. Genital and anal areas as in Fig. 2D. *Legs.*–Measurements: tibia I, 153μ; tarsus

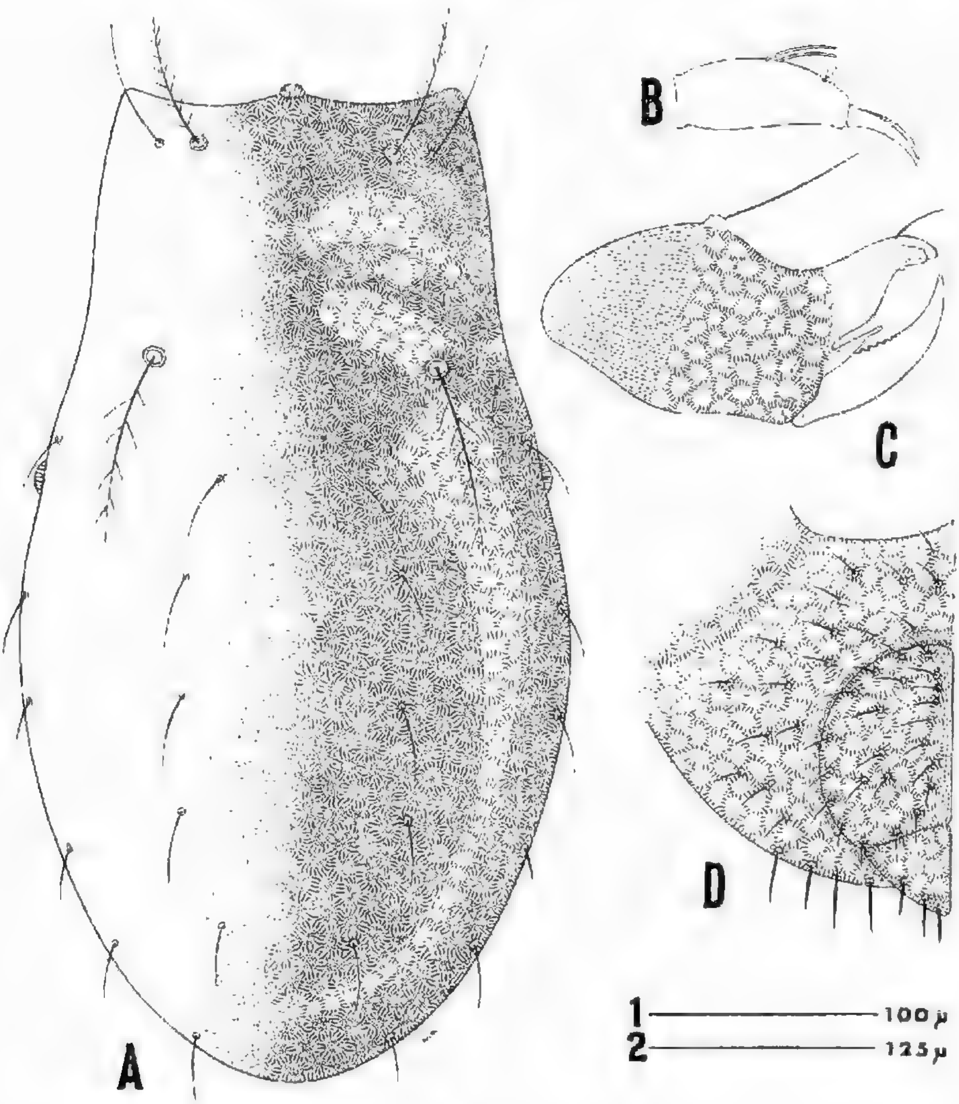

Fig. 2.–*Labidostomma womersleyi*, n. sp., holotype female. Figs. A and D, scale 1; Figs. B and C, scale 2. A, dorsum of idiosoma; B, tarsus 1 showing two solenidia and branched famulus; C, lateral aspect of right chelicera; D, ventral aspect of opisthosoma showing paragenital, genital and anal regions.

I, 75μ; pretarsus I, 31μ; tibia IV, 143μ; tarsus IV, 148μ; total lengths of legs (excluding coxae and pretarsi): I, 572μ; II, 452μ; III, 392μ; IV, 551μ. Famulus with single dichotomy; solenidia long, extending almost to tip of tarsus I (Fig. 2B).

Male.—Unknown.

Holotype.—Female, collected at Remarkable Creek, Wilmington, South Australia, altitude 2,000 feet, September 18, 1958, by H. M. Cooper, in moss.

Location of Type.—The South Australian Museum, Adelaide.

Remarks.—Although the new species is based on a single female, the differentiating characters are unique when compared with those of any known species from the Australian realm. This new species is named in honour of Dr. H. Womersley of the South Australian Museum. All drawings are of the holotype.

ACKNOWLEDGMENT

The authors wish to thank the University of Nebraska Research Council for funds to employ a scientific illustrator.

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BASSIA UNIFLORA (FVM.)R.BR. (CHENOPODIACEAE) AND ALLIES IN AUSTRALIA

BY ERNEST H. ISING

Summary

An examination of herbarium specimens of *Bassia* Sect. *Anisacantha* Series 1 Anderson (Proc.Linn.Soc.N.S.Wales **48(1923)322)** revealed specifically distinguishing characters of *B. uniflora* (R.Br.) FvM. and *B. diacantha* (Nees) FvM, (The latter name had been treated in the more modern local floras as a synonym of the former.) These two and four new species, *B.burbidgeae, B. constricta, B. eichleri and B. gardneri,* are described. *A* key for the determination of the species recognized in the series (except *B. anisacanthoides)* is given. Of each species the distribution is illustrated by citation of a selection of the approximately 600 specimens examined from the following herbaria: AD, ADW, BRI, CANB, MEL, NSW, NT, I', PERTH, SYD (symbols as in Index Herbariorum ed. 4), and special features are briefly discussed.

BASSIA UNIFLORA (FvM.)R.Br. (CHENOPODIACEAE) AND ALLIES IN AUSTRALIA

by Ernest H. Ising

(*Communicated by Hj. Eichler*)

[Read 13 October 1960]

SUMMARY

An examination of herbarium specimens of *Bassia* Sect. *Anisacantha* Series I Anderson (Proc.Linn.Soc.N.S.Wales 48(1923)322) revealed specifically distinguishing characters of *B. uniflora* (R.Br.)FvM. and *B. diacantha* (Nees)FvM. (The latter name had been treated in the more modern local floras as a synonym of the former.) These two and four new species, *B. burbidgeae*, *B. constricta*, *B. eichleri* and *B. gardneri*, are described. A key for the determination of the species recognized in the series (except *B. anisacanthoides*) is given. Of each species the distribution is illustrated by citation of a selection of the approximately 600 specimens examined from the following herbaria: AD, ADW, BRI, CANB, MEL, NSW, NT, P, PERTH, SYD (symbols as in Index Herbariorum ed. 4), and special features are briefly discussed.

Since Ferdinand von Mueller (Census Austral.Pl. 1(1882)30) transferred the Australian species described in the genera *Chenolea*, *Sclerolaena*, *Anisacantha*, *Echinopsilon*, *Kentropsis*, *Dissocarpus*, *Eriochiton*, *Osteocarpum* and *Coilocarpus* to the genus *Bassia*, he was, in Australia, followed by most of the writers of State Floras and check lists. J. M. Black, for example, in his Flora of South Australia ((1924)188), follows Anderson's "Revision of the Australian species of the genus *Bassia*" (Proc.Linn.Soc.N.S.Wales 48(1923)317-355, t. XXXIV-XXXVI) in this "lumping" trend.

Domin (Bibl.Bot.89(1921)625) pointed out that the circumscription of the genera within the *Chenoleae* (sensu Benth. and Hook.f., Gen.Pl.3/1(1880)46) represents greatest difficulties, and that one may become inclined to lump into one genus all the groups of species which have been described as genera. He, however, regards such a procedure as being not suitable. The unification of *Sclerolaena* and *Anisacantha* he regards as fully justified; the delimitation of the other genera, however, will, in Domin's opinion, be only possible following a thorough monographic study.

Ulbrich in his treatment of *Chenopodiaceae* (in Engler u. Prantl, Natürl. Pflanzenfam. 2nd ed.16c(1934)448,449, 532-540) referred to the Australian species treated in modern Australian State Floras under *Bassia* as belonging to the genera *Austrobassia*, *Sclerolaena*, *Dissocarpus*, *Coilocarpus* and *Sclerobassia*. All these genera are restricted to Australia whereas *Bassia* (sensu Ulbrich) occurs in the Mediterranean area, Orient to Central Asia, Siberia, and one species in Central Europe (naturalized in North America) but is absent from Australia.

Black (Trans.Roy.Soc.S.Austral. 58(1934)175-176) explained the reasons why he did not follow Ulbrich's treatment and retained the generic name *Bassia* for the Australian species in the 2nd edition of his Flora of South Australia ((1948)301-308).

It appears, nevertheless, desirable that the justification of the Australian genera distinguished by Ulbrich be examined carefully and the Australian species referred to *Bassia* by other authors be revised in view of their generic position.

This large task could not be undertaken for the present study which deals only with a few selected species which I regard as being closely allied. It is noteworthy that two of them are treated by Ulbrich as *Austrobassia* and three are referred to as *Sclerolaena*. The other species recognized here were unknown when Ulbrich published his treatment.

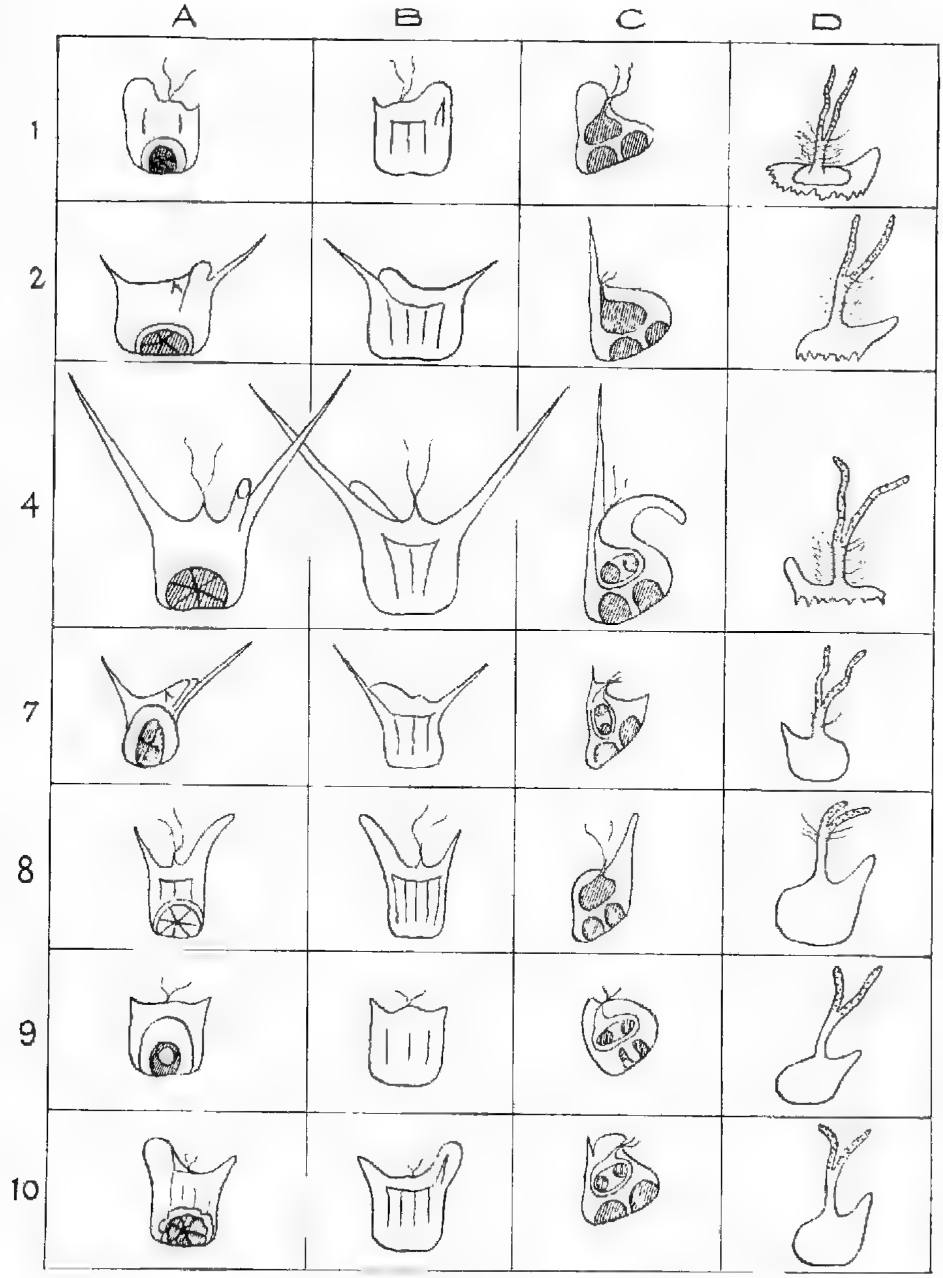
In this study the species are treated as *Bassia* from conventional reasons (in order not to confuse nomenclature without sound reasons), following Black's remarks, and especially as the group dealt with here has been selected as defined in Anderson's revision.

The species of the present study belong to *Bassia* Sect. *Anisacantha* Ser. *I* Anderson (Proc.Linn.Soc.N.S.Wales 48(1923)322). According to Anderson this series is characterized and distinguished from the remainder of the genus as follows:

> Sect. *Anisacantha*: Perianth becoming hardened from the base, usually much hardened in fruit; flowers solitary; without any wing-like expansion; spines acicular, not flattened.
>
> Ser. *I*: Fruiting perianth much hollowed at base, the cavity occupying almost or more than half the perianth.

All species belonging to this series with the exception of *B. anisacanthoides* (FvM.)Anders. are treated hereunder. Of *B. anisacanthoides* (*Sclerolaena anisacanthoides* (FvM.)Domin according to Ulbrich's classification) which differs from the other species of this series by "fruits with 5-6 spines" and which is known from Queensland and New South Wales (Broken Hill district), I have seen no specimens.

1a. Fruit covered with long silky hairs, spines 2, rarely 3 . . . . 3. *B. eriacantha*
1b. Fruit densely tomentose to glabrous; spines 0-3
  2a. Tubercle on posterior face at base of one of the spines hooked; margin of areole at base of fruit ciliate . . . . 4. *B. gardneri*
  2b. Tubercle on posterior face at base of one of the spines not hooked; margin of areole at base of fruit glabrous.
    3a. Spines ± parallel and erect.
      4a. Fruiting perianth soft, longitudinal furrows deep; spines 1-3 unequal in length and thickness . . . . 5. *B. tatei*
      4b. Fruiting perianth hard, longitudinal furrows shallow; spines 2, equal, acicular 6. *B. parallelicuspis*
    3b. Spines divergent (slightly in *B. uniflora*).
      5a. Fruiting perianth thin walled, easily broken, usually longer than broad.
        6a. Tubercle large, beak-like, erect, prominent, usually longer than spines 8. *B. caput-casuarii*
        6b. Tubercle inconspicuous, much shorter than spines . . . . 7. *B. constricta*
      5b. Fruiting perianth thick walled, not easily broken (except *B. diacantha*); about as long as broad.
        7a. Style glabrous or almost so.
          8a. Seed horizontal to slightly oblique; spines 0-2½ mm. long.
            9a. Leaves lanceolate, villous; perianth tomentose; tubercle almost absent, not decurrent . . . . 9. *B. eichleri*
            9b. Leaves linear, pubescent; perianth glabrous; tubercle often prominent, decurrent . . . . 10. *B. burbidgeae*
          8b. Seed vertical to slightly oblique; spines 3-7 mm. long; tubercle small, slightly decurrent . . . . 11. *B. holtiana*
        7b. Style pilose or hirsute; seed horizontal to slightly oblique; perianth tomentose.
          10a. Leaves ± clavate, imbricate, densely tomentose; spines absent to about ½ mm. long; tubercle prominent . . . . 1. *B. uniflora*
          10b. Leaves narrow to broad linear, not imbricate, ± densely pubescent; spines usually 1-7 mm. long; tubercle not prominent 2. *B. diacantha*



Scale for Figs. A to C 2 mm.

Fig. 1: *Bassia uniflora* (R.Br.)FvM.; 2: *B. diacantha* (Nees)FvM.; 4: *B. gardneri* Ising; 7: *B. constricta* Ising; 8: *B. caput-casuarii* Willis; 9: *B. eichleri* Ising; 10: *B. burbidgeae* Ising; A: Fruiting perianths (hairy indumentum omitted), posterior face; B: anterior face; C: median section; D: Styles. Figures A-C drawn to same scale (as shown in drawing); D: various indefinite magnifications (to indicate hairs on style and direction of radicle only). (All drawings from type specimens.)

J. **Bassia uniflora** (R.Br.)FvM., Census Austral.Pl. 1(1882)30; FvM., Second Census 1(1889)51; Tate, Handb.Fl.Extratrop.S.Austral.(1890)51,218; Anders. Proc.Linn.Soc.N.S.Wales 48(1923)329 p.p.; Black, Fl.S.Austral. (1924)190 p.p.; Gardner, En.Pl.Austral.Occid.(1930)38 p.p.; Black, Fl.S. Austral.2nd ed. (1948)303 p.p.; Blackall, W.Austral.Wildf. 1(1954)153 p.p.— *Sclerolaena uniflora* R.Br., Prod.1(1810)410; Moq.in DC., Prod. 13/2(1849)123 ("semen verticale" appears to be an error), Benth. Fl.Austral. 5(1870)194; FvM., Fragm. 8(1873)38; Ulbrich in Engler & Prantl. Nat.Pfl. fam. 16c(1934)534.— Fig. 1 A-D.

Undershrub, diffuse, much branched, covered with a dense indumentum. Branches terete, densely tomentose. Leaves ± linear-clavate, slightly tapering to base, 4-8 mm. long, 1½-2 mm. wide near apex, acute (obtuse in appearance before clothing is removed), ± thick, very densely tomentose, imbricate and erect chiefly in upper part of branches. Flowers solitary. Stamens 5, filaments membranous, dilated to base. Fruiting perianth pear-shaped, 1½-2 mm. long, wide and thick, tomentose; anterior face convex, with several vertical and one horizontal rib; posterior face convex, with 1-2 vertical ribs. Spines usually 2, up to ½ mm. long or one or both rudimentary. Tubercle very obtuse, large, often higher than limb. Limb inconspicuous. Base ± circular, oblique, deeply hollowed; septa radiating; margin glabrous. Style linear, hirsute; stigmatic branches 2, red. Seed horizontal to slightly oblique; radicle superior.

South Australia. R. Brown 3076: AD 96011073 (isotype: fragment of holotype from BM); Fowlers Bay. 1802.— H. Basedow: NSW 45549: Kingoonya to Mt. Eba. IV-V 1917.— J. M. Black: AD, NSW 45551: Tarcoola. IX.1920.— N. T. Burbidge and M. Gray 4621 and 4622: CANB: ca. 50 km. south of Mt. Willoughby Station. 10.X.1955.— J. B. Cleland: AD 95820125: Beltana. 23.IX.1956.— id.: AD 95820104: Cape Thevenard, ca. 400 km. west of Port Augusta. 14.VIII.1928.— id.: AD 95820108: Pintumba, ca. 90 km. east of Western Australian border near the coast. 20.IX.1957.— R. L. Crocker: ADW 4685 (b and c only): Kalabity Station, 10 km. north of Olary. IX.1939.— C. M. Hilton 797: ADW: Yudnapinna. 13.VII.1954.— E. H. Ising: AD 95907080: Oodnadatta. 29.VII.1952.— T. G. B. Osborn: NSW 45554: Flinders Is. 10.I.1924.— Richards: MEL: Between Eucla and Fowlers Bay. 1875.— D. E. Symon: AD, ADW 20917, 20918: Ceduna-Thevenard coastline, E.P., sandy soil over limestone, 2.X.1959.— id.: AD, ADW 20919-20922; ca. 20 km. N. of Koonibba Siding, road to Inila Rock. E.P., mallee flat, red soil. 30.IX.1959 (not quite typical).— id.: AD, ADW 20923, 20924: Pt. Sinclair, near Penong. E.P., sandy dunes near the beach front. 27.IX.1959 (fruits and leaves larger).— id.: AD, ADW 20925, 20926; ca. 6 km. N. of Fowlers Bay, E.P., in light sandy soil in cleared mallee. 29.IX.1959 (leaves less densely tomentose).— J. G. Verco and W. G. Torr: NSW 45555: St. Francis Is., Nuyts Archipelago. II.1909.— J. H. Willis: MEL: Great Australian Bight, ca. 13 km. south of White Wells. 28.VIII.1947.

Western Australia. N. T. Burbidge 1535: PERTH: Pardoo Station. VII.1941.— A. Cunningham 162. MEL: Dirk Hartog's Island. Voyage of "Bathurst". 1822.— Forrest: MEL: Lat. 31°46′, Long. 128°20′.— E. R. L. Johnson 46 (f): AD. ca. 22 km. north of Forrest. 28.X.1955.— Oldfield (?): NSW 30267: Murchison River. 1882 (very close to type).— A. W. Bebblewhite 8: CANB; Forrest, Nullarbor Plain. 26.IX.1945.

New South Wales. R. Carolin 323: SYD: Sandy Creek Gorge, Fowlers Gap, 112 km. N. of Broken Hill. VIII.1957.— J. T. Waterhouse: SYD: N. of Fowlers Gap. 31.V.1954. (Both these specimens from Fowlers Gap are not quite typical.)— A. Cunningham: P; Liverpool Plains. 1826. (Perianths undeveloped but probably belongs to this species.)

The original description of *Sclerolaena uniflora* R.Br. evidently requires a comma after "solitariis" followed by "foliis". This would then make the description intelligible and in harmony with the type specimen.

In R. Brown's ms. notes (microfilm in AD) the leaves of this species are described as obtuse; this appears correct if the apex outline is observed with its very dense tomentose covering. When the indumentum is removed the leaves are found to be acute, although not prominently so.

Both Anderson and Black describe the seeds as horizontal, but they are more often slightly oblique.

B. uniflora is confined to the coastal and dry interior portions of South and Western Australia and north of Broken Hill in New South Wales.

In 1924 Black described a new variety as *B. uniflora* (R.Br.)FvM. var. *incongruens* (Trans.Roy.Soc.S.Austral. 48(1924)254). Two collections were cited, one from Hergott (Marree) and one from Arkaringa Creek. The one from Marree (J. M. Black) (chosen as lectotype of the variety) is *B. constricta* Ising and the one from Arkaringa Creek (Miss Staer) is *B. holtiana* Ising. Both these specimens are referred to by Anderson (l.c. 329, the locality of the second misspelt "Arkianga") as *B. uniflora*.

2. **B. diacantha** (Nees) FvM., Census Austral.Pl. 1(1882)30; FvM., Second Census 1(1889)51; FvM., Ic.Austral.Salsol.Pl.(1889)t. LXXVIII; Tate, Handb.Fl.Extratrop.S.Austral. (1890)51, 218; Moore and Betche, Handb.Fl. N.S.Wales (1893)111; Diels and Pritzel, Bot.Jb. 35(1904)186 (specimen not seen); Maid. and Betche, Cens.N.S.WalesPl. (1916)69.— *Anisacantha diacantha* Nees in Lehm., Pl. Preiss. 1(1845)635; FvM., Fragm. 7(1869)14; 9(1875)75.— *Kentropsis diacantha* (Nees)Moq. in DC., Prod. 13/2(1849) 138.— ? *Anisacantha kentropsidea* FvM., Trans.Vict.Inst. 1(1855)133; FvM., Hook.Kew J. 8(1856)204.— *Sclerolaena diacantha* (Nees)Benth., Fl.Austral. 5(1870)194 (incl. var. *longispina*? Benth., l.c. 195 p.p.); Bailey, Syn.Queensl.Fl. (1883)407; Bailey, Queensl.Fl. 4(1901)1257; Bailey, Compr. Cat.Queensl.Pl. (1913)409; Ulbrich in Engler and Prantl, Nat.Pfl.fam. 16c(1934)534.— *Chenolea diacantha* (Nees)FvM., Fragm. 10(1876)91.— [*Bassia uniflora* (non (R.Br.)FvM.) Anders., Proc.Linn.Soc.N.S.Wales 48(1923)329 p.p.; Black, Fl.S.Austral. (1924)190 p.p.; Ewart, Fl.Vict. (1930)456; Gardner, En.Pl.Austral. Occid. (1930)38 p.p.; Black, Fl.S.Austral. 2nd ed. (1948)303 p.p.; Blackall, W.Austral. Wildfl. 1(1954)153 p.p.]— Fig. 2 A-D.

I have not seen the type specimen of *Anisacantha kentropsidea* FvM. for which special search has kindly been made in K and MEL. The application of this name remains therefore somewhat doubtful. F.v.Mueller placed it as synonym of *A. diacantha* in his Fragm. 7(1869)14.

Low shrub, pubescent, branching. Branches terete, tomentose. Leaves linear, 5-22 mm. long, ½ to 1½ mm. wide (usually about 1 mm. wide), acute, pubescent, usually thin and spreading. Flowers solitary. Stamens 5; filaments membranous, dilated to base. Fruiting perianth about 2 mm. long and 2½ mm. broad, tomentose; anterior face convex with several longitudinal and one horizontal rib; posterior face convex. Spines 2, 1½-2 mm. long (sometimes longer), nearly equal, divergent, tomentose in lower part, otherwise glabrous. Tubercle obtuse, small, decurrent, higher than limb. Limb short, bent downwards. Base ± ovate, deeply hollowed; margin glabrous. Style linear, hirsute; stigmatic branches 2, red. Seed horizontal to slightly oblique; radicle superior.

Western Australia. L. Preiss 2379: MEL (isotype of *Anisacantha diacantha* Nees; the holotype could not be traced at HBG): Quangen Plains (Victoria): III.1840.— Anonym.: PERTH: Trans.Railway Survey. 1901.— R.H.: PERTH: Coolgardie. V.1899.— E. T. Bailey 13: PERTH: Muntadgin. X.1945.— 357: CANB, PERTH: Wadderin Rocks. IX.1947.— W. D. Campbell: P: Boulder. 28.VII.1900 (Perianths undeveloped but most likely this species).— W. V. Fitzgerald: AD 95938007: Nannine. IX.1903.— C. A. Gardner 1723: PERTH: Bendering. 17.VI.1922.— 6542: PERTH: Cunderdin. 23.X.1943.— id.: PERTH: Nalyerting. VII.1940.— R. Helms NSW, MEL: Victoria Desert, Camp 53. 16.IX.1891.— E. H. Ising: AD 95938002: Wyalkatchem. 1.IX.1926.— M. Koch 1372: MEL, PERTH: Cowcowing. IX.1904.— 2873: NSW: Merredin. 19.X.1923.— J. H. Maiden: NSW 45564: Cue. X.1909.—E. Merrall. MEL, Golden Valley. 1888.—A. Morrison: PERTH: Wongan Hills. 7.X.1903.— L. C. Webster: NSW 45565: Coolgardie. 1900.

South Australia (selection only). Anonym. (Herb. J. M. Black): AD: Marree: 11.X.1917; Pinnaroo. 12.X.1918; Woolshed Flat. 2.X.1916; Berri. X.1924; Tarcoola. 1920; Dublin. 12.IX.1932.— W. H. Andrew: AD 95708122: Mt. Bayley near Beltana.

10.VIII.1920.— H. G. Andrewartha 6498: ADW: 38.4 ex. Curnamona. 24.III.1937.— D. Bates: AD: Ooldea. II.1921 and 25.VIII.1921.— E. C. Black: AD 95708133: Renmark. I.1907.— J. M. Black: AD, NSW 45558. Melrose. 15.X.1915.— id.: AD, NSW 45556: Murat Bay. 13.XI.1915 and 17.XI.1915.— id.: AD 95708133. Pt. Noarlunga. 15.I.1905.— id.: AD 95708123: Wudinna. 10.XI.1915.— id.: NSW 45552: Tarcoola.— id.: AD 95708138: Wirrawilla, ca. 34 km. south-south-east of Marree. 15.X.1917.— N. T. Burbidge: CANB 12219: Yudnapinna. 11.IX.1946. G. H. Clarke: ADW 3206: Kingston Park. 12.IX.1936.— J. B. Cleland: AD 95820149. Ernabella, Musgrave Range. 25.IX.1945.— id.: AD 95820003: Halletts Cove. 24.IX.1932.— id.: AD 95820037: Pinery, Port River. 27.XI.1928.— id.: AD 95820013: Mantung. 18.VIII.1924.— id.: AD 95819070: Parachilna. 20.VIII.1921.— id.: AD 95820035: Ooldea Soak. 20.VIII.1939.— id.: AD 95820093: Between Poochera and Ceduna. 5.X.1954.— id.: AD 95820008: Near sea-edge, Bluff, Encounter Bay. 8.I.1932.— id.: AD 95820009: Goyders Lagoon. 23.VIII.1931.— id.: AD 95820010: Oodnadatta. I.1927.— id.: AD 95820079: Coondambo. 29.X.1929.— id.: AD 95819073: Pt. Germein. 3.XI.1936.— J. Cover: BRI 014279: Frome River, Mulpooriua. I.1956.— R. L. Crocker: ADW 4681B and 4686: Yudnapinna Stn. 12.X.1939 and 16.X.1939.— id.: AD 95939009: ca. Diamantina River, Burt's Waterhole. 15.VII.1939.— id.: AD 95939008: Simpson Desert Expedition, Camp 19. 27.VI.1939 (a. only).— id.: AD 95939008: ibid. Camp 48. 4.VIII.1939 (b. only).— Hj. Eichler 13744: AD: Monash. 19.IV.1957.— 15615: AD: Marino. 4.I.1959.— W. Fahlbohm: MEL: Apex of Spencers Gulf. 1889.— E. Giles: MEL: North of Fowlers Bay.— F. M. Hilton 673, 677: ADW: Yudnapinna Stn. 1102. 9.VII.1954.— 1438: ADW: Copley Gorge. 10.IV.1955.— id.: ADW 19092: Near Salt Lake, Nullarbor Plain. 24.VIII.1955.— E. H. Ising: AD 95907123: Evelyn Downs Stn., ca. 120 km. south-west of Oodnadatta. 26.VIII.1954.— id.: AD, ADW 11540, 11563, NSW 45545: Other collections from Evelyn Downs. 1952-1955.—1603: AD: Ooldea. 13.IX.1920.— 1718, 1737 and 1757: AD, MEL, NSW, BRI: Tarcoola. 21.IX.1920.— id.: AD 95907090: Mt. Mary, near Morgan. 3.X.1922.— id.: AD 95907088: Halletts Cove. 21.IV.1924.— id.: AD 95907098: Ucolta. 23.IV.1932.— id.: AD 95907095: Taroonda. 9.I.1937.— id.: AD 95907091: Mt. Maria, Wilmington. 21.X.1928.— id.: AD 95907079: Farina. 6.VIII.1954.— 2872: AD: Pedirka. 21.VIII.1932.— id.: AD 95907077: Wudinna, E.P. 19.X.1938.— id.: AD 95907092: Pt. Germein. 3.XI.1936.— L. A. S. Johnson: NSW 42374: Marino. 25.IX.1957.— M. Koch 292: MEL: Mt. Lyndhurst. IX.1899.— F. Mueller. NSW 45557, MEL: Holdfast Bay. 1847 and V.1851.— B. J. Murray 102: AD: Arcoona, ca. 65 km. west of centre of Lake Torrens. 10.IX.1927.— T. R. Paltridge: AD 95939013: Koonamore Vegetation Reserve. 21.IX.1930.— L. Reese: AD 95708125: Minnie Downs, ca. 165 km. south-south-east of Birdsville, Qsld. 1927.— A. E. V. Richardson: ADW 981: Buckleboo, E.P. III.1931.— id.: ADW 980: Murray Mallee. IV.1931.— K. D. Rohrlach 120: AD. Pinkawillinie. 15.II.1959.— R. Schodde 1078: AD: Sandleton, 30 km. south-west of Blanchetown. 30.III.1959. 1118, 1120 and 1123: AD: Olary Spur, Koonamore Vegetation Reserve. 27 and 28.V.1959.— J. G. O. Tepper 338 and 350: MEL: Yorke Peninsula. 1879.— D. J. E. Whibley 465: AD: 22 km. east of Parachilna. 29.III.1959.— P. G. Wilson 144: AD: Whyalla-Kimba Road, E.P. 2.X.1958.— 416: AD: 16 km. south of Kyancutta, E.P., ca. 150 km. north of Pt. Lincoln. 13.X.1958.— 485: AD: Minnipa, E.P. 15.X.1958.— 1068: AD: Pt. Willunga. 13.I.1959.— E. Wollaston: AD 95938005: Koonamore Stn., ca. 60 km. north of Yunta. 30.V.1954.

Northern Territory. G. Chippendale 2798, 3937, 3980: AD, BRI, CANB, NSW, NT: ca. 17 km. east of New Crown Stn. 3.IX.1956.— J. B. Cleland: NSW 45541: Brookes Soak, C.A. 15.VIII.1931.— id.: AD 95820004: Hamilton Bore, ca. 90 km. north-west of Alice Springs. 7.I.1927.— R. A. Dale: NSW 45540: Standley Chasm, 64 km. west of Alice Springs. 7.VII.1939.— W. J. Henderson: MEL: Powells Creek. 1895.— E. H. Ising: AD 95907107. Rodinga. 5.IX.1933. 2702: AD: Horseshoe Bend. 24.VIII.1931.— L. Johnson and G. Chippendale 3920: AD, NSW: ca. 28 km. south of Horseshoe Bend. 11.X.1957.— H. Kempe: MEL: Finke River. 1889. M. Lazarides 5979: BRI, CANB, NT: no locality. 12.IX.1956.— 6067: BRI, NT: ca. 5 km. north of Bond Springs Stn. 24.IX.1956.— R. A. Perry 5455: CANB: ca. 11 km. south-east of Ringwood Stn., Simpson Desert. 9.IX.1955.— 3236: CANB, NT: ca. 8 km. east of Alice Springs. 5.III.1953.— D. E. Symon 70: ADW: ca. 19 km. north of Alice Springs. 8.VI.1953.— R. Tate: AD 95911088: Ilpilla Gorge, affluent of Finke River.— R. E. Winkworth 130: BRI, NT: ca. 27 km. north of Kulgera Stn. 10.III.1954.— 149: BRI, NT: ca. 32 km. south of Henbury Head Station. 10.III.1954.— 1179: NT: New Crown Stn. 7.VII.1955.

Queensland. W. Barton: MEL: Armadilla. 1867.— S. T. Blake 5607: BRI: Cunnamulla. 29.IV.1934.— 5689: BRI, NSW: Morven. 1.V.1934.— 6501: NSW: Woodstock. 29.VI.1934.— E. Bowman 262: MEL: Capes River.— H. Clarke: NSW 45537: Mulligan River. II.1904.— R. L. Crocker: AD 95708046: Simpson Desert, ca. 31 km. north-east of Birdsville. 5.VII.1939.— S. L. Everist 734: BRI: Noondoo Stn. 14.XII.1934.— 1608: BRI: Blackall. 13.II.1938. 2816: BRI, CANB: Boatman Stn. 21.III.1947.— 3125: BRI

CANB: Talala. 21.IV.1948.— 3180: BRI, CANB: ca. 21 km. south-east of Bollon 17.VII.1948.— A. A. Holland and G. Gnauck 100: CANB 31874. St. George-Bollon Rd. IV.1953.— C. E. Hubbard and C. W. Winders 6021. BRI: Mungallala. 31.XII.1930.— L. S. Smith 598: BRI: Kindon Stn., Darling Downs. 7.XII.1938.— J. Wedd 821. BRI: St. George. V.1896.— Dr. Wheeler: MEL: towards Stokes Range and Coopers Creek.— C. T. White: BRI 014277: Wyaga, Goondiwindi district. IX.1919.

New South Wales. N. C. Beadle: SYD: Condobolin. 30.I.1946.— Annie Bell: MEL: Booligal, Lachlan River. IX.1887.— E. Betche: NSW 45508: Plains near Bourke. 17.VI.1909.— id.: NSW 45499: Paroo River. IX.1900. id.: NSW, MEL: Warrego River. IX.1885.— A. D. Black: AD 95938003: Broken Hill. X.1917.— E. Breakwell: NSW 45515: Nyngan. V.1912.— N. T. Burbidge 2905. CANB: Deniliquin. 9.I.1950.— E. F. Constable: NSW 4068: Bourke. 16.IX.1947. E. G. Cuthbertson 28: CANB 26895: Urisino Stn., ca. 40 km. west of Wanaaring. 20.V.1952.— H. Deane: NSW 45502: Broken Hill and Tarrawingee. VIII.1893.— F. E. Haviland: NSW 45518: Cobar. IV.1911.— D. J. W. Henderson: NSW 45511: Gundabooka. 2.I.1918.— Mrs. Holding: MEL: Darling River. X.1887.— L. A. S. Johnson: NSW 43765: Taleeban, east of Rankins Springs. 7.V.1955.— 547/152: NSW: Wanaaring. 1.VI.1947.— L. A. S. Johnson and E. F. Constable 997: NSW. Winnathee Stn., 98 km. west of Milparinka. 4.VI.1955.— A. S. Little: NSW 45507: Walgett. X.1899.— J. H. Maiden and J. L. Boorman: NSW 45512: Girilambone. VIII.1910. C. W. E. Moore 1433: CANB: ca. 22 km. from Jerilderie on Darlington Port Road. 21.X.1950.— 349: CANB: "Myall Mundi", Trangie. 26.III.1946.— 1445: CANB 50721: Near Wanganella. 25.X.1950.— A. Morris: NSW 45504: Broken Hill 715: ADW, NSW, BRI: Mt. Sturt Stn. near Milparinka. 27.IX.1921.— 2294: ADW, BRI: Stephens Creek, Broken Hill. 12.VIII.1928.— 1055: ADW: Thorndale. 12.I.1924.— A. Cunningham: P: Lachlan River. (Perianths undeveloped but probably this species.)— F. v. Mueller: MEL: Lachlan River. 1878.— id.: MEL: Murrumbidgee River. IX.1878.— C. T. Musson 129: MEL. Namoi River. 1890.— L. B. Peacocke: NSW 45516: Miandetta (Nyngan to Cobar). 1.X.1952.— J. Pidgeon and J. Vickery: NSW 45503: 96 km. east of Broken Hill. 20.VIII.1939.— id.: NSW 50265: Broken Hill. 21.VIII.1939 (form with glabrous style).— J. H. Riches 41: CANB: Tchelery, Moulamein. 28.X.1949.— 72 p.p.: CANB ('b and c'): 64 km. east-north-east of Broken Hill. 13.XI.1949.— R. Roe R422: CANB: Byrrock. 14.XI.1941.— J. W. Vickery: SYD: Collarendri-Walgett 21.XII.1934.— O. B. Williams 65: CANB: Wanganella. 18.VIII.1949.

Victoria. H. B. Browne 15: CANB: ca. 80 km. from Swan Hill. 20.VIII.1946.— J. Dallachy: MEL, AD: 179 Sand hills, Pine Plains. Wimmera. 2.X.1861.— J. Malone: NSW 45530: Underbool. X.1915.— F. Mueller: MEL: Avoca. 1853.— F. M. Reader: MEL: Shire of Dimboola. 17.XI.1892 and 2.IX.1900.— id.: MEL, NSW 45533: Wimmera. 1892.— E. J. Rowlands 8: MEL: Bannerton via Robinvale. 31.VIII.1958. C. Walter: NSW 45532: Lake Hindmarsh. X.1899.— W. W. Watts 463: NSW. Nandaly. IX.1917.— 835: NSW: Dumosa Road ca. 12 km. from Wycheproof. XI.1917.— H. B. Williamson: AD: Lake Albacutya.

This species is perhaps the most widely distributed of the genus *Bassia* in Australia.

It may appear that the narrow-linear leaf forms (less than 1 mm. in width), which, remarkably enough, are mostly confined to Queensland and New South Wales, should be separated specifically. This, however, is not advisable as other distinguishing characters have not been observed. Generally the leaves in the dried state are linear, i.e., with parallel margins, without any actual widening towards the summit which is usual in the clavate leaf of *B. uniflora*.

The hair clothing of the leaves is ± pubescent and very rarely approaching the density of the tomentose indumentum of *B. uniflora*.

The character of the style has rarely been used for diagnostic purposes. It has been found to be a good one. In both *B. uniflora* and *B. diacantha* the style is ± hirsute and often the lower part of the stigmatic branches are the same.

Sometimes the tubercle has a slight bend forward.

Other characters such as the limb, base and filaments generally constant.

One of the specimens cited with the original description of *Sclerolaena diacantha* var. *longispina ?* by Bentham (Fl.Austral. 5(1870)195: "Wimmera, Dallachy") is *Bassia diacantha* (Nees)FvM. I have not seen the other specimens quoted by Bentham, but part of one of them is referred by Anderson

(Proc.Linn.Soc.N.S.Wales 48(1923)337) to *B. obliquicuspis* Anders. and another part to *B. patenticuspis* Anders.

3. **B. eriacantha** (FvM.)Anders., Proc.Linn.Soc.N.S.Wales 48(1923)328; Black, Fl.S.Austral. (1924)190; Gardner, En.Pl.Austral.Occid. (1930)38 ('ericantha'); Black, Fl.S.Austral. 2nd ed. (1948)303; Blackall, W.Austral.Wildfl. (1954)152.— *Kentropsis eriacantha* FvM., Fragm. 2(1861)140.— *Sclerolaena eriacantha* (FvM.)Ulbrich in Engler and Prantl, Nat.Pfl.fam. 2nd ed. 16c(1934)534.— [*Anisacantha lanicuspis* (non FvM.)FvM., Fragm. 7(1869)14 p.p.] [*Sclerolaena lanicuspis* (non (FvM.)FvM. ex Benth.) Benth., Fl.Austral. 5(1870)195 p.p.; Maid. and Betche, Census N.S.Wales Pl. (1916)69 p.p.]

Additional details to description: Flowers solitary. Stamens 5, filaments membranous dilated downwards. Style, connate part ± hirsute, stigmatic branches 2, red. The long, dense, silky covering of the perianth, particularly the hairs on the margin of the areole are a marked feature of this species. The limb is ± erect.

New South Wales. H. Beckler: MEL (part of holotype): Darling River (desert), N.S.Wales, Victorian Expedition 1860.— N. C. Beadle: SYD: 16 km. east of Broken Hill. V.1941.

Northern Territory. M. Lazarides 5749A: AD: ca. 14 km. south of Deep Well. 19.VIII.1956.— E. H. Ising: AD 96008017: Macdonald Downs Station. ca. 240 km. N.E. of Alice Springs. 1.IX.1933.

South Australia. J. B. Cleland: AD 95820038: Abminga. 8.VIII.1931. E. H. Ising 1806: AD: Kingoonya. 23.IX.1920.— 2664: AD: Oodnadatta. 8.IX.1931.— 2902: AD: Pedirka. 1.IX.1932.— 1752: AD: Tarcoola. 21.IX.1920.— R. H. Pulleine: AD 95820112: Nonning. V.1931.

4. **Bassia gardneri** Ising, sp.nov. Fig. 4 A-D.

Fruticulus, indumento fulvus. Rami ± costati, tomentosi. Folia linearia, 7-20 mm. longa, 1-2 mm. lata, acuta, tenuia, pubescentia. Flores solitarei. Stamina 5; filamenta membranacea, deorsum dilatata. Perianthium fructiferum ca. 2½ mm. longum et latum, dense tomentosum; facies anterior convexa, aliquot costis longitudinalibus et uno costa horizontali bases spinis connectu; facies posterior convexa, 3 costis longitudinalibus. Spinae 2, 5-6 mm. longae, fere aequales, divergentes, magnam partem plerumque dense tomentosae. Tuberculum obtusum, apice uncinato; costa decurrens, crassa. Limbus brevis, inclinatus, ciliatus. Basis elliptica vel prope circularis, obliqua, profunde excavata; septa radiata; margo dense ciliatus. Stylus linearis hirsutus; rami stigmatici 2, sub-rubri, multo exserti. Semen horizontale vel leviter obliquum; radicula supera.

Undershrub, indumentum brownish. Branches ± ribbed, tomentose. Leaves linear, 7-20 mm. long, 1-2 mm. wide, acute, thin, pubescent. Flowers solitary. Stamens 5, filaments membranous, dilated downwards. Fruiting perianth ca. 2½ mm. long and broad, densely tomentose; anterior face convex with several longitudinal and one horizontal rib connecting the bases of the spines; posterior face convex with ca. 3 longitudinal ribs. Spines 2, 5-6 mm. long, nearly equal, divergent, usually densely tomentose for most of length. Tubercle obtuse, hooked at summit; rib decurrent, thick. Limb short, bent downwards, ciliate. Base elliptic to almost circular, oblique, deeply hollowed; septa radiating; margin densely ciliate. Style linear, hirsute; stigmatic branches 2, pink, much exserted. Seed horizontal to slightly oblique; radicle superior.

Western Australia. C. A. Gardner 6184: PERTH (holotype); AD 96010004 (isotype): Wandagee, Minilya River. 8.X.1941.— W. V. Fitzgerald: NSW 45563: Nannine. IX.1903.— C. A. Gardner 6047: PERTH: 96 km. east of Carnarvon. 20.IX.1941.— 6193a: PERTH: Wandagee. 8.X.1941. A. W. Humphries: PERTH: Wooleen, Killer Paddock. 23.IX.1950.— J. H. Maiden: NSW 45562: Laverton. IX.1909.

B. gardneri is recognized chiefly by its hooked tubercle, densely ciliate margin of the areole at the base of the fruit and long ribbed branches. It is only known from semi-arid localities in Western Australia.

5. **Bassia tatei** FvM., Vict.Nat. 7(1890)66; FvM., Icon.Austral.Salsol.Pl. (1891) t.71; Tate. Trans.Roy.Soc.S.Austral. 19(1895)80; Koch, Trans.Roy.Soc.S. Austral. 22(1898)106; Anders., Proc.Linn.Soc.N.S.Wales 48(1923)331; Black, Fl.S.Austral. (1924)193; 2nd ed. (1948)303.— *Austrobassia tatei* (FvM.)Ulbrich in Engler and Prantl, Nat.Pfl.fam. 2nd ed. 16c(1934)532.

Additional details to description: Style linear, hirsute; stigmatic branches 2, thick at base, tapering upwards.

South Australia. R. Tate: AD 96034019 (isotype): Lake Torrens. 11.VI.1883.— H. W. Andrew: AD 95941046: Farina. 15.VII.1920.— id.: AD 95941041: Murnpeowie. 26.VII.1920.— H. G. Andrewartha 8300: ADW: Purple Downs Stn. V.1938.— J. B. Cleland: AD 95820105, 95941047: Marree. 13.VIII.1934.— R. L. Crocker: AD 95941042: Towards Lake Eyre, Camp 34, Simpson Desert Expedition. 21.VII.1939.— Hj. Eichler 12989: AD: ca. 3 km. south of Leigh Creek. 26.IX.1956.— R. Hill 76: AD. Witchelina. 14.VII.1955.— F. M. Hilton: ADW 21309: Between Mt. Lyndhurst and Avondale. 10.IV.1955.— M. Koch: NSW 45496: Mt. Lyndhurst. VIII.1897 (det. R. Tate).— id. 192 p.p.: AD, BRI, MEL, NSW: ibid. VIII, IX and X.1898 and VIII.1899.— T. R. N. Lothian 114, 115, 118, 119, 120, 122, 127, 128, 131: AD: Near Leigh Creek. 26.IX.1959 and 1.X.1959.— M. Murray: AD 96034020: Cootanoorina. id.: AD 96034021: Nilpinna Flats.— D. E. Symon: ADW 11537: Farina. 20.VI.1953.— R. Tate: NSW 45497: no locality (possibly isotype, received from Adelaide University Herbarium on II.1903)

6. **Bassia parallelicuspis** Anders., Proc.Linn.Soc.N.S.Wales 48(1923)331, t.34 H-I.; Black, Fl.S.Austral. (1924)193; 2nd ed. (1948)303.— *Austrobassia parallelicuspis* (Anders.)Ulbrich in Engler and Prantl, Nat.Pfl.fam. 2nd ed. 16c(1934)532.

Additional details to description: Limb short, erect, pilose; style usually glabrous; stigmatic branches 2; several longitudinal weak ribs on anterior face of perianth; radicle superior.

South Australia. M. Koch 292 p.p.: NSW 45492 (lectotype): Mt. Lyndhurst. XII.1897.— J. B. Cleland: AD 95820007, NSW 50268: Pedirka. 6.VIII.1932.— id.: AD 95820078: Mt. Chambers Gorge. Flinders Range. 30.V.1937.— id.: AD 95820076: Illbunga. 8.VIII.1931.— R. L. Crocker 2: AD: Abminga Creek. 3.VI.1939.— E. H. Ising 2678, 2873, 2910: AD: Pedirka. 22.VIII.1931, 21.VIII.1932, 1.IX.1932.— M. Koch 292 p.p.: NSW 45491 (syntype): Mt. Lyndhurst. IX.1899 (quoted by Anderson l.c. as VIII.1899).— 292 p.p.: PERTH: ibid. X.1898.— 292 p.p.: AD: ibid. X.1899.— B. J. Murray 191 p.p: AD: Arcoona. 16.IX.1927.

New South Wales. N. C. Beadle: SYD: Yalpunga. X.1939.

Northern Territory. S. A. White: AD 95951002: Finke River between Crown Point and Horseshoe Bend. Aug. 1913.— R. L. Crocker: AD 95052018: Charlotte Waters (Simpson Desert Exped.). 27.V.1939.

7. **Bassia constricta** Ising, sp.nov.— *B. uniflora* var. *incongruens* Black, Trans.Roy.Soc.S.Austral. 48(1924)254 p.p. (specimen from Hergott).— Fig. 7 A-D.

Fruticulus; rami tenuiter costati, sparse tomentosi. Folia linearia, 3-10 mm. longa, ± 1 mm. lata, acuta, tenuia, pubescentia. Flores solitarei. Stamina 5; filamenta membranacea, deorsum dilatata. Perianthium fructiferum medialiter constrictum, 1½-2½ mm. longum, 1⅓-1⅔ mm. latum, apice unilateraliter producto; muri tenui, stramineai, sparse tomentosi; facies anterior concava, aliquot costis longitudinalibus costa horizontali singulari prominenti; facies posterior concava. Spinae plerumque 2, interdum inchoatae, ½-4 mm. longae, divergentes, inaequalis, aciculares vel obtusae, fere vel omnino glabrae. Tuberculum obtusum, in costae tenui decurrenti. Limbus brevis, inclinatus, ciliatus. Basis oblonga valde obliqua saepe sursum in flabello producto, ± tumida, profunde excavata; septa radiata, inconspicuora; margo glaber, planus. Stylus linearis, fere vel omnino glaber; rami stigmatici 2, sub-rubri. Semen verticale; radicula supera.

Undershrub; branches finely ribbed, sparsely tomentose. Leaves linear, 3-10 mm. long, ± 1 mm. wide, acute, thin, pubescent. Flowers solitary. Stamens 5; filaments membranous, dilated downwards. Fruiting perianth ± constricted in middle, 1½-2½ mm. long, 1½-1¾ mm. broad, unilaterally produced at the summit, walls thin, straw coloured, sparsely tomentose; anterior face concave with several longitudinal and one prominent horizontal rib; posterior face concave. Spines usually 2, sometimes both or one only rudimentary, ½-4 mm. long, unequal, acicular or obtuse; divergent, glabrous or almost so. Tubercle obtuse, decurrent in a thin rib. Limb short, bent downwards, ciliate. Base oblong, very oblique, often extended upwards in a lip; ± swollen, deeply hollowed; septa radiating, inconspicuous; margin glabrous, flat. Style linear, glabrous or almost so; stigmatic branches 2, pink. Seed vertical; radicle superior.

South Australia. E. H. Ising 4000: AD 95909007 (holotype), L, NSW, US, Z: Oodnadatta. 29.VIII.1955.– J. M. Black s.n.: AD 95946028 (lectotype of *B. uniflora* var. *incongruens* Black), NSW 43546: Hergott (Marree). 14.X.1917.– H. W. Andrew: AD 95708135: Murnpeowie, ca. 100 km. north-east of Leigh Creek (Telford). 19.VII.1920.– J. M. Black: AD 95946029: Hergott (Marree). 11.X.1917.– id.: AD 95946027: Mundowdna. 15.X.1917.– N. T. Burbidge: CANB 13148: Parachilna Gorge. 1.IX.1946.– J. B. Cleland: AD 95817068: Mt. Lyndhurst Station, 45 km. north-east of Leigh Creek. 19.V.1924.– id.: AD 95820142: Beresford. 25.VIII.1932.– id.: AD 95820131: 8 km. N. of Marree. 5.VIII.1929.– F. M. Hilton 1243: ADW: Mern Merna, ca. 35 km. south of Hawker. 8.IV.1955.– 1326: ADW: Mt. Lyndhurst, west side. 9.IV.1955.– 1396: ADW: Near Lake Frome, alluvial plains. 10.IV.1955.– 1410: ADW: Between Lyndhurst and Avondale. 10.IV.1955.– E. H. Ising 3993: AD: Algebuckina, ca. 60 km. south of Oodnadatta. 3.XI.1953.–id.: AD 95909088: Evelyn Downs, ca. 120 km. south-west of Oodnadatta. VIII.1953. (Further collections of E. H. Ising from Evelyn Downs in AD.)– id.: AD 95909089: Farina, ca. 55 km. north of Leigh Creek. 18.VIII.1933.– 2655: AD: Marree, ca. 340 km. north of Port Augusta. 21.VIII.1931 (and s.n. of 18.VIII.1933, 15.VII.1955 and 31.X.1955).– 2668 and 3752: AD: Oodnadatta, ca. 350 km. north-west of Marree. 7.IX.1931 and 26.IX.1953.– id.: AD: Oodnadatta. 16.VII.1955 and 30.VIII.1955.– id.: ADW 11657: Oodnadatta. 25.IX.1953.– F. S. Jones: AD 95909067: Oodnadatta. 5.VIII.1934.– E. C. Millard: AD 95909090: Warburton River = Diamantina River in north-east corner of South Australia.– T. G. B. Osborn: NSW 45547: Mt. Lyndhurst. XII.1912.– D. E. Symon: ADW 10599: Oodnadatta. 18.VI.1953. (This specimen was seen by L. A. S. Johnson and determined by him as a new species (affinity *B. patenticuspis*) on 11.I.1955.) F. D. Warren: AD 95909091: Finniss Springs, ca. 65 km. west of Marree. 5.IX.1926.

New South Wales. Anonym: MEL: Upper Darling R. 1890.– J. H. Riches 72 p.p.: CANB 21579 (a): 64 km. E.N.E. of Broken Hill. 13.XI.1949.

The fruiting perianth is longer than broad, usually constricted in the middle, produced at one side at summit and base ± elongated upwards; these characters, with the vertical seed, are good distinguishing features.

8. **B. caput-casuarii** Willis, Vict.Nat. 73(1957)153.—Fig. 8 A-D.

This species is remarkable for its large tubercle; this and the whole perianth is likened by its author to a cassowary's head and is a good distinguishing character. The hollow tubercle in many, if not all, the species of *Bassia*, acts as a receptacle and protection for the radicle, and this is the case with this species. The seed is vertical or almost so.

Victoria. E. Ramsay: AD 95715012 (isotype): Meridian Road, ca. 5-6 miles (8-7 km.) south of Benetook, north-west Victoria. 1.VII.1950. (Holotype in MEL, not seen.)

9. **Bassia eichleri** Ising, sp.nov.—Fig. 9 A-D.

Fruticulus parvus, 10-20 cm. altus, ramis et ramulis numerosis, ascendentibus, tomentosis. Folia linearia vel anguste lanceolata, 7-14 mm. longa, ad basem ca. 1½ mm. lata, sursum acuminata, sessilia, ± imbricata, acuta, tenuia, ± villosa. Flores solitarei. Stamina 5, filamentis membranaceis, deorsum dilatatis. Perianthium fructiferum prope globosum, ca. 2 mm. longum et latum; muri crassi, tomentosi; facies anterior convexa, pluribus costis longitudinalibus; facies posterior convexa. Spinae 2, ½-2½ mm. longae, interdum inchoatae, divergentes, aciculares, prope glabrae. Tuberculum parvulum, haud decurrens. Limbus brevis, inclinatus, ciliatus. Basis elliptica, obliqua, profunde excavata; septa radiata, inconspicua; margo glaber; stipes crassus, saepe excentricus. Stylus linearis, fere vel omnino glaber; ramis stigmaticis 2, subrubris. Semen horizontale vel leviter obliquum; radicula leviter ascendens.

Undershrub, small, 10-20 cm. high, many ascending tomentose branches and branchlets. Leaves linear-lanceolate 7-14 mm. long, ca. 1½ mm. wide in lower part, tapering to apex in upper part, sessile, ± imbricate, acute, thin, ± villous. Flowers solitary. Stamens 5, filaments membranous, dilated downwards. Fruiting perianth almost globular, ca. 2 mm. long and broad; walls thick, tomentose; anterior face convex with several longitudinal ribs; posterior face convex. Spines 2, ½-2½ mm. long, often rudimentary, divergent, acicular, almost glabrous. Tubercle very small, not decurrent. Limb short, bent downwards, ciliate. Base elliptic, oblique, deeply hollowed; septa radiating, inconspicuous; margin glabrous; stripes thick, often excentric occupying ca. half of cavity. Style linear, glabrous or nearly so; stigmatic branches 2, pink. Seed horizontal to slightly oblique; radicle slightly ascending.

SOUTH AUSTRALIA. E. H. Ising 4001: AD 95907073 (holotype): BM, IA, K, L, MEL, NSW, US: Evelyn Downs, ca. 120 km. south-west of Oodnadatta. 28.X.1955.— 3997: AD: ibid. 16.IX.1955.— id.: AD 95907074: ibid. 8.X.1955.

The lanceolate leaves, small globular almost spineless fruiting perianths with their thick walls and thick stipes clearly divide this species from others in this series.

10. Bassia burbidgeae Ising, sp.nov.—Fig. 10 A-D.

Rami graciles, tomentosi. Folia linearia, 5-10 mm. longa, ca. 1 mm. lata, ± acuta, tenuia, pubescentia, patentia. Flores solitarei. Stamina 5, filamentis membranaceis, deorsum dilatatis. Perianthium fructiferum pyriforme, 1½-2½ mm. longum, 1½-2 mm. latum, glabrum, fusco-rubrum; facies anterior convexa, aliquot costis longitudinalibus et una costa horizontali bases spinis connecta; facies posterior convexa, pluribus costis longitudinalibus. Spinae 2, ½-2 mm. longae, interdum uno inchoato, divergentes, glabrae, crassae. Tuberculum obtusum, latum, saepe amplius quam dimidium tubo longius, interdum apice leviter inclinato vel uncinato, in costa tenui decurrenti. Limbus brevis, inclinatus, ad apicem tuberculi ciliatus. Basis ± circularis, obliqua, profunde excavata; septa radiata; margo glabro. Stylus linearis, glaber; rami stigmatici 2, rubri. Semen horizontale vel leviter obliquum; radicula supera.

Branches slender, tomentose. Leaves linear, 5-10 mm. long, ca. 1 mm. wide, ± acute, thin, pubescent, spreading. Flowers solitary. Stamens 5, filaments membranous, dilated downwards. Fruiting perianth pear-shaped, 1½-2½ mm. long, 1½-2 mm. broad, glabrous, dark red; anterior face convex with several longitudinal and one horizontal rib connecting the bases of the spines; posterior face convex and with several longitudinal ribs. Spines 2, ½-2 mm. long, sometimes one rudimentary, divergent, glabrous, thick. Tubercle obtuse, sometimes more than half as long as tube, often slightly bent forward at summit, or hooked, decurrent in a thin rib. Limb short, bent downwards, ciliate to summit of tubercle. Base ± circular, oblique, deeply hollowed; septa radiating; margin glabrous. Style linear, glabrous; stigmatic branches 2, reddish. Seed horizontal to slightly oblique; radicle superior.

WESTERN AUSTRALIA. N. T. Burbidge 84: PERTH (holotype), AD 96010005 (isotype): Glenorn Station. VIII.1938.— 71: PERTH: ibid. IV.1938.

The fruiting perianths of this species are quite distinct in this group in being glabrous (although *B. tatei* becomes glabrous in age) and dark red in colour; the large broad tubercle is unusual which is sometimes nearly as long as the tube. It is confined to Western Australia, and only two collectings were received for examination.

11. **Bassia holtiana** Ising, Trans.Roy.Soc.S.Austral. 78(1955)111, Fig. I, 17-19.—[*B. uniflora* var. *incongruens* Black, Trans.Roy.Soc.S.Austral. 48(1924)254 p.p. (lectotype excluded; cf. *B. constricta* Ising).]

South Australia. E. H. Ising 3624: AD 95708045 (holotype): Evelyn Downs, 120 km. south-west of Oodnadatta. VIII.1953.— id.: s.n.: AD: Evelyn Downs (further collections from type locality). 18.X.1952, 11.VIII.1954, 20.X.1953 and 19.VIII.1954 (perianth reddish almost glabrous), 27.VIII.1955 (leaves densely villous, perianth glabrous), 16.VIII.1952 (perianth densely tomentose), and VIII.-X.1952-3.— Miss Staer s.n. (Herb. J. M. Black): AD 95942007: Arkaringa. VIII.1914. (This is one of the specimens which have been cited in the original description of *B. uniflora* (R.Br.)FvM. var *incongruens* Black, yet J. M. Black did not write the varietal name on its label.)

ACKNOWLEDGMENTS

My thanks are expressed to the following: the curators of the Herbaria AD, ADW, BRI, CANB, MEL, NSW, NT, P, PERTH and SYD for the loan of specimens; Mr. L. Dutkiewicz for preparing drawings; Dr. Hj. Eichler for help, advice and facilities given in the State Herbarium of South Australia; Mr. P. G. Wilson for the translation of the diagnoses into Latin.

CONTRIBUTIONS TO THE FLORA OF CENTRAL AUSTRALIA

BY G. M. CHIPPENDALE

Summary

New records of ***32*** species, deletion of four species, and notes on three species are given for Central Australia.

CONTRIBUTIONS TO THE FLORA OF CENTRAL AUSTRALIA

No. 2

by G. M. CHIPPENDALE

[Read 13 October 1960]

SUMMARY

New records of 32 species, deletion of four species, and notes on three species are given for Central Australia.

NOTE

The specimens mentioned in this paper, when not collected by the writer, have been either donated to the Northern Territory Herbarium at Alice Springs, or have been notified by personal communication.

In quoting specimens collected by members of C.S.I.R.O., M. Lazarides and R. A. Perry, I have used the citation "Herb. Aust." with the collector's initials and number. This has been necessary, as these collectors have overlapping numbers, and to my knowledge, these numbers do not represent a number from the Canberra Herbarium.

OPHIOGLOSSACEAE

Ophioglossum coriaceum A. Cunn. This species has been repeatedly collected on Ayers Rock, but has not been published as a new record for Central Australia before.

GRAMINEAE

Aristida echinata Henr. 9·5 m. north-north-west of Alice Springs, M. Lazarides, 12/6/1958 (Herb. Aust. ML5183). 2 m. north-east of Hermannsburg, M. Lazarides, 16/5/1955 (Herb. Aust. ML5312).

A new record for Central Australia.

Avena fatua L. 37 m. south-east of Yuendemu, M. Lazarides, 16/7/1956 (Herb. Aust. ML6010). An escape plant, probably from hay, and hardly to be considered as a naturalised plant as yet. It is, however, a new record for Central Australia.

Digitaria eriolepis Henr. Hatches Creek township, M. Lazarides, 9/5/1957 (Herb. Aust. ML6264).

A new record for Central Australia.

Eriachne isingiana J. M. Black. 2 m. south-south-east Aileron, M. Lazarides, 22/8/1956 (Herb. Aust. ML5790).

A new record for Central Australia.

Eriachne mucronata R. Br. var. *desertorum* C. A. Gardner. 32 m. north-east of MacDonald Downs Homestead, M. Lazarides, 8/9/1956 (Herb. Aust. ML5924).

A new record for Central Australia.

Paspalidium clementii (Domin) C. E. Hubbard. Elkedra Station, M. Lazarides, 29/3/1956 (Herb. Aust. ML6210).

A new record for Central Australia.

Sorghum plumosum (R. Br.) Beauv. 14 m. north-west Ooratippra Homestead, M. Lazarides, 11/6/1958 (Herb. Aust. ML5272).

A new record for Central Australia.

MORACEAE

Ficus platypoda A. Cunn. var. *minor* Benth. Dr. E. J. H. Corner of University of Cambridge has redetermined a number of specimens previously placed under *F. platypoda* var. *platypoda*, so that the variety is a new record in Central Australia.

CHENOPODIACEAE

Atriplex pseudocampanulata Aellen. 13·1 m. east of Finke town, G. Chippendale and L. Johnson, 12/10/1957 (NT3933).

A new record for Central Australia.

Bassia diacantha (Nees) F. Muell. Following redeterminations by Mr. E. H. Ising of many specimens previously placed under *B. uniflora*, this makes a new record for Central Australia.

Bassia quinquecuspis (F. Muell.) F. Muell. var. *quinquecuspis*. 35 m. south of Napperby H.S., M. Lazarides, 28/9/1956 (Herb. Aust. ML6082). 36·2 m. east of New Crown H.S., G. Chippendale and L. Johnson, 12/10/1957 (NT3940). 26 m. east of Armstrong River, G. Chippendale, 25/6/1958 (NT4651).

A new record for Central Australia.

Bassia quinquecuspis (F. Muell.) F. Muell. var. *villosa* (Benth.) R. H. Anderson. 24 m. south of Barrow Creek Township, R. A. Perry, 3/9/1955 (Herb. Aust. RAP5353).

A new record for Central Australia.

AMARANTHACEAE

Following critical determinations of a large number of specimens by Dr. G. Benl, Munich, the following are new records for Central Australia:

Ptilotus alopecuroideus (Lindl.) F. Muell. var *longistachyus* (W. V. Fitzg.) Benl. 1 m. south of Glen Edith, G. Chippendale, 24/6/1959 (NT6257). 11 m. south of Plenty River, G. Chippendale, 14/8/1959 (NT6514).

Ptilotus astrolasius F. Muell. 14·2 m. south-east of Tanami, G. Chippendale, 3/5/1958 (NT4266).

Ptilotus atriplicifolius (A. Cunn. ex Moq.) var *elderi* (Farmar) Benl. Mt. Olga, G. Chippendale, 13/9/1956 (NT2889). 6 m. south of Police Station, Harts Range, G. Chippendale, 9/7/1957 (NT3482).

Ptilotus calostachyus (F. Muell.) F. Muell. var. *procerus* (Diels) Benl. The Granites, G. Chippendale, 2/5/1958 (NT4212).

Ptilotus fusiformis (R. Br.) Poir. var. *fusiformis*. 6·1 m. south-east of Tanami, G. Chippendale, 2/5/1958 (NT4258).

Ptilotus latifolius R. Br. var. *maior* (C. A. Gardn.) Benl. 22·1 m. east of New Crown H.S., G. Chippendale, 12/10/1957 (NT3936). Simpson Desert, 46 m. north of Andado H.S., G. Chippendale, 7/9/1959 (NT6602).

AIZOACEAE

Trianthema australis Melville. This is delated from records of Central Australian plants, as the original record was based on a specimen from Charlotte Waters, which has been redetermined as *T. galericulata* Melville.

Trianthema oxycalyptra F. Muell. 30·2 m. north-west of The Granites, G. Chippendale, 2/5/1958 (NT4229).

A new record for Central Australia.

LEGUMINOSAE

Daviesia chordophylla Meissn. This is deleted from records of Central Australian plants, following redetermination by Miss H. Aston, Melbourne Herbarium, of the specimen quoted by Chippendale (1960). This specimen is now placed as *Daviesia* sp. aff. *teretifolia* R. Br.

Swainsona burkei F. Muell. *subsp. burkei* A. Lee. This was omitted in error from the Check List of Central Australian Plants (1959). The subspecies occurs widely in Central Australia.

MIMOSACEAE

Acacia gonoclada F. Muell. ex Benth. 13 m. east-south-east of Tanami, M. Lazarides, 22/4/1957 (Herb. Aust. ML6253).

A new record for Central Australia.

CAESALPINIACEAE

Cassia chatelainiana Gaud. This is deleted from the records of Central Australian plants, as the record was based on a G. F. Hill specimen No. 393, which was redetermined by Mr. D. Symon as shown in the following species.

Cassia costata Bail. et White. 70 m. north of Survey Camp IV (about 20 m. north of Lander River), G. F. Hill, 28/6/1911 (G. F. Hill, 393).

A new record for Central Australia.

Cassia luerssenii Domin. 23 m. west of Pine Hill H.S., G. Chippendale, 11/8/1959 (NT6439).

A new record for Central Australia.

EUPHORBIACEAE

Phyllanthus ramosissimus (F. Muell.) Muell.-Arg. Tempe Downs, Thornton, undated. A specimen noted while examining specimens in Melbourne Herbarium.

A new record for Central Australia.

SAPINDACEAE

Dodonaea petiolaris F. Muell. 2 m. south-west of Lucy Creek Station, M. Lazarides, 5/9/1956 (Herb. Aust. ML5901). This specimen matches the fragmentary type and other specimens in Melbourne Herbarium.

A new record for Central Australia.

MALVACEAE

Abutilon macrum F. Muell. 12 m. north of Gosse's Bluff, G. Chippendale, 4/4/1958 (NT4159).

Originally recorded by Tate (1896), but herbarium specimens seen were without reliable labels. Now definitely recorded in Central Australia.

MYRTACEAE

Thryptomene parviflora (F. Muell.) Domin or vel. aff. Palm Valley, G. Chippendale, 25/8/1956 (NT2678).

A new record for Central Australia, but will need further examination when more records are made.

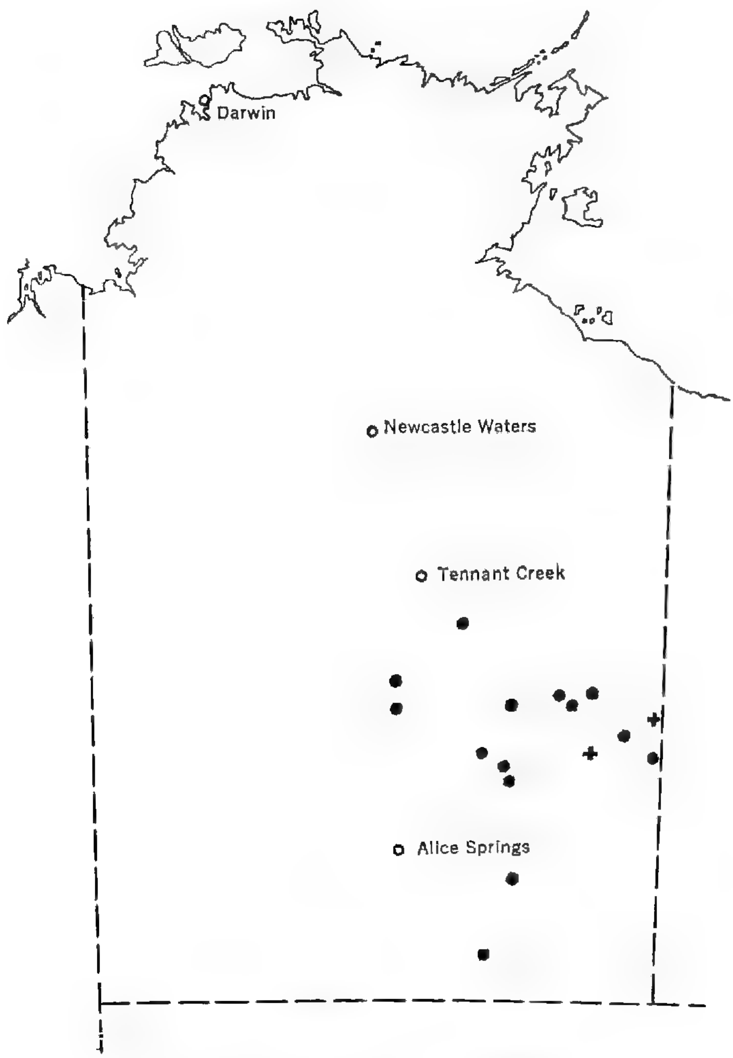
BORAGINACEAE

Heliotropium crispatum F. Muell. ex Benth. Can be deleted from Central Australian records, as was based on two specimens which have been redetermined as *H. bacciferum* Forsk., viz., Ellery Creek, G. Chippendale, 15/4/1956 (NT2037). 2 m. north-east of Limestone Bore, Napperby, G. Chippendale, 17/5/1956 (NT2073).

MYOPORACEAE

Eremophila alternifolia R. Br. 32 m. north-north-east of Angas Downs H.S., M. Lazarides, 20/6/1958 (Herb. Aust. ML6131).

A new record for Central Australia.



+ Recorded by Smith (1956).
● New records.

Eremophila dalyana F. Muell. 7 m. south-south-east of MacDonald Downs H.S., M. Lazarides, 8/9/1956 (Herb. Aust. ML5931). 9 m. west of deserted Huckitta H.S., G. Chippendale, 13/8/1959 (NT6488).

A new record for Central Australia.

Eremophila exotrachys Kraenzl. Previously rarely collected but now known to occur frequently in the sandridge areas west and south-west of Alice Springs. It is found mostly under trees between sandridges.

Eremophila obovata L. S. Smith var. *obovata*. Following the description of this species in 1956, it has been recorded in many localities in Central Australia as shown in Fig. 1.

RUBIACEAE

Anotis scleranthoides (F. Muell.) Domin. 35 m. south-west of Alice Springs, R. A. Perry, 10/9/1955 (Herb. Aust. RAP5475).

A new record for Central Australia.

COMPOSITAE

Angianthus tomentosus Wendl. 30 m. south-south-west of Napperby H.S., M. Lazarides, 28/9/1956 (Herb. Aust. ML6088).

A new record for Central Australia.

Helipterum sp. nov. aff. *albicans*. As recorded in the Check List (1959), this refers to the species described in last year's Transactions as *Helipterum saxatile* P. G. Wilson.

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ARCHAEOLOGICAL STONE IMPLEMENTS ALONG THE LOWER RIVER WAKEFIELD, SOUTH AUSTRALIA

BY H. M. COOPER

Summary

This paper records the occurrence of large stone implements, many primitive in type and manufacture, discovered upon a series of former native occupational sites adjoining the banks of the lower reaches of the River Wakefield. Their resemblance to material from Hallett Cove (Cooper, 1959) and also the similarity in position of the principal camps in both areas is discussed and it is suggested that at least some of the implements may represent the earliest stone culture associated with man in these parts of South Australia. A brief description relating to relevant physical and floral features at present prevailing in the district is given.

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by H. M. Cooper*

[Read 13 October 1960]

SUMMARY

This paper records the occurrence of large stone implements, many primitive in type and manufacture, discovered upon a series of former native occupational sites adjoining the banks of the lower reaches of the River Wakefield. Their resemblance to material from Hallett Cove (Cooper, 1959) and also the similarity in position of the principal camps in both areas is discussed and it is suggested that at least some of the implements may represent the earliest stone culture associated with man in these parts of South Australia.

A brief description relating to relevant physical and floral features at present prevailing in the district is given.

INTRODUCTION

The River Wakefield (native name Undalya) rises in elevated country north of Manoora. Its water flow is augmented by many small creeks and watercourses which drain considerable areas with yearly average rainfalls of up to 26 inches, during its course through hilly country for a distance of about 25 miles. Thence it emerges on to the open plains through a gorge with almost perpendicular cliffs in the Dalkey Hills (*vide* accompanying plan) which exhibits in this place a fine example of rock scenery. It resembles a typical "gum creek" of the Far North upon entering the plains, its meandering course being lined for a few miles downstream with fine examples of *Eucalyptus camaldulensis* (Red Gum). The stream thereafter wanders across almost flat country by way of a multiplicity of bends, some so sharp as to almost encroach upon each other until it finally enters Gulf St. Vincent in the vicinity of Port Wakefield. The total length of its lower course from the Dalkey Hills' gorge to the sea, owing to the extraordinary manner in which it meanders across the plains, must be nearly 40 miles if one includes all the minor curves and bends.

The present stream appears to be cutting itself a channel in the bed of an old river valley which in places is about 500 yards wide and at a point about one mile below its exit from the gorge it has scoured deeply into the alluvial banks producing a vertical cliff over 65 feet in height.

The River Wakefield runs permanently, and often strongly, from upstream until about half a mile below its emergence from the gorge, when its flow disappears below the sandy bed. There is no more permanent running water between this place and the sea with the exception of a soak, somewhat saline, in the vicinity of Whitwarta. The river, after good winter rains, runs as far as the gulf, sometimes in heavy flood, but normally ceases to flow below the spot mentioned near the gorge during September or October. The sea, which rises about ten feet at spring tides, extends upstream for about half a mile above Port Wakefield. No tributaries nor even watercourses of any consequence enter the river downstream from just below its exit from the hills whence practically the whole of its normal flow is derived.

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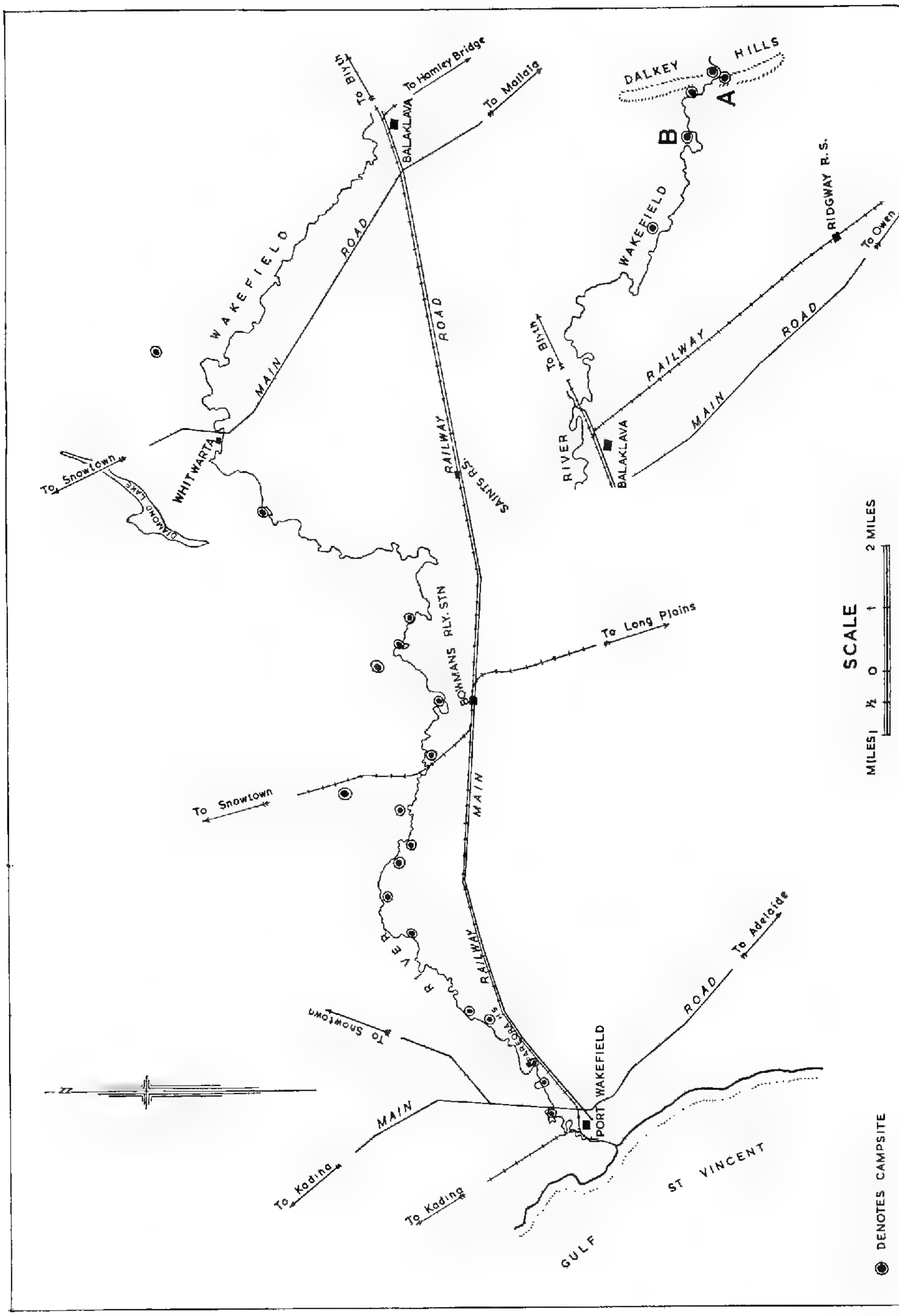

DALKEY HILLS
A
B
WAKEFIELD
RIDGWAY R.S.
To Owen
RAILWAY
MAIN ROAD
To Blyth
RIVER
BALAKLAVA
To Hamley Bridge
To Mallala
WAKEFIELD
MAIN ROAD
WHITWARTA
To Snowtown
DIAMOND LAKE
RAILWAY ROAD
SAINTS R.S.
BOWMANS RLY. STN
To Long Plains
To Snowtown
MAIN
RAILWAY
RIVER
To Snowtown
To Adelaide
ROAD
PORT WAKEFIELD
MAIN
To Kadina
To Kadina
GULF ST VINCENT
SCALE
MILES 1 ½ 0 1 2 MILES
DENOTES CAMPSITE

AVERAGE ANNUAL RAINFALLS IN INCHES

Plains:	
Port Wakefield	12·8
Balaklava	14·3
Hills:	
Auburn	22·6
Mintaro	23·7
Watervale	25·7

ELEVATIONS IN FEET OF RAILWAY STATIONS ABOVE LOW WATER SPRING TIDES, PORT ADELAIDE

Port Wakefield	18
Bowmans	96
Saints	147
Balaklava	224
Ridgway	287
Watervale	1,359

FLORA

The flora of the plains' country, through which the river runs below the gorge, has mostly disappeared as the result of clearing the land for cultivation, but scattered patches which survive serve to indicate in part some of the larger species which grew there recently. They include *Casuarina stricta* (Drooping Sheoak), *Acacia salicina* (Broughton Willow), *Eucalyptus camaldulensis* (Red Gum), *Eucalyptus oleosa* (Red Mallee), *Pittosporum phillyreoides* (Native Apricot), *Callitris propinqua* (Native Pine), *Eucarya acuminata* (Native Peach or Quondong) and *Melaleuca pubescens* (Black Teatree).

All the above species disappear, however, after descending downstream to a point a little above Port Wakefield where the country has been almost denuded of the local flora, being replaced with dense thickets of *Lycium ferocissimum* (African Boxthorn). The littoral vegetation, commencing below this place and working inland from the sea-shore, includes, amongst others, a sequence of the following species: A coastal fringe of *Avicennia marina* (Mangrove); *Arthrocnemum* and *Salicornia* spp. upon the saline flats; *Atriplex* spp. including *A. paludosa* upon the slightly higher ground, and also *Nitraria schoberi* (Nitre Bush).

DESCRIPTION OF CAMP-SITES AND THEIR ASSOCIATED STONE IMPLEMENTS

The principal camp-site discovered by the writer is one situated upon level elevated ground at a height of about 100 feet adjoining the western limit of the Dalkey Hills on the south side of the river and identified upon the accompanying plan as Camp A. Its location, an ideal one for primitive man, provides an extensive view of the surrounding country generally and at its immediate foot runs a permanent water supply along the river bed. Material for the massive stone implements, in addition, was readily available in part from a large supply of waterworn pebbles in the river-bed just below the camp and also from large angular blocks of convenient natural size weathering out of a quartzite outcrop situated upon a hill adjoining the eastern boundary of the site.

The material employed, although comprised chiefly of coarse quartzites, includes a small proportion of other rocks, including igneous, milky quartz, chalcedony, fossiliferous Lower Cambrian limestone and a type of quartzite, fluviatile in origin, apparently rare in this locality, which due to its excellent conchoidal fracture, produced the best trimmed implements.

The presence hereabouts of a large number of slightly used hammerstones is of economic interest because it indicates that they were discarded after little use owing to the ease with which replacements could be made from the river-bed. This is in marked contrast to well-worn examples found upon many camp-sites elsewhere in South Australia where, owing to the absence or scarcity of suitable material, they were in the nature of family treasures and retained regardless of heavy wear due to continuous use.

An examination of 170 large implements found upon Camp A reveals the existence of two well-defined types, (1) "horsehoof"-shaped cores mostly with well-developed stepped trimming, having in most cases discoidal or semi-discoidal flat bases, and (2) pebbles and angular blocks of casual shapes possessing a simple flaked working edge.

These two groups are separated by a large intermediate series of other massive implements, variable and nondescript in form which tends to merge the whole assemblage to such a degree as to render impossible the satisfactory demarcation of any arbitrary division between types (1) and (2). It appears convenient, therefore, to consider them as a single unit, tentatively at least.

Some "horsehoof"-shaped implements, type (1), derived from water-worn pebbles, possess natural rounded or curved bases and this form, which is retained without trimming in any way, is in marked contrast to the conventional flat-bottomed examples. Many "horsehoofs" were reduced to a state of "overhang" by wear and retouching such as Fig. 11. Fig. 1, on the other hand, which weighs 4¾ lb., and is the largest of this type yet recorded, shows little evidence of use. A few examples possess two distinct and separate trimmed flat-bottomed working margins, the second being produced by merely reversing the implement when worn and flaking the nether side as a replacement. *Vide* Fig. 8. Others, occasionally, are made from blocks with a natural "keel" (such as Fig. 7) which is retained, the margins upon both sides being trimmed in the normal fashion.

Pebbles and angular blocks - type (2) — from which a few flakes have been struck, provided simple but efficient single-edged cutting and chopping tools. No predetermined effort was made to select material uniform in shape, the prime requirement being provision for the primitive flaking referred to. Vide Figs. 12 and 13. The nether sides of some of the implements indicate that they had been reversed when in use and used as hammers similarly to others at Hallett Cove. The simplicity of construction needed for the evolution of the massive implements, generally, is indicated by the existence of a comparatively small number of discarded waste flakes struck off during their manufacture. The only other large types found were two or three pebble choppers with well-executed stepped trimming — somewhat comparable with poorer examples in the Kangaroo Island series — Cooper (1943) and two biface implements.

The occurrence of very few small quartzite implements upon Site A indicates that even the poorest examples of large trimmed cores were manufactured deliberately as tools and do not, therefore, represent discarded working cores. An examination of material found upon camp-sites proceeding downstream discloses that the incidence of small implements — apparently more recent and Murundian in type (Hale and Tindale, 1930) — increased and that of the larger implements decreased as the coast was approached. This ratio was apparent in an even more marked degree upon camp-sites on the low-lying extensive areas around the head of the gulf above Port Wakefield. The possible use by the earlier communities in the vicinity of Camp A of simple thin flakes of

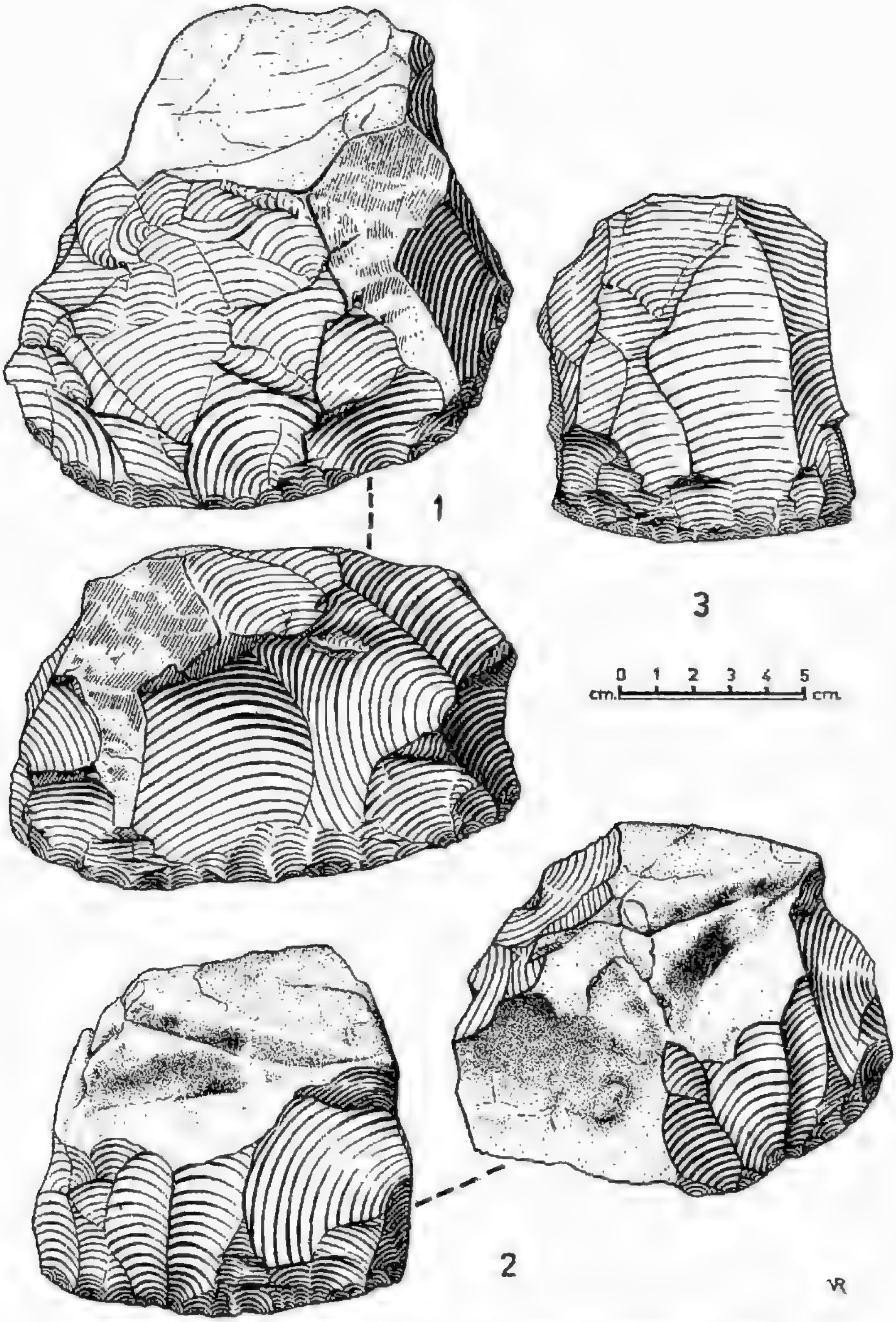


Fig. 1. Large implement derived from a flat block. Weight 4¾ lb. Uniface.

Fig. 2. "Horsehoof"-shaped with flat base. Trimmed along one straight working edge. Semi-uniface.

Fig. 3. Uniface implement with flat base.

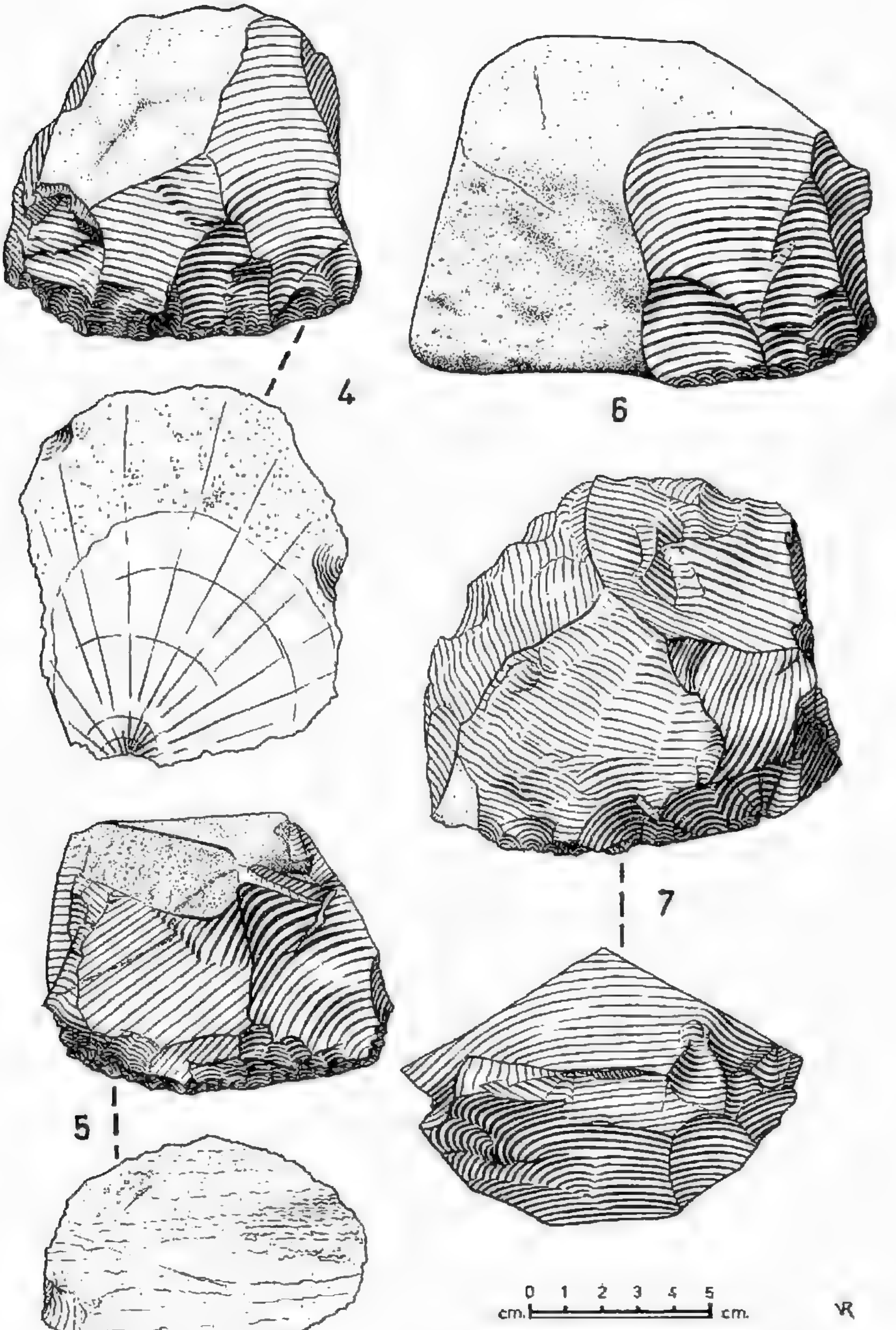


Fig. 4. Uniface implement, almost discoidal. Made from a thick flake.
Fig. 5. Ovate uniface implement. Figs. 3, 4 and 5 have been made from superior material and possess well-executed secondary stepped trimming.
Fig. 6. Angular water-worn block with primitive trimming. "Horsehoof" shape.
Fig. 7. Large angular block with "keeled" base both margins of which have secondary trimmed working edges.

milky quartz, devoid of secondary trimming, is referred to in detail later in this paper.

The locations, generally, of camp-sites along the lower reaches of the River Wakefield were confined to situations upon the banks sufficiently high to be free from inundation due to heavy flood rains in the hills. This refers more especially to the vicinity of sharp bends where floodwaters bank up and spread out over large areas rendering them unfavourable for human occupation.

A small field just below Pareora H.S. adjoining the river, where a large patch of reeds suggests the possible existence of a soak below the surface, yielded about 40 hammerstones and one or two millstones but a lack of discarded chippings. This suggests the former existence here of a women's camp, probably a fairly recent one, established for domestic purposes.

Site B, upon the north bank of the river, is situated upon a raised and extensive level expanse of cultivated land which leads down in this place by a gentle slope to the old river valley hereabouts about 250 yards wide. The 60 large implements found upon this site are comparable with those from Camp A. There is no permanent water supply in the river bed fronting Camp B at the present time, but it is probable that one may have existed during the period of its occupation.

A "horsehoof" core with its well-defined trimmed working faces greatly smoothed was discovered upon a raised cultivated field 300 yards inland from the channel of the present river, together with others in normal condition, about one mile below Camp B. The reason for the heavily rolled condition of this interesting specimen is difficult to explain.

All large implements collected upon the camps denoted on the accompanying plan, with the exception of two biface tools already mentioned, possess semi-uniface and, rarely, uniface trimming. The flaking in every case appears to have been confined solely to hammer dressing. The total number of large implements recovered from camps along the river exceeds 350 and the total distance necessarily traversed on foot during the survey amounted to over 100 miles. The examination of this area is by no means complete, because it was found impracticable to follow every small curve and bend in the meandering stream during the time available. Large type material upon camps which may have been overlooked, however, is unlikely to alter, appreciably, the general trend of that discovered.

Local inquiries confirm that neither Camp A nor Camp B, the principal sources of material discovered, had been examined previously and probably none of the others with the possible exception of one. The material recovered, therefore, may be considered as truly representative of the stone implements used and left behind by the former inhabitants of these areas.

An examination of a typical series of the large implements, 47 in number, practically all from Camps A and B and of which the accompanying drawings are representative, indicates a concentration of individual weights which does not differ materially from an average of almost 2·6 lb. There are occasional specimens, however, such as Fig. 1 (4⅞ lb.) and Fig. 15 (1⅝ lb.) widely outside the prevailing weights, a variation which appears to occur in many material cultures.

Neither pebbles nor rocks, apart from Kunkar-Travertine, were found in the bed of the river or upon its adjoining banks, below a point about three-quarters of a mile from its emergence through the hills, to the sea. A little material of inferior quality, however, may have been secured upon the surface of undulating country away from the river near a weathered bar of sandstone which crosses the bed of the stream above Bowmans. The main portion of the

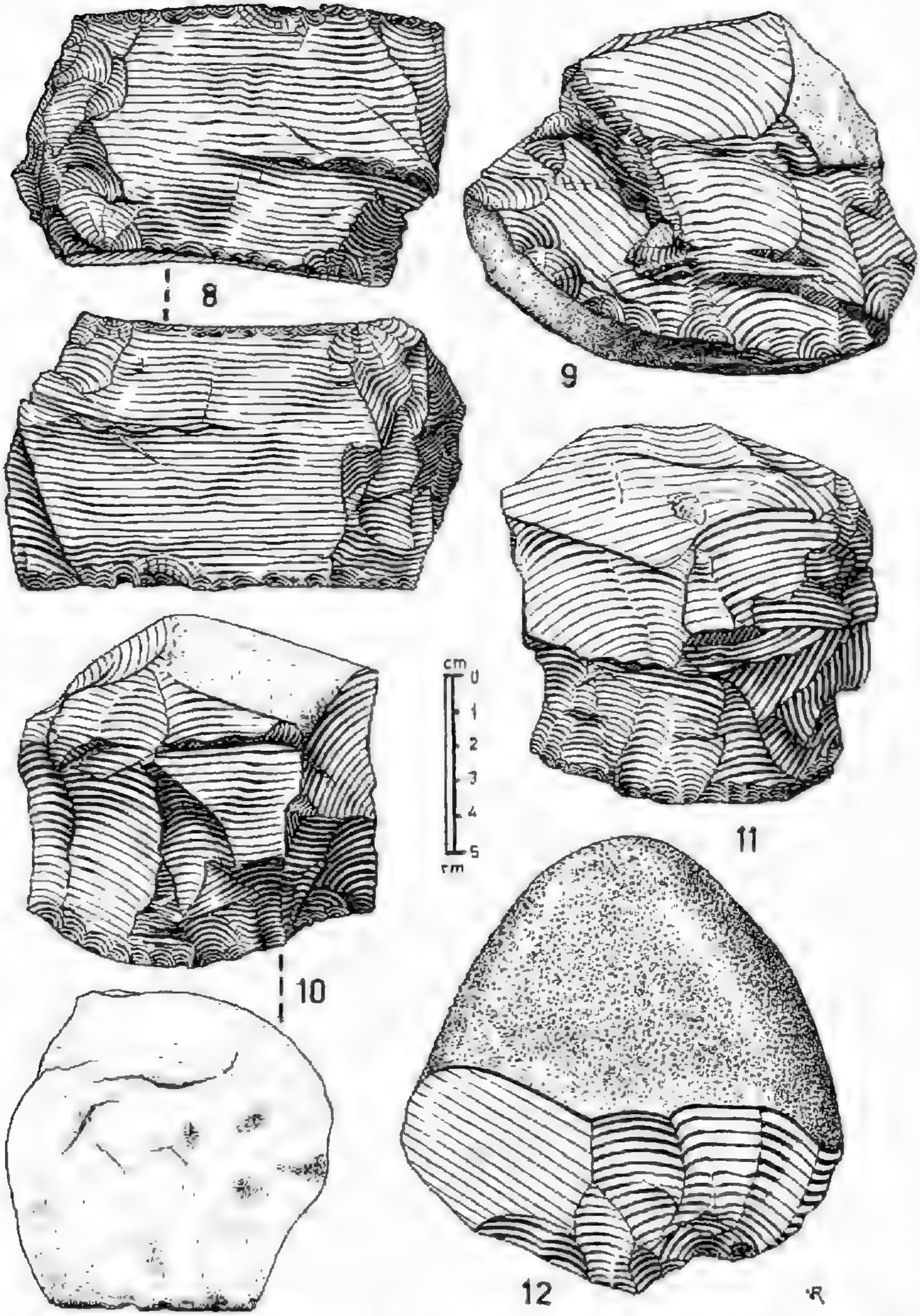


Fig. 8. Trimmed core, original form probably "horsehoofed" in shape. It has two very worn working faces, one evidently serving as a replacement for the original. Weight 3 lb.

Fig. 9. A worn trimmed core implement derived from a water-worn pebble whose original rounded base has been retained. Some pitting and bruising indicate its additional use as a hammer. Weight 3 lb.

Fig. 10. "Horsehoof" trimmed core, commencing to exhibit signs of wear, shown by its sides tending to become vertical, the result of continued use and consequent retouching of stepped trimming.

Fig. 11. "Horsehoof" trimmed core with the development of "overhang" due to excessive wear and necessary reshaping.

Fig. 12. A flat water-worn pebble which exhibits simple flake trimming upon its working edge.

workshop material, therefore, appears to have been transported downstream from the river-bed and slopes in the vicinity of Camp A. Implements and hammerstones of fine-grained quartzite pebbles towards the Port Wakefield section of the river may have been derived from Yorke Peninsula and the South Hummocks Ranges to the west and north-west of Port Wakefield, where such material is available. Stone for the manufacture of implements discovered along the lower reaches of the river, therefore, could have been secured from at least two sources with a possible overlap somewhere along the course of the stream.

The existence of a very small proportion of large implements, which exhibit trimming and shaping of a high order, amongst the material existing along the River Wakefield and possibly elsewhere should not be considered, without some qualification, as being associated, necessarily with a more refined culture period rather than with those of similar technique but inferior workmanship. No native worker in stone, however superior his skill as a craftsman, can produce a finished implement of the finest quality if his supply of rocks is confined to those refractory in nature such as granites, micaceous schists, coarse, gritty quartzites and milky quartz. The trimming of all implements of outstanding merit found in the area referred to in this paper was due to the excellence of the material, apparently limited in supply, which was utilised in their manufacture. This suggests that they may not belong, necessarily, to a later period. Type, not workmanship alone, appears to warrant consideration in many cases when determining the correct sequence in which to place such artifacts where stratification does not occur.

A few examples of the shells of *Anadara trapezia*, a species of sea-shell extinct in this area and elsewhere, as far as is known in all South Australia, were found upon several camp-sites below Bowmans, including one showing evidence of use as a scraper. Another, with extensive wear, was discovered at Port Arthur near the head of the gulf opposite Port Wakefield.

Large native kitchen middens composed of this species along parts of the New South Wales coast, where it is a living form, indicate its use as a favourite source of food supply. No similar mounds nor hearths have been discovered upon camping grounds in South Australia including the head of Gulf St. Vincent and the Port Wakefield area where extensive stratified layers and lagoon deposits exist. These include unusually large single valves up to 6¾ ounces in weight and over 4½ inches long. An isolated occurrence of *Anadara trapezia* shells *in situ*, about 1½ miles upstream from Port Wakefield, exists in a small surface capping of Kunkar-Travertine situated upon a slight rise in agricultural land about 200 yards from the river-bed. Its height above low water spring tides — 25 feet — suggests their possible association with a late Pleistocene terrace. The absence of *Anadara trapezia* middens and their casual appearance upon camp-sites, apparently collected for domestic purposes, tend to suggest that they were already fossil forms when carried there during the native occupation.

Paired *Anadara trapezia* shells, dug up *in situ* by the author from a little below the surface of a salt lagoon a few miles inland from Port Wakefield, have been supplied for a Carbon 14 Dating which should prove of interest, even indirectly, in relation to certain aspects referred to in this paper.

DISCUSSION AND TENTATIVE CONCLUSIONS

All the camp-sites described in this paper lie just within the N.E. boundary of the now extinct Kaurna (Adelaide) tribe, their neighbours in this direction being the Ngadjuri people (Tindale, 1940). Material discovered along the River Wakefield, in the absence of caves and rock shelters suitable for native occupation and resultant stratification which are somewhat rare in South Australia, is confined to implements embedded near the surface and disturbed by ploughing during the course of agricultural pursuits in the fields. A small rock shelter, suitably situated at a moderate elevation in the gorge cliffs adjoining Camp A was examined for possible stratified material, but without success. The decomposed nature of the rock composing it, however, indicates that its formation may be recent. A search for other shelters along the river above the gorge in hilly country might prove more successful.

An examination of material from Camps A and B, the principal sites, of which the accompanying drawings are representative, indicates that the assemblage of stone implements is composed of, it may be repeated, types (1) and (2) with an intermediate admixture of various shaped forms, which tend to link them, as already described in this paper.

Type (1) is "horsehoofed" in shape with stepped trimming which suggests a more advanced technique in flaking than that employed in type (2). The presence of large numbers of examples in group (1) with excessive wear indicates that it was of considerable economic importance in the camp life of the natives and if contemporaneous with the simpler form of hand chopper (type 2) it may have been utilised for domestic purposes of another nature or for the completion of wooden implements primarily fashioned by those of type (2). The "horsehoof", however, in view of its stepped trimming technique, may represent a later cultural period.

Type (2) was trimmed with a definitely preconceived motive, irrespective of its natural form, for the production of a heavy implement fashioned to provide a simple working edge which with the aid of its weight would be quite effective in supplying the needs of primitive man, such as cutting, chopping and scraping. The great diversity in shape of pebbles and blocks chosen for the construction of this type indicates the simplicity of its construction and, indirectly, tends to reflect the primitiveness and lack of variety of the makers' domestic and hunting equipment.

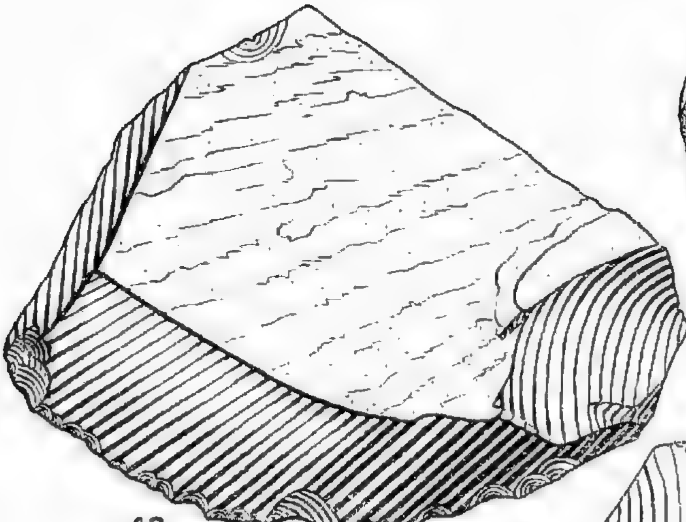
It is most difficult to define any arbitrary distinction for the separation of types (1) and (2) into two well-defined blocks because the intermediaries, as described before, tend to merge the one into the other. It seems probable, however, that all, whether they were contemporaneous or are indicative of a gradual refinement in technique with the passing of time, are the components of a stable dominant material culture which endured over a considerable period more especially if undisturbed by any incoming influences from outside.

Possible uses would have included cutting and chopping boughs and branches for the manufacture of clubs, spears, wurlies or shelters, for scraping purposes generally, including the final preparation of hunting weapons and domestic appliances and also the making of toe holds for the ascent of trees in search of food. All the above, therefore, with few exceptions may have been employed as general purpose tools.

The almost total absence of millstones and pounders may indicate that the natives of that period were hunters who relied upon the chase to a large extent for their sustenance.

It seems reasonable to assume, too, that the peculiar native flora of their times, somewhat similarly to that existing today, would have tended, amongst other causes, to have made them not food producers but food gatherers.

In order to attempt a true evaluation of the significance and purpose of archaeological stone cultures of primitive form, such as those referred to in this paper, it is helpful to bear in mind the changes in climate, flora, possible isolation and environment generally existing at that time when compared with more recent and even historic periods. Jennings (1957) referring to primitive



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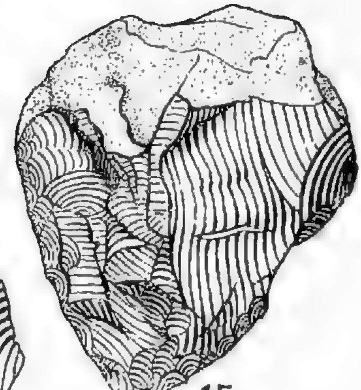

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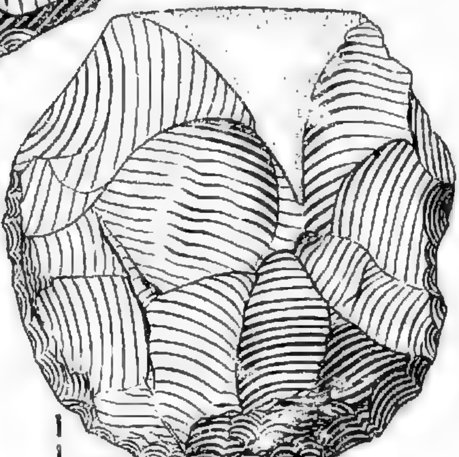

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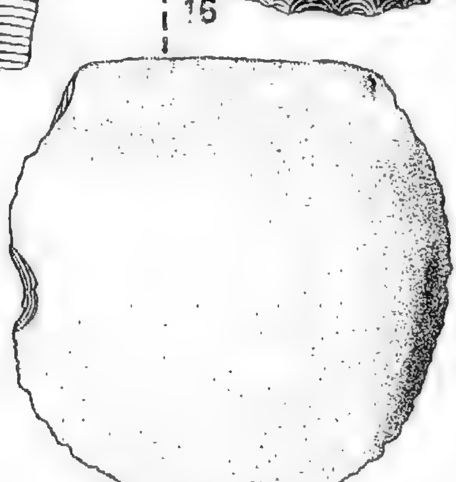

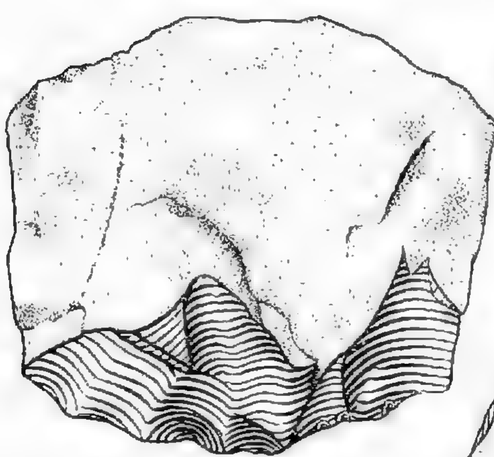

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0 1 2 3 4 5
cm. cm.

Fig. 13. A thin, flat, angular slab with a roughly fashioned working margin.

Fig. 14. An angular and irregularly shaped water-worn block which has been very simply trimmed. Flat base.

Fig. 15. A triangular-shaped implement with well developed stepped trimming; similar to Hallett Cove, Fig. 12 (Cooper, 1959). Irregular-shaped nether surface.

Fig. 16. A well designed implement formed from a flat water-worn pebble. The trimmed working edge extends around about three-quarters of its periphery; the remainder being retained in its natural shape, apparently, as a grip for the hand.

man in North America remarks: "His entire economy and, of course, his objects of material culture were geared to the resources of the land."

Stone age man, even during the early developmental periods of his material cultures – despite the need for massive stone implements for his essentially heavy requirements – would have an undoubted need for comparatively small, thin pieces of rock with sharp knife-like edges for various light duties, such as blood letting and ceremonial rites, cutting and shaping the skins of animals in the preparation of skin cloaks and other suchlike duties, the nature of which

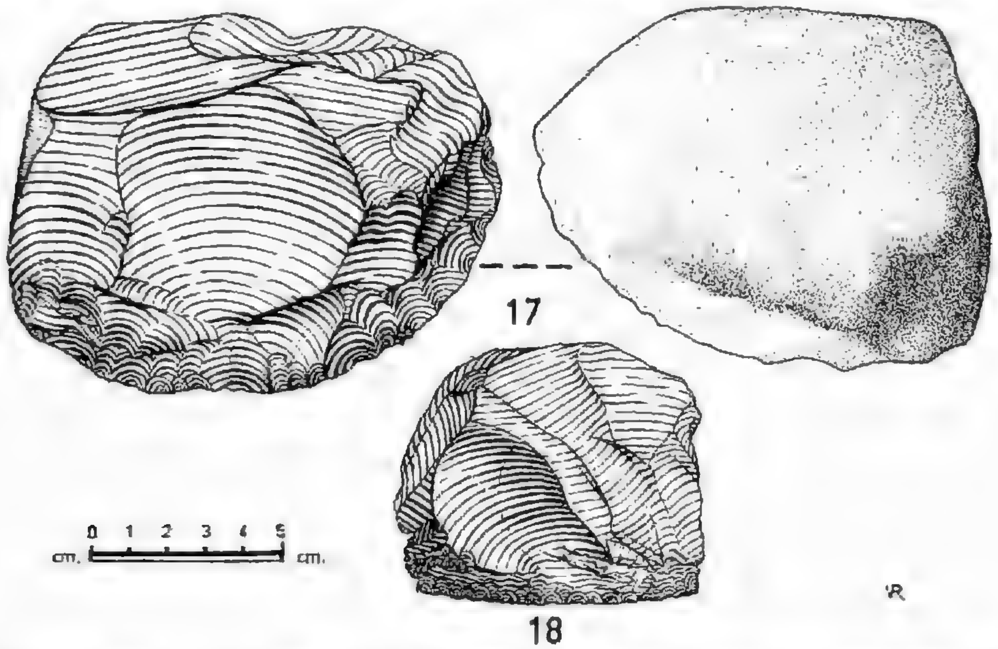

Fig. 17. A massive water-worn pebble implement. Its stepped trimming is somewhat similar to the more inferior examples amongst the characteristic Kangaroo Island pebble chopper industry. Weight 2⅜ lb.

Fig. 18. A "horsehoof"-shaped trimmed core found by Holmes (1895) at Mitla, Mexico.

Figured specimens 1 to 17 are all core implements with the exception of Fig. 4, which has been derived from a flake. Figs. 1, 3, 4, 5 and 11 were provided with a uniface trimmed working margin; the remainder, as far as the worn condition of some permits, appear to have been semi-uniface in design.

would depend chiefly upon climatic and environmental conditions at present obscure. The earliest materials for such work, doubtless, were natural random fragments of rock with sharp edges which he could secure from the surface of his hunting grounds. These, it is logical to suppose, he found later could be replaced with simple and far more efficient primary flakes easily made by striking them off a block of rock with a hammerstone.

Reference was made by Cooper (1960) to the existence upon certain Kangaroo Island camp-sites not only of a very limited number of small milky quartz implements with secondary trimming, but also an unduly large quantity of small cores of the same material from a few of which they had evidently been derived. These were associated, however, with scores of simple primary flakes, many with keen edges, some of which were lightly chipped upon their nether sides. This often suggests damage due to use and if true in this case it indicates that these particular flakes were deliberately made and explains the existence of an otherwise inexplicably large number of small working cores.

A number of milky quartz cores, similar in size and shape to those of Kangaroo Island, were found upon the River Wakefield Camp A, but practically no small implements of that material with secondary trimming. There exists, however, an abundance of simple flakes, many sharp edged, similar to those upon the island. The manipulation of milky quartz to produce secondary trimming is most difficult owing to its refractory nature as already stated, but this material provides, with little difficulty, thin primary flakes with razor-like edges ideally suitable for light cutting purposes. The probable contemporary use of the latter for such purposes by the makers of the massive implements described herein merits some consideration.

In the absence of confirmatory stratified material the age of the River Wakefield large implements, similarly to those at Hallett Cove which they so closely resemble (Cooper, 1959), must be one of surmise at the present time. The complete absence of tools of other than primitive forms, however, tends to suggest that in part at least they represent the earliest occupation of man in both areas. The types from these two localities are almost similar in conception and some individual specimens from both areas are weathered to such an extent that they can be overlooked entirely unless examined with the greatest care.

The general situations of Camps A and B near the River Wakefield gorge, in addition, are significantly identical with those upon the high ground bordering both sides of the creek and gorge at Hallett Cove, and in many cases other sites found upon Kangaroo Island.

It appears, therefore, that these large implements from the River Wakefield area are archaeological in period, belong to the culture termed Kartan and are possibly Negrito (Tasmanoid) in origin. The occupational period may have been wetter and colder than that now prevailing.

These early communities along the river, if this proves to be true, were probably very small ones, later to be driven out or assimilated by the advancing Australoids or other new arrivals. The astonishingly high proportion of "horsehoof" and intermediary types worn, apparently, to the utmost limit of their usefulness, may suggest that for some purposes at least they were equal or superior to newly formed tools, especially in the light of the availability of an unlimited supply of raw material. This significant proportion, upon the other hand, may strengthen the suggestion that the communities were very small ones.

The scarcity and in places the almost total absence of the smaller types, generally recognised as more recent, along the course of the River Wakefield to the sea and the areas around the adjoining head of Gulf St. Vincent, together with the paucity of food shell remains in the vicinity of the latter, may appear somewhat surprising. It suggests, however, that the area as a whole was an unattractive one to the aborigines during recent times due to its aridity, large areas of saline marsh, precarious water supplies and consequent scarcity of game.

It may be of interest to refer in this particular place to the existence of "horsehoof"-shaped trimmed implements discovered by W. H. Holmes in Mexico amid the ruin of buildings apparently associated with a Mayan Period which was described by him in 1895.

Fig. 18 is a drawing based upon the third reproduction in his Plate XLII and as will be observed it is remarkably similar in design, including stepped trimming and wear, to a typical smaller implement of "horsehoof" shape from South Australia. Holmes noticed other specimens of corresponding shape but larger in bulk.

These implements were found in large numbers by Holmes not only in the soil of the surrounding fields, but also intermixed with the adobe mortar employed in constructing the great buildings of the Mayan Period.

Holmes, in discussing the source of these implements, concludes that he could not determine, with the evidence at his disposal, whether they were contemporaneous with the construction of the Mayan buildings — and were in consequence devised to dress in some way the stone utilised in the building of their edifices — or whether they represented an earlier culture period upon the same site and were merely retrieved from the nearby fields by the Mayans for admixture with their adobe material in order to strengthen it or for some other purpose now unknown.

The existence of "horsehoof" trimmed cores in Mexico, similar in type to those of South Australia, does not indicate, necessarily, that both series are of the same antiquity. This is a problem which is governed to a considerable degree both by the period of time needed for their diffusion by primitive man, often over considerable distances — assuming that they were derived from a common source — and also by the length of their persistence in a given locality.

Their use intermixed with the adobe mortar in the latter suggestion by Holmes, therefore, would indicate the presence of an earlier material culture period upon the same site.

The rapid expansion of settlement and commercial activities in the vicinity of Adelaide has necessarily obliterated, dispersed or buried the original camping grounds inhabited by the former native dwellers of the surrounding plains and coastal areas. These localities, fortunately, were carefully examined during recent years by several experienced collectors and the implements retrieved have been classified and stored in the South Australian Museum for future reference.

The material discussed in this paper owing to its deposition, being merely displaced and exposed from near the surface by the ploughing of the fields, assists but little in terms of constructive stratification, but similarly to that recovered elsewhere upon the Adelaide Plains, it will be of assistance at some later date when further information may enable a correct sequence of the relevant periods to be established.

ACKNOWLEDGMENTS

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THE OCCURRENCE AND COMPARATIVE MINERALOGY OF SOUTH AUSTRALIAN MAGNESIAN CROCIDOLITES (RHODUSITES)

BY D. KING, M.SC.

Summary

The numerous deposits of crocidolite asbestos in South Australia are confined to dolomite and marble horizons of the Precambrian and Cambrian bedded sequences. South Australian and Bolivian crocidolites differ in chemical composition, physical properties, mode of origin and industrial importance from the wellknown commercial crocidolites (or blue asbestos) of South Africa and Western Australia. No related fibrous amphiboles of intermediate chemical composition have been described in published literature and it is suggested that two varieties of crocidolite can, therefore, be distinguished. These are *crocidolite* proper and *magnesian crocidolite* (*rhodusite*)

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[Read 13 October 1960]

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INTRODUCTION

Crocidolite occurs at numerous localities in the Flinders Ranges of South Australia, mostly in bedded dolomitic rocks of the Proterozoic Torrensian Series. The most productive of the crocidolite deposits, none of which are currently mined, were those in the Precambrian dolomites of the Robertstown district (Fig. 1 (6)). Other deposits occur in the same rock sequence at Burra (Morphett's Shaft), near Eurelia and Orroroo (Hd. of Coomooroo), in the Hawker district (Hds. of Wonoka, Arkaba and Adams), and at Oraparinna Station in the northern Flinders Ranges. Similar deposits occur in the same Precambrian formations 3½ miles south of Mt. Fox, in the Peake and Denison Ranges (Fig. 1 (1)) and in marbles of Cambrian age near Dutton township (Hd. Dutton).

In most of these deposits, including those of the Cambrian marbles at Dutton, the crocidolite is localised within zones of intense fracturing, and is accompanied by irregular discordant bodies of a mafioigneous-looking rock. Crocidolite veins occur within this rock and extend into the adjacent dolomites.

The igneous-looking rocks are composed mainly of albite, biotite and tourmaline and in the largest observed outcrops are up to 100 feet wide. The following brief petrographic descriptions, and others previously published (King, 1955), illustrate that these rocks are very variable in composition, distribution of constituent minerals and grain size.

Specimen No. P 224/55 from the quarry floor, Blue Hole deposit, Robertstown, consists mainly of albite and a very dark iron-rich tourmaline. Small flakes of a pale biotite accompany the albite and some crystals of alkali-amphibole are also present. The grain size of the albite and tourmaline varies from 0·2 to 0·6 mms. An adjacent coarser specimen contains abundant tourmaline with some associated quartz, deeply weathered feldspar and crocidolite. Banded aggregates of tourmaline occur adjacent to veins of crocidolite.

Specimen No. A 1476/56 from the southern face of the same quarry is composed of orthoclase, iron-rich tourmaline and interstitial, randomly orientated biotite. Minor amounts of albite, quartz and yellow rutile are also present. A chemical analysis of the specimen is presented in Table 4.

A distinctly different rock is exposed in the adit just east of the main road at Reudiger's workings, Hundred of Bright. Specimen No. 176/55 from this locality consists essentially of a pale-coloured magnesian biotite with accessory

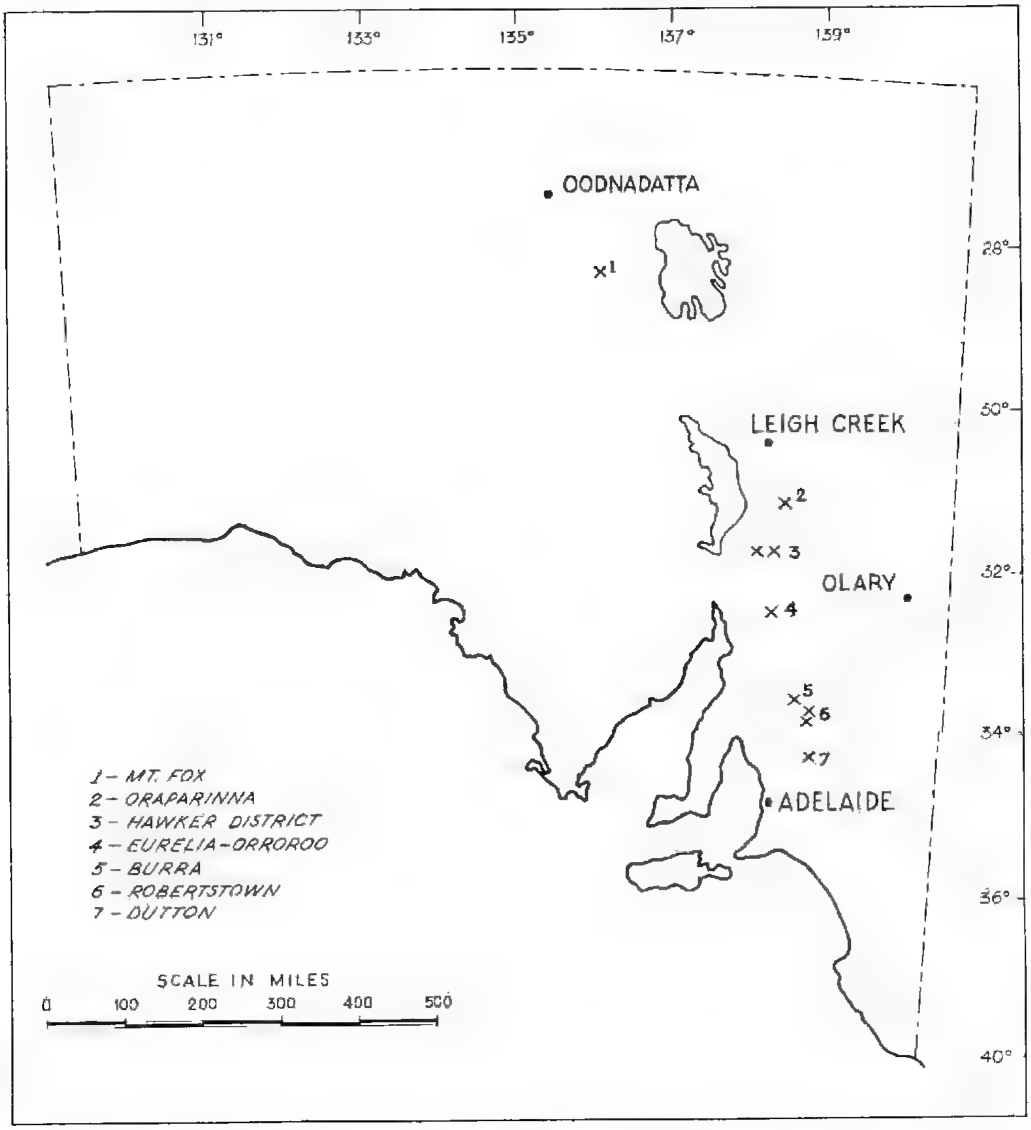

Fig. 1. Map of South Australia showing distribution of crocidolite asbestos deposits.

hematite, magnetite, pyrite, quartz, apatite and rutile. Feldspar and tourmaline are absent.

Trenches in the Hallelujah Hills area, Hd. of Bright, expose fibrous crocidolite accompanying a medium to fine-grained rock (P.176/55) composed of green biotite, andesine feldspar and prisms of alkali-amphibole (riebeckite).

The biotite grains occur in clumps which appear to be pseudomorphous after amphibole. Small crystals of tourmaline are present.

The mineral described as tourmaline in these rocks differs from common tourmaline in being readily friable, and apparently is very susceptible to weathering. It occurs as brownish-black anhedral grains which are strongly pleochroic in thin section. The refractive index ($\eta_\epsilon = 1{\cdot}705$: $\eta_\omega = 1{\cdot}735$) is exceptionally high.

A sample of dolomite from adjacent to an asbestos vein at Reudiger's Workings, Robertstown, was analysed with the following result:

Silica, 4·16 p.c.; calcium carbonate, 48·8 p.c.; magnesium carbonate, 39·9 p.c.; oxides of iron and alumina, 6·68 p.c.

Thin beds of magnesite are interbedded with the dolomites of the Torrensian Series. There are also numerous rock phosphate deposits throughout the State in the same sequences (King, 1955). These minerals normally occur independently of the crocidolite and the tourmaline rocks.

Other Crocidolite Occurrences.

The major producing crocidolite deposits of South Africa and Western Australia are confined to bedded ironstones adjacent to dolomites in the Precambrian sedimentary terrains. Miles (1942) observed in Western Australia that "the crocidolite occurs as conformable seams enclosed in the banded ironstones which are frequently interbedded with thin bands of dolomite". Dealing with the Transvaal crocidolite deposits, Hall (1919) states that "the veins invariably lie in country rocks of the banded ironstone type and close to the underlying dolomites".

The Bolivian deposits (Ahlfeld, 1943) are likewise "limited to the vicinity of dolomitic beds", but in this case of possibly Cretaceous age.

No igneous rocks are known in proximity to the Western Australian or Bolivian deposits. In South Africa, while some amosite deposits are considered to have been induced by hydrothermal solutions derived from the Bushveld intrusion, the crocidolite is developed to a similar extent over wide tracts far beyond the influence of the igneous rocks (Peacock, 1928).

COMPARATIVE MINERALOGY

(a) *Physical Properties.*

In all the deposits described above, the crocidolite is found in a wide variety of physical states, including an earthy amorphous form described as incipient* or potential crocidolite (Peacock, 1928; Miles, 1942), aggregates of interlocking minute fibres termed crocidolite wool (King, 1955), the commercial crocidolite asbestos, and prismatic crystals described as needle riebeckite. These distinctive forms of crocidolite are usually closely associated and are considered to represent progressive stages of crystal integration in the process of crocidolitisation, reflected in their chemical composition by a gradual loss of water (Peacock, 1928).

The tensile strength of the South Australian and Bolivian crocidolites is very variable but consistently less than that of the commercial blue asbestos. Accordingly, they are of subordinate industrial importance, and unsuitable or inferior for the production of protective fabrics and in asbestos-cement products. The weak fibre crocidolites have, however, a limited market as a refractory packing, being a better insulator than blue asbestos (Gartrell, 1929), and as a filter medium and medical dressing (Asilican Compound). These are special

* A similar form of crocidolite from an occurrence in the Abriachan district of Scotland has been named *Abriachanite*.

uses related to their unusual tendency to flocculate in water and form a matte by wet separation, but the demand for such products is now largely satisfied by fibre glass materials.

(b) *Chemical Composition.*

The few previously recorded chemical analyses of South Australian crocidolite asbestos (Jack, 1920; Wymond and Wilson, 1951) are representative of the grade of fibre which has been mined. However, in view of the wide range

TABLE 1.

New analyses of South Australian Crocidolite.

	S.A.1.	S.A.2.	S.A.3.	S.A.4.	S.A.5.
SiO_2	51·58	54·32	49·06	54·24	51·25
Al_2O_3	2·08	1·70	1·10	2·11	1·51
Fe_2O_3	17·53	16·11	9·16	16·07	18·04
FeO	5·30	4·87	1·23	5·09	2·26
MgO	11·18	12·38	18·30*	11·48	13·00
CaO	0·14	0·26	6·58*	0·12	0·33
Na_2O	6·82	6·48	5·68	7·08	7·81
K_2O	0·12	0·22	1·12	0·32	0·30
H_2O+	0·11	0·14	0·30	0·16	0·57
H_2O-	2·40	2·65	1·12	2·34	4·51
TiO_2	0·28	0·33	0·21	0·36	0·26
CO_2	—	—	6·15*	—	
SO_3	Nil	0·01	0·02	0·03	—
Cl	0·05	—	0·17	0·08	—
Total	100·59	99·50	100·56	100·38	99·87

Analyst P. C. Hemingway.

* Dolomite impurity.

S.A.1. Dull, earthy, lavender-coloured "incipient" crocidolite, Reudiger workings, Robertstown. The sample contains both earthy material and layers of fibres. The earthy portion contains traces of felspathic material together with many minute opaque grains.

S.A.2. Pale blue silky, slip-fibre crocidolite, Reudiger workings, Robertstown. The sample consists of crocidolite with only traces of fine interstitial material.

S.A.3. Silvery grey, slip-fibre crocidolite, Reudiger workings, Robertstown. It consists mainly of crocidolite containing traces of a colourless asbestos with a much lower R.I. and positive elongation. Dolomite is abundant as an impurity.

S.A.4. Lavender coloured cross-fibre crocidolite which partly reduces to a powder on crushing, Blue Hole deposit, Robertstown. The sample contains both flexible and brittle varieties of short-fibre crocidolite, with similar optical properties. The flexible fibres contain little interstitial material, while the brittle crocidolite has up to 5 per cent. of extremely fine grained impurities.

S.A.5. Pale blue-grey, silky, long fibre crocidolite—washed state, Oraparinna Station. The crocidolite is free from granular impurities. A few of the fibres have a relatively low R.I. and positive elongation.

of forms and physical properties of the mineral, additional chemical analyses representing a variety of crocidolite types were undertaken. The selected samples were prepared for chemical analysis by microscopic methods, so that they were essentially freed of impurities. Mineralogical details of the analysed samples are recorded along with the new chemical analyses in Table 1. Sample S.A. 3 contains a noteworthy amount of dolomite, which is reflected in the analyses by the higher values for lime, magnesia and carbon dioxide, and by a proportional decrease of the elements constituting crocidolite.

TABLE 2.

Chemical composition of crocidolite asbestos — summary of published analyses.

	Crocidolite or Blue Asbestos (Strong fibre)						Magnesian Crocidolite (Weak fibre)							
	Western Australia			South Africa			Rhode Is.	Bolivia			South Australia		India	Siberia
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SiO_2	51·86	51·94	45·51	51·94	50·71	50·66	51·03	56·10	54·08	54·68	53·48	54·87	54·48	54·01
Al_2O_3	0·03	0·24	0·78	0·20	0·00	0·04		0·66	2·90	3·90	5·32	1·78	2·10	0·23
Fe_2O_3	20·26	18·93	26·05	18·64	20·45	22·64	17·88	15·60	14·50	13·98	15·16	16·41	15·79	15·70
FeO	14·84	15·25	15·07	19·39	17·41	17·05	21·19	4·06	6·85	7·40	3·44	5·38	5·02	9·42
MnO	0·01	0·01	Nil					Nil	0·08	0·21	Present	Trace	0·08	0·14
MgO	3·26	3·94	2·49	1·37	2·28	1·99	0·09	14·50	11·72	12·25	10·90	11·34	12·11	10·01
CaO	0·49	0·40	0·11	0·19	0·15	0·01		1·11	2·10	1·27	0·72	0·46	1·04	1·52
Na_2O	6·12	6·00	5·43	6·07	5·75	5·16	6·41	5·05	5·55	5·55	6·30	6·77	6·34	6·22
K_2O	0·28	0·26	0·05	0·04	0·07	0·09		0·71	0·40	0·46	0·70	0·25	0·32	0·35
H_2O+	1·97	2·67	3·50	2·58	2·50	2·62	3·64		1·80	0·72	2·32	1·62	0·40	2·25
H_2O-	0·68	0·72	1·24	0·31	0·96	0·15		0·03			0·72	0·51		
TiO_2	0·03	0·01	Nil					Trace	0·01		Nil	0·68	Nil	Trace
CO_2	0·02	Nil	0·03								0·22	Nil		
P_2O_5	0·05	Nil	Nil										Trace	
Cr_2O_3	Nil	Nil	Nil											
Total	99·90	100·37	100·26	100·73	100·28	100·40	100·24	97·82	100·02	100·42	99·28	100·06	98·31*	99·85

* Residue 0·63.

1. Crocidolite, Hamersley Ranges, Western Australia (Simpson, 1929-30).
2. Crocidolite, Hamersley Ranges, Western Australia (Simpson, 1929-30).
3. Riebeckite Rock ("potential crocidolite"), Australia (Simpson, 1929-30).
4. Fibrous crocidolite; Griqualand West, South Africa (Peacock, 1928).
5. Incipient crocidolite; Griqualand West, South Africa (Peacock, 1928).
6. Acicular crocidolite; Griqualand West, South Africa (Peacock, 1928).
7. Crocidolite, Rhode Island (Chester & Cairns, 1887).
8. Fibrous crocidolite, Bolivia (Whittaker, 1949).
9. Fibrous crocidolite, Bolivia (Gumucio, 1949).
10. Fibrous crocidolite, Bolivia (Ahlfeld, 1943).
11. Crocidolite concentrate (wet processing), Hd. Bright, Sth. Aust. (Jack, 1921).
12. Long fibre crocidolite, Robertstown, Sth. Aust. (Wymond & Wilson, 1951).
13. Bababudanite, Mysore, India (Smeeth, 1908).
14. Rhodusite from Siberia.

The analyses show that the various forms of crocidolite from the South Australian deposits are of uniform chemical composition, and are largely composed of silica (54 p.c.), ferric iron (16-18 p.c.), ferrous iron (2-6 p.c.), magnesia (11-13 p.c.) and soda (6-8 p.c.).

The analyses listed in Table 2 are representative of the published chemical analyses of crocidolites. They show that the South Australian crocidolite is identical in chemical composition with asbestos from the Cochabamba Province of Bolivia (Ahlfeld, 1943), but differs considerably from the commercially important crocidolites mined in South Africa and Western Australia. Thus, two varieties of crocidolite can be identified on the evidence of chemical composition and correspond with the two different types recognised in the marketing of crocidolite.

1. The common variety of *crocidolite* (crocidolite proper or blue asbestos) from South Africa, Western Australia and Rhode Island is a sodium iron silicate with a subordinate content of magnesia (1-4 p.c.). It is a high quality asbestos.

2. The limp and silky asbestos which is found in South Australia and Bolivia is a *magnesian crocidolite* and differs from the common variety in containing from 10-15 p.c. magnesia and up to 5 p.c. alumina, which take the place of ferrous and ferric iron. The silica content is slightly higher in the magnesian varieties. Bababudanie from India and rhodusite from Siberia (Smeeth, 1908) are also to be classed chemically as magnesian crocidolites.

The available analyses provide no evidence of the existence of any crocidolite intermediate in composition between the two varieties.

Despite the contrast in chemical composition, the two varieties have in common the peculiarity of occurring in any one deposit in a number of physical states, including the amorphous or incipient form. Miles (1942) remarks that . . . "the close similarity in composition of the pure crocidolite to 'potential' crocidolite and to the associated host rocks from both Western Australia and South Africa is remarkable". This is equally true of the magnesian crocidolites.

The superior insulating qualities of the magnesian crocidolite is probably to be related to the high magnesia content. The much lower tensile strength of the magnesian variety accords with the observation of Dutoit quoted by Frankel (1913) that the strength of crocidolite is proportional to the amount of ferrous oxide in the molecule—2-6 p.c. in magnesian crocidolite as compared to 17-19 p.c. in blue asbestos proper. A higher silica content (54 p.c. as compared to 52 p.c.) and higher magnesia content may account for the greater brittleness, as was found with chrysotile asbestos (Soboleff and Tatarinoff, 1933).

(c) *Optical Mineralogy.*

The optical constants of crocidolite and magnesian crocidolite are given in Table 3. The data on the South Australian crocidolite is a combination of the published work of Wymond and Wilson (1951) and determinations by M. J. Bucknell on samples collected by the author. Only slight variations from the mean optical constants given were observed in the numerous specimens examined.

The main difference to be noted is the lower refractive index of the magnesian crocidolite, which is even more evident by reference to the complete determination for South African blue asbestos by Peacock (1928), viz., $\alpha = 1 \cdot 698$, $\beta = 1 \cdot 699$, $\gamma = 1 \cdot 706$

(d) *X-ray.*

X-ray studies of the magnesian crocidolite from Bolivia and the common variety from South Africa by Whittaker (1949) . . . "show a greater resemblance to one another than to fibre photographs of other amphibole varieties. It is thus confirmed that the mineralogical classification of the Bolivian material as crocidolite is correct, in spite of some considerable differences in properties from South African crocidolite". Garrod and Rann (1952) also observed close similarities in the unit cell dimensions of Bolivian and Western Australian crocidolites.

(e) *Electron Micrographs.*

The electron micrographs (Figs. 2 and 3) provide a further means of comparison of the crocidolites. Fig. 2a is a sample of the best grade blue asbestos from Wittenoom Gorge, Western Australia, and Figs. 2b, 3a and 3b are magnesian crocidolite from the Blue Hole deposit, Robertstown, South Australia. The specimens were prepared by teasing and dispersion in water and separation of the finest fibres which remained in suspension. These were dried on collodion films on the microscope specimen carriers.

TABLE 3.

Optical constants of crocidolites.

		Crocidolite Western Australia Miles, 1942	*Magnesian Crocidolite* South Australia
Refractive Index	α	--	1·665
	β	1·695	--
	γ	--	1·670
Pleochroism		Strong.	Strong
	X	Deep prussian blue	Blue green (or sky blue)
	Y	Indigo blue	Yellow to greenish yellow
	Z	Yellowish green	Violet
Extinction	X∧C	2 to 3 degrees or less	0 to 6 degrees
Absorption		Strong	Strong
Birefringence		Weak	Weak to moderate
Elongation		Length fast	Length fast

The micrographs illustrate the superior quality of the Western Australian mineral, which is seen to be frayed longitudinally into ultrafine unbroken fibres which are bent in places into smooth curves. The fibres of the Robertstown asbestos are much shorter and coarser by comparison, with some irregular broken edges (Fig. 3a) which may be due to intergrowths of other minerals, such as talc, as observed in some thin sections.

In both cases, the finer fibres appear to be tubular and similar in this respect to chrysotile asbestos (Bates *et al.*, 1950). The tubular form of the magnesian crocidolite is clearly evident from Fig. 3b, at X 15,000 magnification. This micrograph shows the presence of discontinuities along the length of the tubicles marked by darker-coloured rings orientated normal or slightly oblique to the length of the fibres. The orientation of the rings is consistent in individual fibres and may correspond to crystal directions. The minute cylindrical partings are commonly of slightly greater diameter than the adjoining sections of the individual tubes (Fig. 2b), and are similar to the "multiple tubes" which Bates *et al.* (op. cit.) described in chrysotile.

ORIGIN

It is evident from the investigations cited that the process of crocidolitisation is largely confined to rocks of dolomitic composition; and that, in the case of crocidolite proper as found in Western Australia and South Africa, it involved the recrystallisation of rock material in situ, under conditions of mild load metamorphism.

Peacock (1928) conceives crocidolitisation as . . . "a mild, static, non-additive metamorphic process resulting in the chemical union, along soda-rich bedding planes, of the necessary constituents already in situ". The process is described as a . . . "sweating action, facilitated by interstitial rock moisture, and induced by a moderate rise of temperature and pressure such as would result from simple burial of the ironstones to moderate depths". The same conclusions are recorded by Miles (1942) in his report on the Western Australian deposits.

The magnesian crocidolites are found similarly in proximity to dolomitic rocks, but the mineralogy of these deposits is indicative of a different mode of origin which would involve the introduction of some of the constituent elements by hydrothermal solutions.

TABLE 4.

Chemical analysis of the tourmalinised biotitic rock, Blue Hole deposit, Robertstown.

SiO_2	49·38
Al_2O_3	20·40
Fe_2O_3	2·70
FeO	1·60
MgO	8·20
CaO	0·62
Na_2O	1·50
K_2O	9·58
H_2O+	1·08
H_2O-	1·96
TiO_2	2·22
CO_2	0·31
SO_3	0·02
Cl	0·10
Total	99·67

Ahlfeld (1943) considers that the magnesian crocidolites of Bolivia are a product of dynamic metamorphism, accompanied by the introduction of iron and magnesia by thermal solutions. Hematite, pyrite, chalcopyrite and the calcium boro-silicate, danburite are associated minerals.

The magnesian crocidolites of South Australia are likewise confined to bedded dolomites and marbles, but are localised in faulted zones and commonly in intimate association with small and irregular bodies of albite, biotite and tourmaline-bearing rocks. Wymond and Wilson (1951) have described such rocks from Robertstown at meta-dolerites and tourmalinised meta-dolerites and attribute the crocidolitisation to . . . "late magmatic activity associated with 'doleritic' intrusion". Rocks associated with the Oraparinna crocidolite deposits are also classed as dolerites (McBriar, 1949). The writer has since expressed the opinion (King, 1955) that the so-called dolerites are not intrusive igneous bodies but are of metasomatic origin. The evidence favouring this view is considered below.

The igneous-looking rocks vary considerably incomposition. Their principal constituents occur in the following combinations—albite-tourmaline-biotite; orthoclase-biotite-tourmaline; biotite; biotite-andesine-riebeckite. Albite-biotite types with variable tourmaline are the most abundant (Wymond and Wilson, 1951). Marked variations such as these are found within individual exposures and the erratic distribution of tourmaline is clearly apparent in the outcrops.

A sample of the freshest available rock from the Blue Hole deposit, Robertstown, was analysed with the results shown in Table 4. A petrographic description of this sample (No. A 1476/56, above) reveals an unusually high content of orthoclase, reflected in the chemical analysis by a high potash content (9·58 p.c.). Although albite is the more common feldspathic constituent of the rocks examined in section, and probably in all of the more highly decomposed exposures, the low content of CaO (0·62 p.c.) does not accord with the classification of these rocks as dolerites. The average lime content of Tasmanian dolerites, for example, is 11·34 p.c.

Over extensive areas, these albite-biotite igneous-looking rocks have been found only within the dolomitic members of the bedded sequences.

The principal mineral constituents of these rocks also occur in variable amounts as replacement clots and veins in the adjacent dolomites. A specimen from the Hallelujah Hills deposits (P65/56) is described as a metasomatised dolomitic rock composed of tourmaline, dolomite and albite. Vesicle-like structures evident in the hand specimen are composed of albite and granular dolomite enclosed by an aureole of tourmaline. Another specimen (P177/55) from Reudiger's Workings is a dolomitic marble which is replaced in small clots by biotite, feldspar and ferruginous material. Hematite is abundant in the interstices of the marble.

The mineral assemblage of the crocidolite-bearing rocks is in many respects comparable with that of the talc deposits of the Gumeracha district, distant some sixty miles southerly of Robertstown. Talc is locally abundant in the dolomites in proximity to the asbestos occurrences, while albite, tourmaline, rutile, magnesian-rich biotite (and phlogopite), pyrites and apatite are common to both types of deposits. According to Stillwell and Edwards (1957) the formation of the talc bodies involved alteration of magnesian rocks by soda-rich solutions.

It is envisaged, therefore, that the biotite-albite-tourmaline and related rock types resulted from metasomatic alteration of dolomites by hydrothermal solutions, derived from a deep-seated acid igneous source, and which entered the dolomites along existing fault zones. The formation of crocidolite would mark a late stage in these processes. This postulated conversion of dolomite into albite-biotite-tourmaline-rich rocks and crocidolite would involve the introduction of solutions rich in soda, ferric and ferrous iron, boron and possibly silica and alumina. It is inferred from the constant association of the crocidolites with dolomites that the magnesia is derived from the dolomites, and not introduced.

ACKNOWLEDGMENTS

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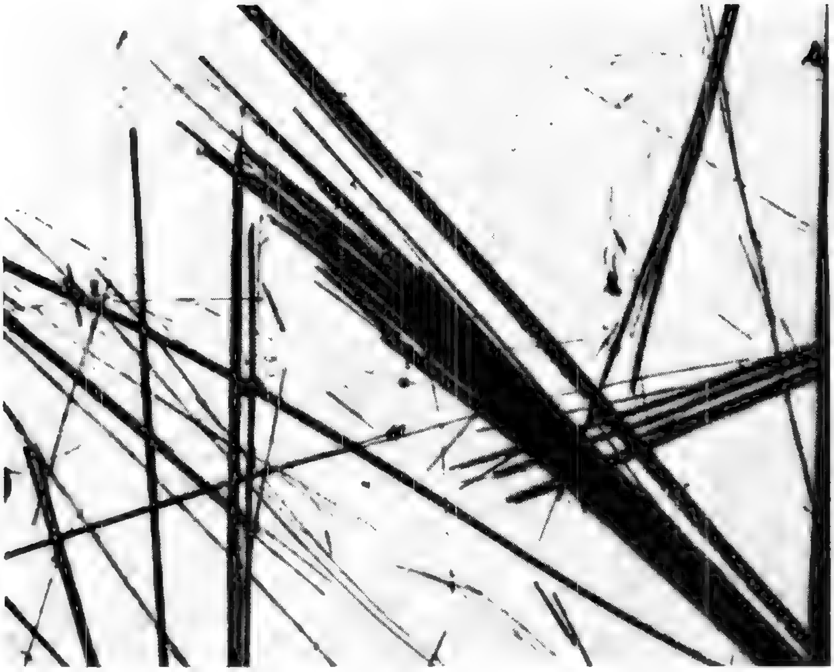

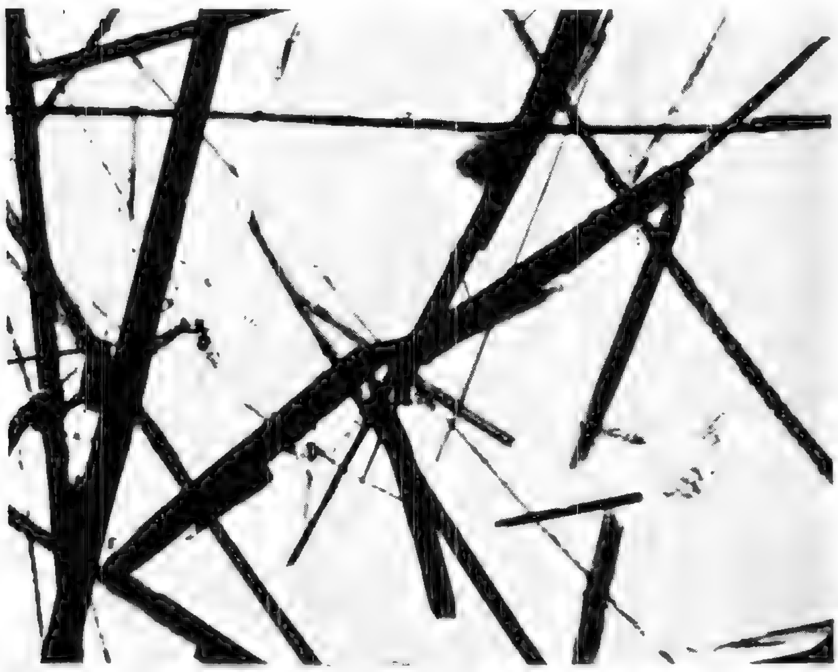

Plate I. Electron micrographs, at x 5,000 magnification, of crocidolite proper from Wittenoom Gorge, Western Australia (a), and magnesian crocidolite from Robertstown, South Australia (b).

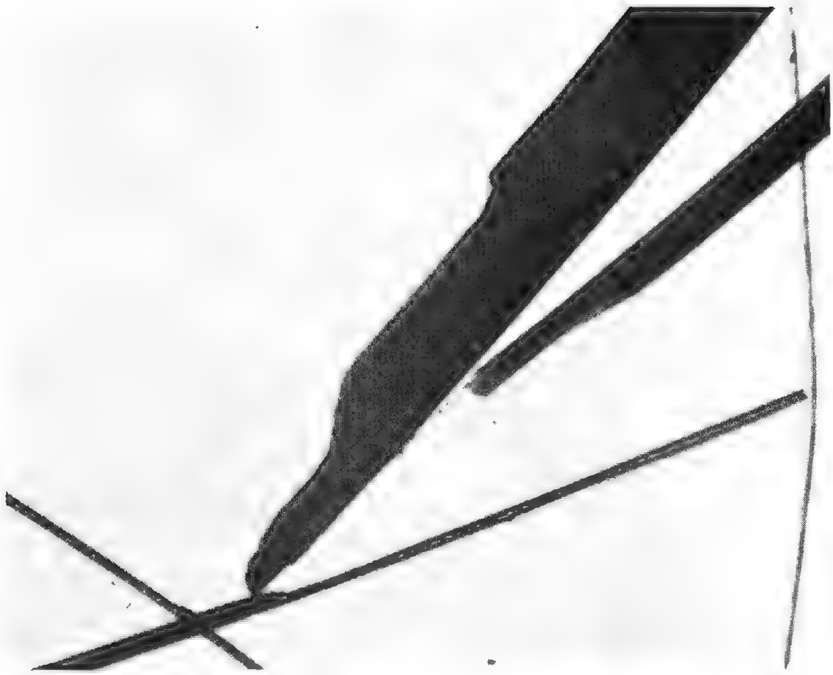

Plate II. Electron micrographs of magnesia crocidolite from Robertstown, South Australia. The top figure (a), at x 5,000, illustrates inconsistencies in the fibrous habit and the lower figure, at x 15,000, shows the tubular form of the individual crystals.

OUTLINE OF THE BIOSTRATIGRAPHY OF ANDAMOOKA OPALFIELD

BY N. H. LUDBROOK

Summary

Precious opal occurs at Andarnooka in conglomerates interbedded with sandy clays carrying a rich microfauna of arenaceous foraminifera of Aptian age. A notable discovery from recent sampling is the presence of late Pleistocene or early Recent marine mollusca and foraminifera in sediments at the top of several of the shafts. This confirms the belief that late Pleistocene-early Recent high sea levels converted the area from Spencer Gulf northwards towards Lake Eyre into an extensive estuary.

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by N. H. LUDBROOK*

[Read 13 October 1960]

SUMMARY

Precious opal occurs at Andamooka in conglomerates interbedded with sandy clays carrying a rich microfauna of arenaceous foraminifera of Aptian age. A notable discovery from recent sampling is the presence of late Pleistocene or early Recent marine mollusca and foraminifera in sediments at the top of several of the shafts. This confirms the belief that late Pleistocene-early Recent high sea levels converted the area from Spencer Gulf northwards towards Lake Eyre into an extensive estuary.

INTRODUCTION

The present paper is based on micropalaeontological examination of 57 samples collected from 17 shafts over a wide area of Andamooka Opalfield by L. C. Nixon and M. B. Langsford in July and August 1958. The general geology, structure and economic geology of the field were discussed in a recent report by Nixon (1960), but biostratigraphic details were not included.

Almost without exception the Cretaceous and younger rocks are extensively kaolinized, a feature commonly produced by weathering in arid parts of South Australia and not of any particular stratigraphic significance. As a high proportion of the Lower Cretaceous foraminifera are arenaceous forms they survive the process of kaolinization but are generally preserved as distorted and deflated tests which are not always easy to identify.

STRATIGRAPHY

The sequence of lithologic units occurring on the field was tabulated by Nixon (l.c. p. 17). Disregarding the red-brown earth and red sand dune cover, three stratigraphic units are present:

1. Late Pleistocene-early Recent marine gypseous sandy clay.
2. Lower Cretaceous (Aptian) mottled red and grey clays, kaolinitic sandy shale and kaolinitic sandstone and conglomerate.
3. Upper Proterozoic (Marinoan) dolomites, quartzites, chocolate shales and brown sandstones.

UPPER PROTEROZOIC (MARINOAN)

The only pre-Cretaceous material examined was sample F 195/58 (3) from a bore near Bickford Ridge which entered chocolate shale and brown sandstone at 80 feet. These belong to the series of dolomites, slates and quartzites tentatively correlated with the Marinoan Series. They unconformably underlie the Lower Cretaceous and outcrop on the north and east of the field (Nixon l.c. p. 15 and Fig. 1).

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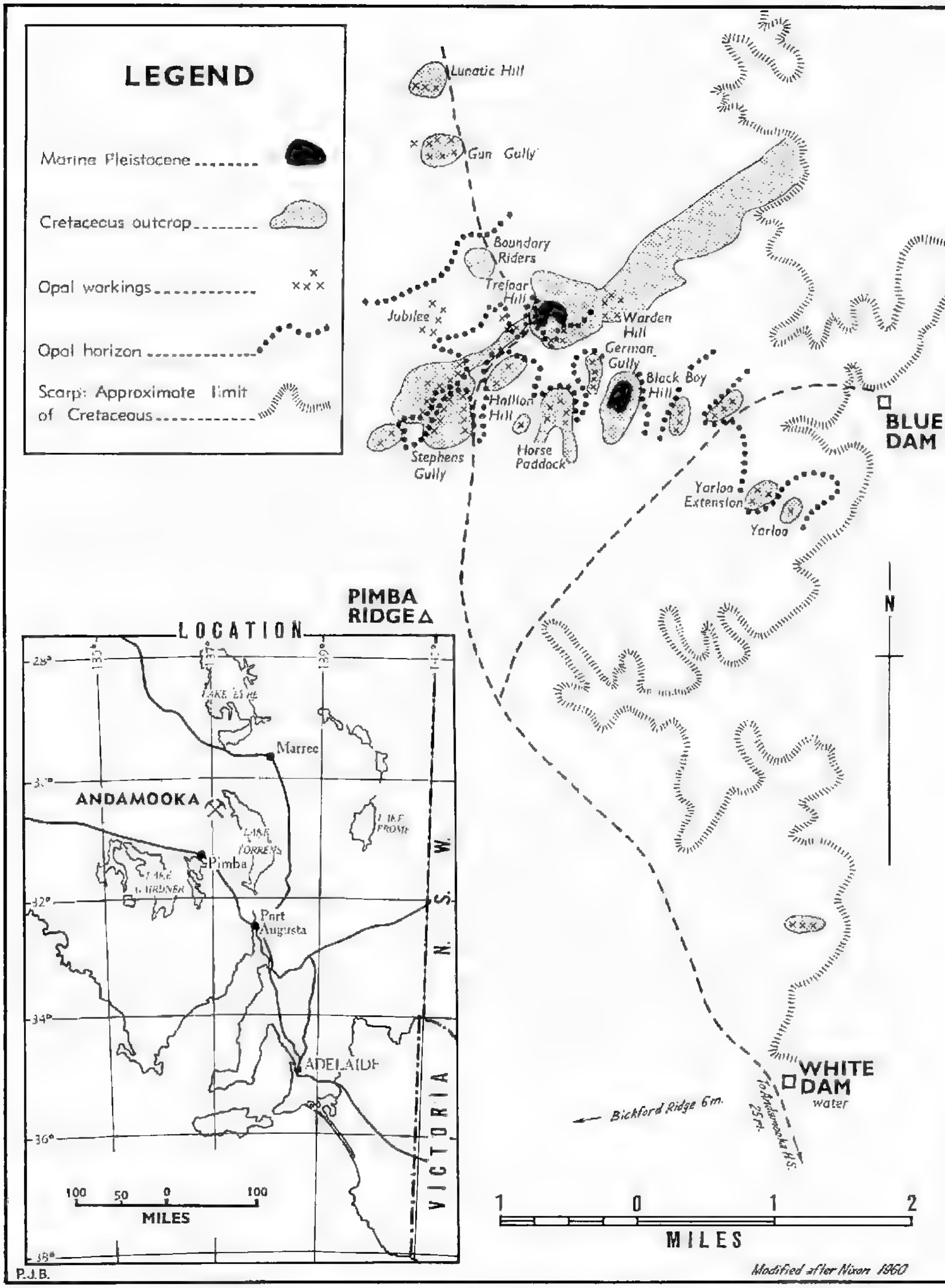
* Palaeontologist, Geological Survey of South Australia. Published with the permission of the Director of Mines.



Andamooka opal field showing Cretaceous outcrops and opal workings.

LOWER CRETACEOUS (APTIAN)

The Cretaceous sediments at Andamooka consist of approximately 75 feet of interbedded clays, shales, sandstones and conglomerate. The upper half of this sequence was sampled from the "bottom gouge" or "bottom toe dirt" upwards to above the opal horizon. The accompanying Table 1 shows the distribution of foraminifera within the horizons "bottom gouge", "below the dirt", "toe dirt", "opal horizon", and "above opal horizon". Twenty-five species of arenaceous foraminifera are present, only nine of which have been described or can be identified at present with named species. They are, however, all common species occurring in the Great Artesian Basin. The assemblage is characteristic of the Aptian (Roma Formation). The "bottom gouge" and toe dirt clays are distinguished by an abundance of *Haplophragmoides chapmani* Crespin. This species has not been recognised above the Lower Albian in South Australia and occurs in varying abundance in the Aptian mainly in siltstones and mudstones. *Textularia anacooraensis* Crespin with which it is associated in most of the Andamooka samples is known to occur only in the lower part of the marine Aptian, to which *Gaudryina* sp. 3 is also limited.

"Genus A" occurs in the Aptian intersected by water bores at Marree.

Most of the associated species have less restricted ranges.

The distribution table indicates no considerable stratigraphic range and the whole of the thin Lower Cretaceous sequence probably should be placed in the lower part of the Aptian equivalent of the Roma Formation.

(1) The "bottom gouge" or lower toe dirt horizon is represented by sample F 146/58 at 29 feet depth in Terry Moore's shaft at Blackboy. The material is mostly clay, very rich in *Textularia anacooraensis* and other associated foraminifera which constitute almost the entire residue after washing.

(2) Between the "bottom gouge" and the "toe dirt" the sediments consist of fine grey-white kaolinitic and sericitic sandstone with a poor foraminiferal assemblage. Most of the samples appear to be unfossiliferous, but a few individuals of *Trochammina* sp., *Haplophragmoides chapmani*, and *Textularia anacooraensis* were recovered from samples F 159/60 and F 160/58 from the lower part of Opal No. 1, north-west of Hallion Hill. This horizon is probably represented in F 162/58 to F 166/58 from the White Dam area, F 167/58 and F 168/58 from Schulton's Shaft, Treloar Hill, and F 170/58 from Opal Creek. Sample F 167/58 carried an unusual test of *Trochammina* sp. 2 in which the agglutinated grains are of opal.

(3) "Toe dirt". Opal miners apply this name to a mottled, partially ferruginized clay or shale immediately below the opal horizon. Most of the clay disappears on washing leaving a residue rich in arenaceous foraminifera, mainly *Haplophragmoides chapmani* and *Textularia anacooraensis*. Foraminiferal tests are heavily ferruginized and brick red in colour. F 139/58, F 145/58, F 148/58, F 153/58, F 158/58, F 169/58, F 174/58, F 177/58, F 180/58, F 183/58, F 185/58, F 187/58, F 189/58, F 190/58 and F 192/58 were taken from this horizon.

(4) Opal Horizon. The conglomerate band in which the opal commonly occurs is represented by sample F 140/58 from W. Cronin's shaft at The Saddle and is distinguished by the presence of *Ammobaculites australis* (Howchin) which occurred in only one sample below this level. At German Gully the conglomerate carries fossil wood and the pelecypod *Pseudavicula australis* (Moore).

(5) Above Opal. The sediments above the opal horizon are heavily kaolinized sandstone and gypseous shale with a rather sparse microfauna in which several species of arenaceous foraminifera are generally represented in small

TABLE 1.

Distribution of Cretaceous foraminifera Andamooka opalfield.

Sample number	Bottom gouge	Below toe dirt			Toe dirt															Opal	Above opal horizon													
	F 146/58	F 159/58	F 160/58	F 167/58	F 139/58	F 145/58	F 148/58	F 153/58	F 158/58	F 169/58	F 174/58	F 177/58	F 180/58	F 183/58	F 185/58	F 187/58	F 189/58	F 190/58	F 192/58	F 140/58	F 141/58	F 144/58	F 149/58	F 152/58	F 155/58	F 156/58	F 157/58	F 161/58	F 178/58	F 182/58	F 184/58	F 188/58	F 191/58	F 193/58
Hyperammina sp. 1	—	—	—	—	v	r			c	—	c	f	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pelosina lagenoides	v	—	—	—	v	—	—	—	—	—	—	—	—	—	—	—	—	—	v	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Involutina sp. 1																																		
Haplophragmoides chapmani	c	f	—	—	a	a	a	a	a	a	a	a	f	r	f	c	f	f	c	—	—	—	—	—	—	—	—	—	—	v	—		v	r
Haplophragmoides dickinsoni						r																												
Haplophragmoides sp. 1					r																													
Haplophragmoides sp. 2												v																						
Ammobaculites australis									v	—	—	—	—	—	—	—	—	—	—	c	—	—	r	—	v	—	r	f	—	—	—	—	—	a
Ammobaculoides romaensis						v														v														
Textularia anacooraensis	a	r	—	r	—	c	v		c	c	—	v	v	—	—	—	r	v	r	r	—	—	a	—	r	f	c	—	r	—	—	—	v	c
Textularia sp. 1						f	v	—	—	r	r														v		c	r						
Textularia sp. 2						r											r	v		r			f	v	r	f		r						f
Textularia sp. 3											v		v				v	v	f							r	v							c
Textularia sp. 5	c	—	—	—	—	f	—		r											r			v											
Siphotextularia sp. 2						c		f	f	f	a	f	f			v			c															
Spiroplectammina cushmani											v																							
Spiroplectammina edgelli											v																							
Trochammina minuta	v			—	—	v	—	—	—	—	—	—	—	—	—	—	v	—		—	—	—	a	—	r	r	—	a	r					
Trochammina sp. 2	—		r	v	—	—	—	—		—	v		—				—	—	—	—				—	—	—	—	r						
Gaudryina sp. 1																										v								
Gaudryina sp. 3																				f	—	—	—		a	—	—	f						
Gaudryinella sp. 1	f	—	v	—	—	f		—	—	r			—	—	—	—	—	—	—	—	—	—	—	f										
Gaudryinella sp. 2												r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	f
Genus A									v	—	—	—	—	—	—	—	—	—	—	—		v	—	—	—	r	—	v						

v very rare 1-2 specimens
r rare 3-5 specimens
f frequent 6-10 specimens
c common 11-25 specimens
a abundant 25 specimens.

numbers. *Textularia anacooraensis* and *Trochammina minuta* are usually present. *Haplophragmoides chapmani* was absent from all but two samples.

PLEISTOCENE-EARLY RECENT

The detection of Recent species of foraminifera and mollusca in samples taken from Kevin's shaft, German Gully, and W. Cronin's shaft, The Saddle, is quite unexpected. This discovery provides positive evidence of the existence of a late Pleistocene or early Recent estuary extending northwards from Spencer Gulf by way of Lake Torrens towards Lake Eyre where brackish water or estuarine foraminifera were recovered from clays intersected in two shallow boreholes and from a thick shell bed with *Coxiella gilesi* 36 feet above the present level of the lake (Ludbrook, 1956).

The foraminiferal assemblage in the sample from Kevin's Shaft consists of *Cribrobulimina polystoma* (Parker and Jones), *Nubecularia lucifuga* Defrance, abundant *Peneroplis planatus* (Fichtel and Moll), *Discorbis mira* Cushman, *Elphidium cf. craticulatum* (Fichtel and Moll). Associated molluscan species are *Macoma deltoidalis* (Lamarck), *Diala lauta* (Adams), *Salinator fragilis* (Lamarck), *Batillaria* (*Zeacumantus*) *diemenensis* (Quoy and Gaimard). Both the foraminifera and mollusca are well preserved. The assemblage is typical of that living in very shallow water in warm, sheltered inlets in South Australia at the present time.

Several other samples from the Gun Gully-Lunatic Hill area contained sporadic examples of *Elphidium*, *Cibicides refulgens*, and bryozoa, but as they appeared to be fortuitous no conclusions are drawn from their occurrence.

Fresh water ostracoda and oogonia of *Chara* were present in samples F 166/58 from White Dam and F 195/58 in red clayey sand from the bore near Bickford Ridge. These are considered to have been recently deposited.

DESCRIPTION OF THE SAMPLES

(1) W. *Cronin's Shaft*, The Saddle.

F 139/58. Floor of shaft.

Iron-stained red and grey clay, washed residues consisting of ferruginized clay, fine angular quartz grains, ferruginized foraminifera.

The sample contains a mixture of Cretaceous and Recent species. The Cretaceous species are dominated by *Haplophragmoides chapmani* and *Textularia anacooraensis*. The Recent species are *Discorbis mira* Cushman, *Elphidium cf. craticulatum* (F. & M.), *Peneroplis planatus* (F. & M.) and *Marginopora vertebralis* Blainville. It would appear that Pleistocene-early Recent material assumed to occur at the top of the shaft has fallen in and contaminated the toe dirt forming the bulk of the sample.

F 140/58. Immediately above toe dirt-opal horizon.

White kaolinitic sandstone with *Ammobaculites australis*. Washings consist of medium angular quartz grains, kaolin, gypsum and some muscovite.

F 141/58. 5 feet above F 140/58. Kaolinitic sandstone with fine to medium angular to subrounded quartz grains with pitted surfaces, some hematite. No microfossils observed.

(2) *Bill's Shaft, Hard Hill*, near German Gully.

F 142/58. At 2 feet depth kaolinized clayey sandstone with medium fine subrounded quartz grains and a good deal of iron staining. No microfossils observed.

F 143/58. At 10 feet depth. Hard resilicified kaolinitic sandstone.

F 144/58. At 20 feet. White kaolinitic sandstone with a few foraminifera.

F 174/58. At 25 feet. Iron-stained mottled siltstone—toe dirt—with abundant foraminifera dominated by *Haplophragmoides chapmani* (68 examples).

(3) *Terry Moore's Shaft*, Blackboy.

F 145/58. 27-28 ft. 6 in. Mottled red and grey clay (toe dirt), washings consisting of kaolin, fine angular quartz grains, abundant partly ferruginized foraminifera dominated by *Haplophragmoides chapmani* (84 examples) and *Textularia anacooraensis*.

F 173/58. 28-29 feet. Hard kaolinitic grit with quartzite pebbles.

F 146/58. At 29 feet. Lower toe dirt horizon. Most of the sample is clay and the residue consists almost entirely of foraminifera, with *Textularia anacooraensis* in abundance (76 examples).

(4) *Yarloo Extension*.

F 147/58. White gypseous kaolinitic rock, the washings consisting mostly of kaolin and gypsum, with a fragment of precious opal. Two doubtful foraminifera only were observed.

(5) *Jubilee*.

F 148/58. No. 1. 19 ft. 6 in. Toe dirt with abundant ferruginized foraminifera, mostly *Haplophragmoides chapmani*.

F 149/58. No. 2. 15 feet. White kaolinized sandstone, with fine angular quartz grains, muscovite, very abundant *Textularia anacooraensis*, and abundant *Trochammina minuta*.

(6) *Kevin's Shaft*, German Gully.

F 150/58. Red surface sandy clay with medium subangular to subrounded quartz grains and grains of silicified sandstone. Abundant iron oxide staining.

F 151/58. At 14 feet. Mottled red and white soft gypseous sandy clay with fine quartz grains and some iron oxide. The sample contains well-preserved foraminifera and mollusca living in shallow estuaries at the present time.

Foraminifera

Cribrobulimina polystoma (Parker and Jones) (1 specimen).
Nubecularia lucifuga Defrance (1 specimen).
Peneroplis planatus (F. & M.) (23 specimens).
Discorbis mira Cushman (1 specimen).
Elphidium cf. *craticulatum* (Fichtel and Moll) (1 specimen).

Mollusca

Macoma deltoidalis (Lamarck) (1 valve).
Diala lauta (Adams) (3 specimens).
Salinator fragilis (Lamarck) (4 specimens).
Batillaria (*Zeacumantus*) *diemenensis* (Q. & G.) (1 specimen).

The material is probably of late Pleistocene or early Recent age.

There is in addition a test of *Trochammina* sp. which may be of Cretaceous age.

F 152/58. At 28 feet. Channel sample over 5 to 6 feet.
White kaolinized shale with fine angular quartz grains, sericite and one specimen each of *Textularia* sp. 2 and *Gaudryinella* sp. 1.

F 153/58. At 30 feet. Toe dirt. Mottled reddish and grey-green clay with abundant *Haplophragmoides chapmani* (58 specimens).

(7) *Garvie's Shaft*, Hallion Hill.

F 154/58. At 6 feet. Hard white kaolinized and silicified sandy shale. No foraminifera were detected.

F 155/58. At 13 feet. White kaolinized sandy shale, with fine to medium angular to subrounded quartz grains, limonite and abundant foraminifera dominated by *Gaudryina* sp. 3 (44 specimens).

F 156/58. At 17 ft. 9 in. White kaolinized sandy shale with fine to medium angular quartz grains and foraminifera dominated by *Textularia anacooraensis* (10 specimens).

(8) *Shaft, Horse Paddock.*

F 157/58. Above opal horizon. White kaolinized sandstone with fine angular quartz grains and a foraminiferal assemblage with a few individuals of several species.

F 158/58. Toe dirt. Ferruginized clay with subrounded to angular quartz grains and abundant foraminifera dominated by *Haplophragmoides chapmani* (66 specimens).

(9) *Opal No.* 1, north-west of Hallion Hill.

F 171/58. 0-1 feet. Hard kaolinized sandy clay. No fossils observed.

F 172/58. 4 ft. 7 in.-5 ft. 6 in. Hard kaolinitic sandstone and conglomerate with occasional facetted pebbles.

F 159/58. 7 ft. 3 in.-10 ft. 2 in. White iron-stained sandy clay with *Haplophragmoides chapmani*. One fragment of precious opal noted.

F 160/58. 10 ft. 3 in.-11 ft. Mostly pinkish white kaolinized sandstone with a few impoverished foraminifera.

(10) *Stevens Gully.*

F 161/58. Adit. Grey-white kaolinitic fine sandstone with fine angular quartz grains, abundant sericite and foraminifera dominated by *Trochammina minuta* (67 specimens).

(11) *White Dam Area.*

F 162/58. East end; working 1½ miles from White Dam. 3 feet. Partly ferruginized kaolinitic sandy shale with fine angular quartz grains, hematite and limonite staining.

F 163/58. 1½ miles from White Dam; soil profile as at Andamooka. 2 feet. Iron-stained kaolinitic sandy shale with fine to medium angular iron-stained quartz grains.

F 164/58. 1½ miles north-west of White Dam. 3 feet. Kaolinized shale with some iron-staining and abundant sericite.

F 165/58. Central workings, bearing 020° from White Dam 300 yds. Iron-stained kaolinized sandy shale.

F 166/58. White Dam. Brownish-white kaolinitic sandstone. Washings consist of light brown fine to medium angular to subrounded quartz grains with much limonite staining. A shell fragment and an oogonium of *Chara* are present, but it is uncertain whether these are of Pleistocene age or of recent introduction.

(12) *Schulton's Shaft*, Treloar Hill.

F 167/58. Below toe rock. White kaolinized shale with some rounded and subangular quartz grains, sericite, a piece of precious opal and a test of *Trochammina* sp. 2 with opaline quartz grains.

F 168/58. At 40 feet. Grey kaolinitic sandstone with sericite.

F 169/58. Toe dirt. Purplish ferruginized shale with abundant ferruginized arenaceous foraminifera dominated by *Haplophragmoides chapmani* (83 specimens).

(13) *Opal Creek.*

F 170/58. Dirty white kaolinitic sandstone with fine even-grained angular quartz grains. No foraminifera were observed.

F 175/58. Hard dark ferruginized sandstone (a) R.L. 945; (b) R.L. 941.

(14) *Lunatic Hill.*

F 177/58, Locality 81 (1). Toe dirt. Mottled ferruginized shale with abundant foraminifera dominated by *Haplophragmoides chapmani* (37 specimens).

F 178/58. 81 (2). 5 ft. above 81 (1). White kaolinized sandy clay. Washings consist mainly of kaolinitic material with fine angular quartz grains and sericite. Cretaceous foraminifera are present, together with *Cibicides refulgens* and bryozoal fragments. The sample, therefore, seems to be a mixture of Cretaceous and Pleistocene material.

F 179/58. 81 (3). 5 feet above 81 (2). Powdery white kaolinitic sand, with iron-stained rounded to subrounded and polished quartz grains.

F 180/58. 82 (1). Toe dirt. Red brown ferruginous shale with *Haplophragmoides chapmani.*

F 181/58. 82 (2). 5 feet above 82 (1). White sandy kaolinized rock, with *Elphidium* cf. *macellum* (F. & M.). ? Pleistocene.

F 182/58. 82 (3). 5 feet above 82 (2). White kaolinized shale with *Haplophragmoides chapmani* and two fragments of ?Pleistocene shell.

F 183/58. 83 (1). Kaolinitic rock with fine angular quartz grains and *Haplophragmoides chapmani.*

F 184/58. 83 (2). 5 feet above 83 (1). Kaolinized shale with medium subrounded quartz and sericite.

F 185/58. 84 (1). Red and white mottled kaolinitic sandy shale with subrounded quartz grains and *Haplophragmoides chapmani.*

F 186/58. 84 (2). 5 feet above 84 (1). Hard white kaolinized sandstone.

(15) *Gun Gully.*

F 187/58. 85 (1). Toe dirt. Pink and white mottled ferruginized shale with abundant *Haplophragmoides chapmani.* There is also one specimen of *Quinqueloculina vulgaris* presumably contaminating from the overlying Pleistocene.

F 188/58. 85 (2). 5 feet above 85 (1). Somewhat ferruginized soft gypseous sandy clay with *Globigerina bulloides, Discorbis* sp. and bryozoa, indicating a Pleistocene or early Recent age.

F 189/58. 86 (1). Toe dirt. Mottled ferruginized shale with *Haplophragmoides chapmani. Textularia anacooraensis.*

F 176/58. 86 (2). 5 feet above 86 (1). Gypseous clay.

(16) *Boundary Riders Hill.*

F 190/58. 88 (1). Mottled red and grey ferruginized shale with *Haplophragmoides chapmani* and *Textularia anacooraensis.*

F 191/58. 88 (2). 5 feet above 88 (1). Kaolinized sandstone with, rarely, *Haplophragmoides chapmani* and *Textularia anacooraensis.*

F 192/58. 89 (1). Toe dirt. Pinkish sandy shale with *Haplophragmoides chapmani* and other species in relative abundance.

F 193/58. 89 (2). 5 feet above 89 (1). White kaolinitic sandstone with abundant foraminifera, including *Ammobaculites australis* and *Textularia anacooraensis.*

F 194/58. 89 (3). 5 feet above 89 (2). Soft powdery clayey sand and kunkar with mostly subrounded iron-stained quartz grains. A sponge spicule and one specimen of *Textularia* were the only organic remains recovered. The sample may be of Pleistocene age.

(17) *Near Bickford Ridge.*

F 195/58. Three samples from bore collected from spoil.

(1) Reddish and buff clayey sand with medium subangular to subrounded quartz grains with both clear and iron-stained quartz grains. Organic remains consist of ostracode fragments, *Chara* and molluscan shell fragments, the age of which is probably Recent.

(2) Sandstone and chocolate shale, containing a small *Trochammina* and two small shell fragments of diverse origin.

(3) Chocolate brown sandstone—presumably bedrock.

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MESOZOIC NON-MARINE MOLLUSCA (PELECYPODA: UNIONIDAE) FROM THE NORTH OF SOUTH AUSTRALIA

BY N. H. LUDBROOK

Summary

Three species of Triassic freshwater mollusca of the family Unionidae occur in the Leigh Creek and Springfield Coal Basins. One species, *Unio eyrensis,* is redescribed and two, *Unio springfieldensis* and *Protovirgus iaenschi,* described *as* new. One Lower Cretaceous (Neocomian) species, *Protovirgus coatsi,* is described from the upper part of the Blythesdale Group on the Gardiner Military Sheet.

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[Read 13 October 1960]

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INTRODUCTION

This report deals with Triassic and Lower Cretaceous freshwater mussels collected by officers of the Geological Survey of South Australia during mapping of the Gardiner Military Sheet, bordering the north-eastern Flinders Ranges, about 350 miles north of Adelaide, and during investigation of the economic prospects of the Springfield Coal Basin about 210 miles north of Adelaide in the Flinders Ranges. The fauna of the Leigh Creek Coalfield is also considered.

Holotype and hypotype material is lodged in the Adelaide University Geology Department.

Abbreviations used for collections are:

A.U.G.D.: Adelaide University Geology Department.
A.M.: Australian Museum, Sydney.
N.M.V.: National Museum, Victoria.
S.A.M.: South Australian Museum.
G.S.S.A.: Geological Survey of South Australia.

THE SPRINGFIELD TRIASSIC FAUNA

During 1958 the South Australian Department of Mines investigated the economic prospects of the Springfield Basin, a structural basin containing Triassic sediments similar in many respects to those of the Leigh Creek Coal Basin. Results of mapping and drilling the Basin (Johnson, in press) and petrological studies of the pseudo-igneous rocks (Johnson and Bucknell, 1959) have been published elsewhere.

The Springfield Basin, located in moderately hilly pastoral country 26 miles north-east of Quorn, 239 miles by road north of Adelaide, is accessible from the road running east from the deserted town of Gordon to Cradock. Fossil freshwater mollusca were collected by W. Johnson and C. von der Borch from the pink and buff argillites at the top of the succession on the remnant mesa in the centre of the basin (Johnson and Bucknell, 1959, p. 247). Further material was collected by Dr. Mary Wade and the writer on April 24, 1960.

Two species are present in the pink and buff argillites, both previously undescribed. The brittle conchoidal fracture of the argillites does not assist

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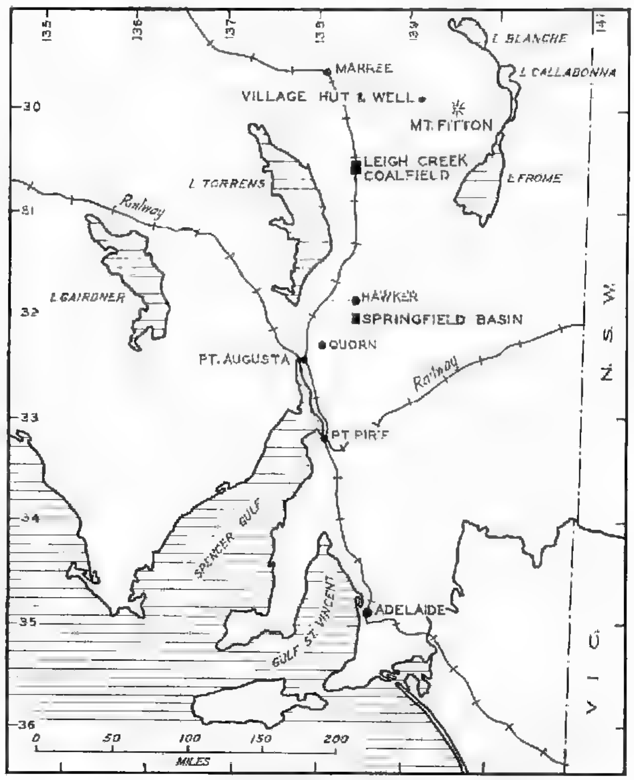
* Palaeontologist, Geological Survey of South Australia, published with the permission of the Director of Mines.

recovery of the specimens; preservation is poor and almost entirely as moulds, with valves open. An occasional specimen occurs with black epidermis retained on the mould. Associated with the mussels are numerous plant remains, principally *"Thinnfeldia" feistmanteli,* recently redescribed (Townrow, 1957) as *Dicroidium feistmanteli.*

THE LEIGH CREEK TRIASSIC FAUNA

The geological setting in which the Triassic molluscs occur on the Leigh Creek Coalfield operated by the Electricity Trust of South Australia has an extensive literature reviewed in Bulletin 31 of the Geological Survey of South



Locality Map.

Australia (Parkin, 1953). *Unio eyrensis* described from the field in 1891 was known only from limonitic casts until 1957 when Mr. A. F. Jaensch of Leigh Creek showed the writer the specimen (pl. 1, fig. 1) from which the external features of the shell can now be described. *Unio eyrensis* has not so far been found in the Springfield Basin, but a specimen of the *Protovirgus* here described as *Protovirgus jaenschi* which is a distinctive species of the Springfield fauna was found among original material from Leigh Creek in the Tate Collection at the University of Adelaide. The Leigh Creek specimens are much more substantial than those from Springfield.

THE LOWER CRETACEOUS SPECIES

The two specimens which represent the entire knowledge of the new species *Protovirgus coatsi* were collected on the Gardiner Military Sheet on the margin of the Great Artesian Basin off the north-eastern slopes of the Flinders Ranges, locality P/L 915 Sheet 115, 1 mile south-south-east of Western Spur, 3 miles south of Village Well. The species occurs as ironstone casts weathered out of ferruginized gritty sandstone with plant impressions belonging to the upper part of the Blythesdale Group. The age is considered to be Neocomian.

SYSTEMATIC POSITION OF THE MATERIAL

In restoring *Unio eyrensis* to the genus *Unio* and confirming Etheridge's recognition of the presence of the Unionidae in the Australian Triassic, the writer differs from McMichael and Hiscock (1958) who have (pp. 493, 495) on the assumption that *Unio eyrensis* was sculptureless and might be presumed to be a primitive mutelid, postulated the arrival of the Australian mutelid stock during the Triassic.

Certain morphological features of *Unio eyrensis* — the deep conical anterior adductor impression bounded by a buttress and the internal subumbonal ventral ridge are related to those of some early Mesozoic genera of the Cypricardiacea, notably *Kalentera* Marwick, 1952, and less closely to *Palaeopharus* Kittl, 1907. The similarity between the hinge-characters of *Palaeopharus* and of *Unio* were observed by Kobayashi and Ichikawa (1951, p. 8), who suggested that *Palaeopharus* might be a transitional form between the Pleurophoridae and the Unionidae, and the Unionidae characterised by pseudo-cardinals might be polyphyletic (p. 9). Cox (1960, p. 81) has recently discussed the possible origins and phylogenetic relationships of the Unionacea.

SYSTEMATIC DESCRIPTIONS

Family UNIONIDAE

Subfamily Unioninae

Genus Unio Philipsson, 1788

Type species (I.C.Z.N.) *Mya pictorum* Linné

Unio eyrensis Etheridge jr.

(pl. 1, figs. 1-6; pl. 2, fig. 5)

Unio eyrensis Etheridge jr., 1891, p. 11, pl. 3, figs. 1-3; 1892, p. 389, pl. 28, fig. 1.
Protohyria eyrensis (Etheridge jr.) McMichael, 1957, p. 228, pl. 13, figs. 8, 11 (*non* figs. 9, 10).

Diagnosis—A large solid fairly broad *Unio*, heavily sculptured with flattened concentric ridges, hinge with two triangular pseudocardinals and one long posterior lateral in the right valve, one triangular pseudo-cardinal and two long posterior laterals in the left valve. Anterior adductor impression deep, bounded by a buttress. Broad low subumbonal-ventral ridge on the interior.

Redescription — External characters (known from hypotype A.U.G.D. F 15472)—Shell inequilateral, elongate-ovate, rounded anteriorly, bluntly pointed posteriorly, inflated and solid. Periostracum thick, dark brown. Sculpture of prominent narrow flattened concentric ridges a maximum of 5 mm. apart in the dorsal half, fine concentric lirae between the ridges; owing to preservation ventral half showing fine growth lines and rest marks only. Beaks somewhat flattened, curved inward and forward, situated anteriorly. Smooth for about 10 mm. then wrinkled with irregular bifurcating plications for about 8 mm. before the first concentric ridge develops.

Anterior margin short, curved downwards under beaks, then roundly curving to ventral margin, posterior-dorsal margin nearly straight; ventral margin gently arcuate.

Ligament large, prominent, long; lunule apparently long, narrow and inconspicuous.

Internal Characters (holotype A.U.G.D. T 1347)—Shell deep, inflated, hinge plate fairly wide and flat with two triangular pseudocardinals and one long posterior lateral in the right valve, one triangular pseudo-cardinal and two long posterior laterals in the left valve.

Anterior adductor impressions deep and conical, bounded posteriorly by a strong buttress, anterior retractor impressions small, posterior adductor impressions inconspicuous. Pallial line firm. A broad low subumbonal-ventral ridge in front of which the shell was probably thicker than it was posteriorly. Ridge represented by a conspicuous sulcus on casts by which the species is mostly represented. The sturdiness of the shell is indicated by the fact that the casts are fully inflated showing no signs of collapse during deposition.

Dimensions—Holotype (internal cast) T 1347: Length 87 mm., height 45 mm., inflation (both valves) 40 mm., ratio posterior:anterior 75:12 mm.

Hypotype. F 15472: Length (est.) 90 mm., height 54 mm., inflation (both valves) 41 mm. posterior; anterior approx. 72:18 mm.

Location of Types—Holotype Tate Coll., A.U.G.D. T 1347; Hypotype A.U.G.D. F 15472; Paratype Aust. Museum, Sydney, A.M. F 9081.

Type Locality—Black Hills, Leigh Creek, latitude 30°30′, longitude 138°25′, on the southern end of the Leigh Creek Coalfield (Parkin, 1953; Parkin and King, 1953b, Sheet Myrtle). 1½ miles south of the present township of Leigh Creek and 3 miles north of the Copley Railway Station, formerly Leigh Creek R.S. and shown as such on H. Y. L. Brown's map 1891. *Unio eyrensis* weathers out as casts from ferruginous sandy shales occurring just above the Main or Telford Seam, which is about 400 feet above the base of the Triassic sequence (verbal information of R. K. Johns).

Material—The holotype T 1347. A note on the original label in Etheridge's handwriting reads "1 taken as duplicate"—this would be the paratype A.M. F 9081, which carries a similar label.

The hypotype A.U.G.D. F 15472 collected by A. E. Jaensch about 1945 in Telford Cut shortly after commencement of operations about 10 ft. from the surface on top of shale on the up-dip of the Cut and now presented to the writer for lodging in the Adelaide University Geology Department, and the following topotypes:

(1) *Adelaide University Geology Department.* 19 specimens in all, including one from Tate's original material labelled "Burnt Plain 10-12 miles north of Leigh Creek". 12 internal casts, about half of which show the hinge features; 3 showing traces of external sculpture, 1 external mould.

(2) *South Australian Museum.* 31 topotypes, including P 2114 2 ferruginous casts labelled "*Unio eyrensis* Tate" from old collection of S.A. School of Mines; P 2589 labelled "*Unio eyrensis* Tate" collected from shale and probably original Tate material, some shell preserved near the umbo, casts of anterior adductor impressions very well shown; P 4435 cast in shale from S.A. School of Mines old collection; P 9096 seven ferruginous casts collected by Sir Thomas Playford 1945; P 13028 twenty limonitized casts collected Dr. B. Daily 7/11/59 from ridge outcropping 1 mile SSW of present town of Leigh Creek.

(3) *Geological Survey of South Australia.* 16 topotypes with the following dimensions:

Length	Height	Inflation	Posterior:anterior
85≠	45	36	73:12
110	55	40	85:25
100	50	41	obscured
75	38	38	60:15
63+	40	32	obscured
78	42	42	obscured
81	43	35	71:10
72+	43	28	57+:15
110≠	52	37	85:25
85≠	46	30	73:12
64	37	24	54:10
92≠	45	35	79:13

≠ estimated.

Geological Survey of Queensland.

Hypotype F 2450 Bundamba S.E. Qld. "in brick clay overlying coal". Ipswich Coal Measures (Upper Triassic) mentioned Etheridge jr. 1892 G.S.Q. Pub. 92, p. 389. Coll. J. Malbon Thompson.

Hypotype F 227 Bundamba S.E. Qld. "in brick clay overlying coal". Ipswich Coal Measures (Upper Triassic) figd. Etheridge jr. 1892 G.S.Q. Pub. 92, pl. 28, fig. 1. Coll. J. Malbon Thompson.

Observations—McMichael (1957, p. 227) introduced the genus *Prohyria* for *Unio johnstoni* Etheridge jr., of which he had 5 specimens, and *Unio eyrensis* Etheridge jr. of which he examined and figured the paratype (A.M. F 9081 pl. 13, fig. 8) and probable topotype (N.M.V. P 16767 pl. 13, figs. 11, 12). The specimen N.M.V. P 16761 (pl. 13, figs. 9 and 10) referred to *U. eyrensis* from Lake Eyre was kindly lent to the writer by the National Museum of Victoria. It is neither morphologically nor lithologically related to the Triassic species and is a well-preserved example of the Aptian marine species *Panopea maccoyi* which, by comparison with other specimens including *Panopea maccoyi* collected by Dr. B. C. Forbes from the Lower Cretaceous of Fred's Springs two miles east of Lake Eyre railway siding, has almost certainly come from the same locality. The locality "Lake Eyre" (attached also to the holotype of *Unio eyrensis*) is a hazard for students of museum specimens, as a fairly wide geographical and stratigraphical range was included in the name "Lake Eyre Basin" in early records.

Unio johnstoni by original designation is the type species of *Prohyria*, but the generic description given by McMichael includes that of the "hinge well developed, with large cardinal teeth" of *Unio eyrensis*. The hinge of *Unio johnstoni* has not been described.

The two species appear to be unrelated. The hinge of *Unio eyrensis* is unionid (pl. 1, fig. 5) and can be reproduced in latex from many of the limonitic casts in which the species is usually preserved. The casts show very characteristic internal shell features — a broad well-marked umbo-ventral depression which corresponds to the internal ridge on the shell interior and the deep conical anterior adductor muscles bounded posteriorly by a buttress are represented negatively (pl. 2, fig. 5). These are clearly visible in the paratype F 9081 (McMichael, pl. 13, fig. 8) and were well illustrated in the original figures of the holotype (Etheridge, 1891, pl. 3, figs. 1-3) here refigured (pl. 1, figs. 2, 3, 4). The internal characters have features in common with the living European *Unio tumidus*, although the pseudo-cardinals are narrowly cuneiform like those of the Bear River Cretaceous *Ligumia vetustus* (Meek) and the Laramie Cretaceous *Margaritifera endlichi* (White), recently allocated (Modell, 1957) to genera other than *Unio*. Etheridge (l.c. p. 12) drew similar comparisons in his original description: "Little more can be said of these Mesozoic Unios, except that they are quite unlike any of the Recent Australian species, being evidently much more substantial shells. In the presence of the partition behind the anterior muscular scars our fossils correspond to a certain extent with some of the more ponderous American species." The species was known only from internal moulds until Mr. A. E. Jaensch collected the splendid specimen (pl. 1, fig. 1) from Telford Cut on the Leigh Creek Coalfield which has enabled the external characters to be determined for the first time. European Tertiary Unios (Modell, 1959) appear to have somewhat similar sculpture.

The species from Bundamba, Queensland, Ipswich Coal Measures (Upper Triassic), referred to *Unio eyrensis* "Tate" (Etheridge, 1892, p. 389. pl. 28, fig. 1) is retained in the synonymy. The two specimens G.S.Q. F 227 (figd. Etheridge l.c. pl. 28, fig. 1) and F 2450 (internal cast mentioned by Etheridge, p. 389) have been kindly lent by the Geological Survey of Queensland. Both are close to and congeneric with *Unio eyrensis*, although the strong concentric ribbing is not preserved. The Queensland specimens are very thick shelled and solid, with relative dimensions: F 2450 length 71, height 34 mm.; F 227 length (estimated) 79, height 38 mm.

Like the Leigh Creek examples, they are preserved as limonitized casts for the most part, with internal features similar to those of the type series. Their habitat was probably similar also. In shape and such features as are preserved the Bundamba specimens may be compared with the living European *U. tumidus* Philipsson and with *Unio karrooensis* Cox from the Manda Beds (Lower Stormberg, or Upper Triassic) of the Ruhuhu Coalfields, Tanganyika (Cox, 1932).

Apart from the conspicuous concentric sculpture, the writer is unable to distinguish any generic characters which would appear to separate the Triassic *eyrensis* from *Unio*. The species has so few morphological characters in common with *Protohyria johnstoni* that its retention in *Protohyria* seems unwarranted. The genus *Unio* is therefore regarded as the best available location for *eyrensis* at present.[1] *Unio* was formerly considered to be established in North America as elsewhere during the Triassic (White, 1907; Henderson, 1935), but most of the American species have now been placed in other genera (Modell, 1957).

The strong sculpture and substantial nature of the shell of *eyrensis* and the restricted area in which most of the specimens are found indicates that they were probably of fluviatile habitat, deposited at the mouth of a river entering the Leigh Creek Basin.

[1]While the present paper was in proof volume 87, part 2, of the Records of the Geological Survey of India dated 1958 was received. This contained a paper by M. R. Sahni and A. P. Tewari entitled New Unionids from the Triassic (Gondwana) Rocks of Tihki, Vindhya Pradesh and Maleri, Hyderabad Deccan. *Rec. Geol. Surv. India* vol. 87, pt. 2, pp 408-417, pls. 1-2, in which the authors have described four species of unionids from the Upper Triassic of India for which the genus *Tihkia* is created. From the figures and description, *Tihkia corrugata* agrees so closely with *Unio eyrensis* that there can be little doubt that they are congeneric. If, therefore, *Unio* is not the correct location for *eyrensis* and *springfieldensis* the genus *Tihkia* should be considered for these species.

Unio springfieldensis sp. nov.

(pl. 2, figs. 1-2)

Diagnosis—A medium sized thin *Unio*, smooth but for growth lines, posterior margin broadly rostrate.

Description—Shell of moderate size, apparently thin and easily squashed, broadly wedge-shaped. Anterior margin somewhat obliquely arcuate; posterior margin produced and broadly rostrate where preserved. Cardinal margin arcuate. Anterior dorsal margin oblique and gently slightly arcuate posterior dorsal margin nearly straight. Ventral margin curved; a slight umbo-posterior ridge. Ligament prominent. Shell apparently nearly smooth but for fine growth lines and irregular concentric folds which are probably mostly due to compression of the shell during deposition. Internal features unknown.

Dimensions—Holotype external mould A.U.G.D. F 15473. Length 75 + (estimated 85) mm.; beak height 30 mm.; posterior:anterior ratio 60:25 mm. Ligament 19 mm. Paratype: A.U.G.D. F 15474. Length 90, beak height 36 mm.

Material—Holotype and paratype both external moulds and examined from latex casts, both valves open and preserved upside down on weathered surface of argillite. Paratype G.S.S.A. F 44/60 figured pl. 2, fig. 2 showing posterior margin. Paratype: External mould of a fairly large specimen preserved upside with 2 valves open flat and partly obscured: valves crumpled. Length 100 mm., beak height 30. Topotypes 2 moulds of single valves and 23 incomplete impressions.

Location of Types — Holotype A.U.G.D. F 15473. Paratype A.U.G.D. F 15474. Paratype Geol. Surv. S.A. F 44/60.

Type Locality—Small central mesa, Springfield Basin. Section 48, Hundred of Cudla Mudla, 13 miles west of Cradock, in pink and buff argillites at the top of the Triassic succession.

Observations—In contrast with *Unio eyrensis*, this thin, smooth species was probably of lacustrine habitat and was deposited in the fine mud of the still waters of the Springfield Basin.

Genus Protovirgus McMichael, 1957

Type species (o.d.) *Unio dunstani* Etheridge jr., 1838

Protovirgus jaenschi sp. nov.

(pl. 2, figs. 3, 4)

Diagnosis—A fairly large inflated and solid *Protovirgus* having close-set fairly coarse rounded ridges with fine growth lines towards the ventral margin.

Description—Shell narrow, elongate-ovate, beaks very anterior, situated at less than the anterior one-tenth, flattened and apparently smooth. Anterior margin short and well curved, posterior margin attenuated, obliquely rounded, dorsal margin nearly straight, ventral margin gently curved, with an inflexion in the posterior one-third. Sculpture of fairly coarse and close rounded ridges with fine growth lines, strong ventral margins. Ligament fairly long and prominent.

Hinge unknown. Shell anterior apparently with a broad subumbonal-ventral ridge represented by a sulcus on the internal cast. Anterior adductor impressions fairly deep, bounded behind by a buttress.

Dimensions—Length 80 mm.; maximum height 31 mm. (posterior to beaks); beak height 30 mm.

Type Locality—According to Tate's old label "Burnt Plain 10 to 12 miles north of Leigh Creek". This is the present location of Lobe C, northern basin, 5 miles north of Leigh Creek township, where shale outcrops continuously around the margin of the Basin (Johns, 1956, p. 138).

Location of Holotype—Tate Coll. A.U.G.D. F 15475.

Location of Paratype—F 15476.

Location of Ideotypes—G.S.S.A. F 80/58 B-C, F 43/60.

Material—The holotype F 15475, the only specimen known from the Triassic of the Leigh Creek Basin.

Paratype, external mould, from the pink argillites at the top of the Triassic succession in the central mesa, Springfield Basin.

Sample F 80/85. Ideotypes, all external moulds from pink argillites top of mesa Springfield Basin.

Observations—The hinge of the species is unknown, but some of the internal characters are preserved on the holotype. The anterior adductor and buttress though less prominent, resemble those of *Unio eyrensis*. In erecting the genus, McMichael (1957, p. 231) noted its uncertain affinities. The visible characters of the South Australian species appear to be similar to those of *Unio* and on present evidence there is no apparent reason for placing *P. jaenschi* elsewhere than in the *Unionidae*.

The species is named for Mr. A. E. Jaensch who collected the first specimen of *Unio eyrensis* showing the external features.

The external resemblance of *Protovirgus jaenschi* to the marine form *Kalentera marwicki* Grant-Mackie is, however, very striking. *Kalentera marwicki* occurs with an abundant associated marine fauna (Grant-Mackie, 1960, p. 77) in the Otapirian (Rhaetic) and Warepan (Norian) of New Zealand.

Protovirgus coatsi sp. nov.

(pl. 2, fig. 6)

Diagnosis—A medium sized *Protovirgus* with gently curved posterior ridge, convex posterior dorsal margin and concave ventral margin.

Description—Shell of medium size, compressed, elongate, narrow, length about 2¼ times maximum height, beaks anterior, situated at about one-fifth of length of shell from anterior. Maximum height just posterior to beaks. Dorsal and ventral slopes approximately parallel; dorsal margin gently convex and elevated posterior to beaks then curving more sharply downwards to the posterior margin which is produced narrowly rounded; dorsal margin slightly excavate, anterior to beaks, then straight; ventral margin concave, with a broad sinuation in the middle of the shell. Posterior ridge fairly well marked and gently arcuate. Beaks flattened, apparently unsculptured, not prominent; ligament moderately prominent, no lunule visible.

Sculpture of concentric ridges.

Internal characters unknown.

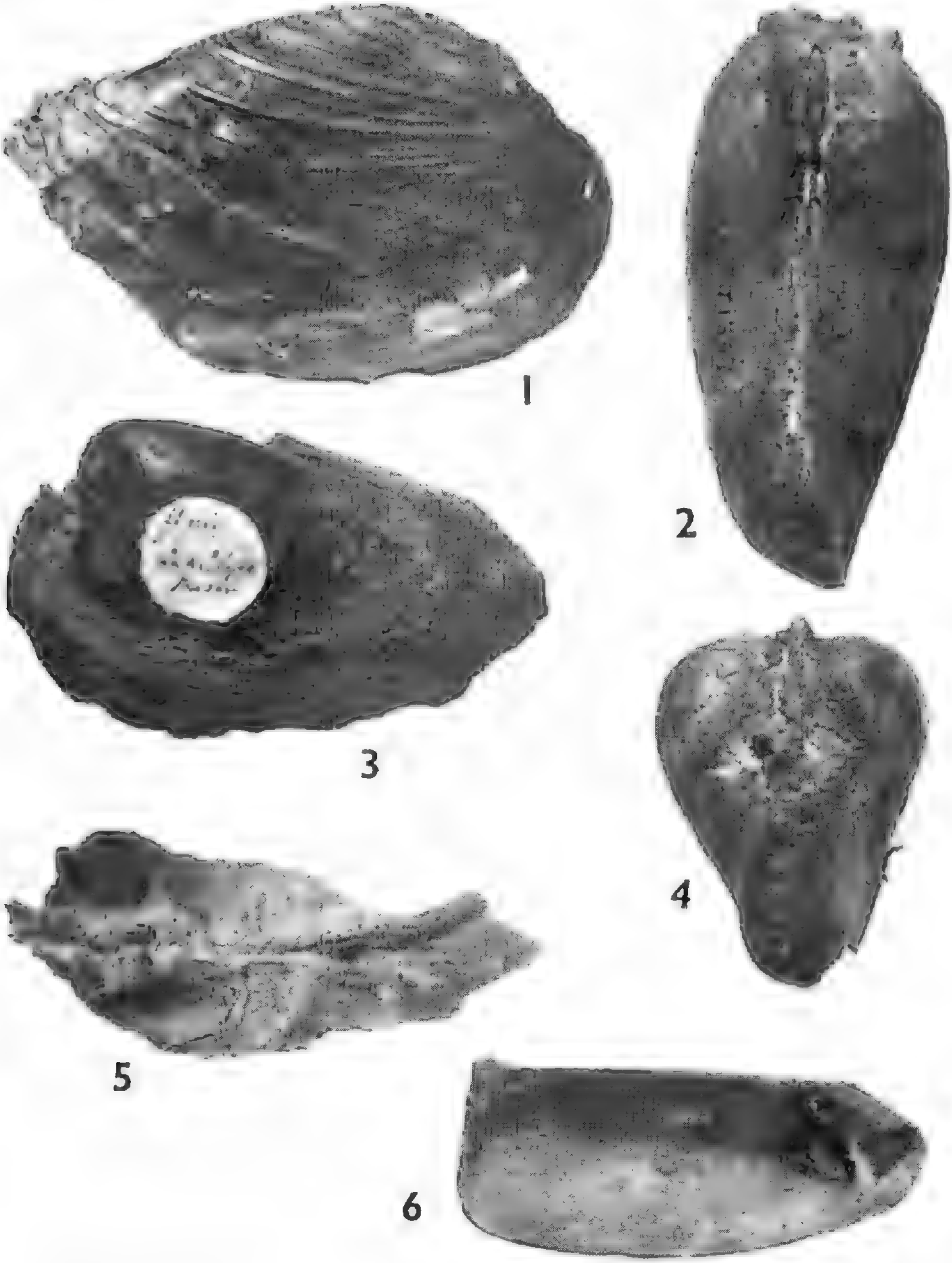
Dimensions—Length 56 mm., maximum height 25 mm., beak height 24 mm., posterior:anterior 45:11 mm.

Type Locality—Gardiner M.S., P/L 915, Sheet 115, 1 mile south-south-east of Western Spur 3 miles south of Village Well in ferruginized gritty sandstone with plant impressions.

Stratigraphic Position—Neocomian sandstones of Blythesdale Group.

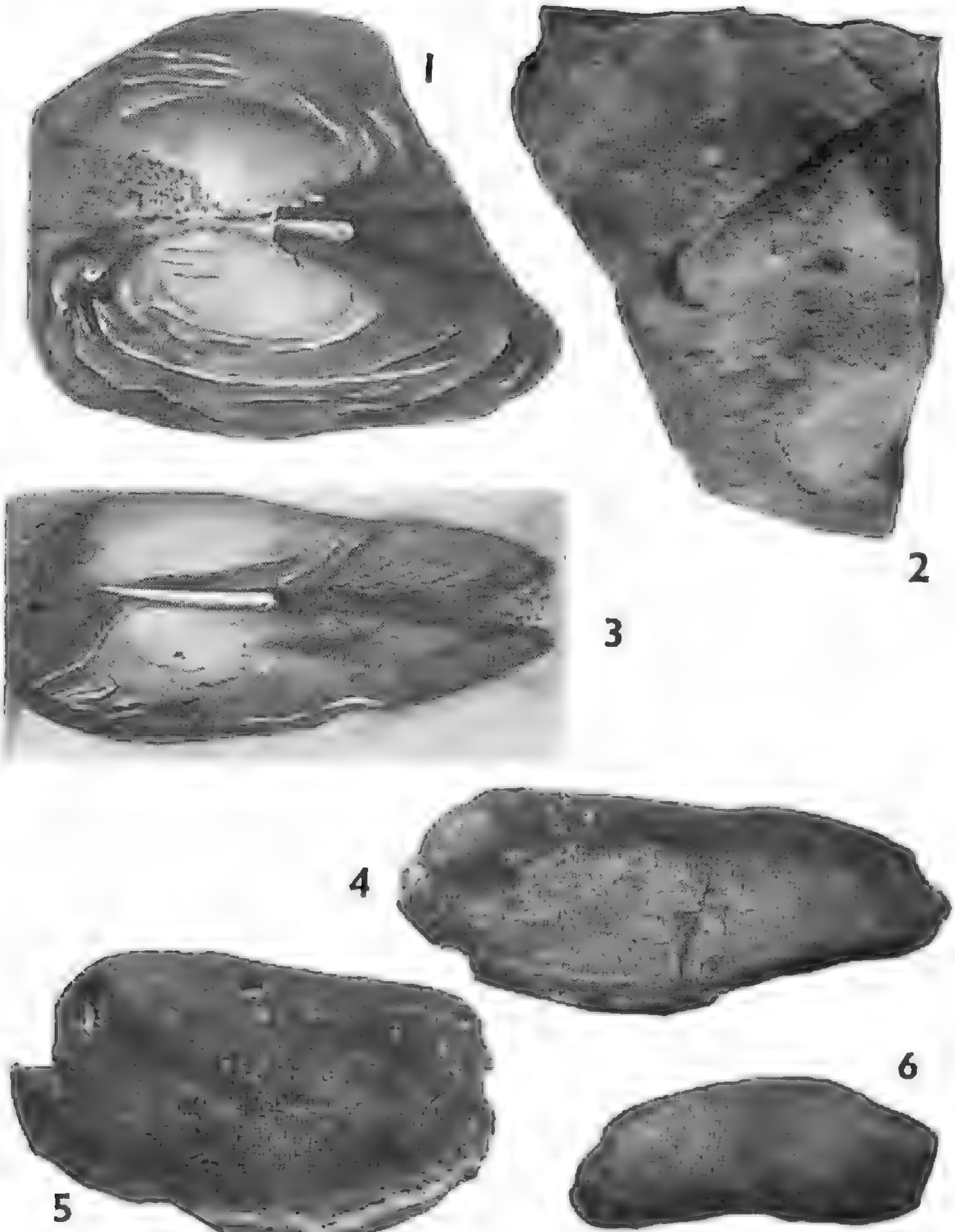
Location of Holotype—A.U.G.D. F 15477.

Material—The holotype, an internal cast in ferruginized sandstone, collected R. P. Coats. One paratype, internal cast of two spread opened valves in ferruginized sandstone, collected N. H. Ludbrook, sample F 114/58.



1. *Unio eyrensis* Etheridge, jr. Hypotype A.U.G.D. F 15472.
2. *Unio eyrensis* Etheridge, jr. Holotype A.U.G.D. T 1347, dorsal view.
3. *Unio eyrensis* Etheridge, jr. Holotype A.U.G.D. T 1347, side view.
4. *Unio eyrensis* Etheridge, jr. Holotype A.U.G.D. T 1347, anterior view.
5. Latex mould of dorsal interior of holotype of *Unio eyrensis* showing hinge features.
6. Latex mould of anterior portion of left valve of holotype of *Unio eyrensis* showing anterior adductor impression and buttress.

All figures natural size, from unretouched photographs of B. Ruxton.



1. *Unio springfieldensis* sp. nov. Latex cast of holotype A.U.G.D. F 15473.
2. *Unio springfieldensis* sp. nov. Paratype F 44/60 with *Dicroidium feistmanteli* on pink argillite.
3. *Protovirgus jaenschi* sp. nov. Latex cast of paratype A.U.G.D. F 15476.
4. *Protovirgus jaenschi* sp. nov. Holotype A.U.G.D. F 15475.
5. *Unio eyrensis* Etheridge, jr. Topotype showing cast of deep anterior adductor impression and cast of umbo-ventral ridge.
6. *Protovirgus coatsi* sp. nov. Holotype A.U.G.D. F 15477.

All figures natural size from unretouched photographs of B. Ruxton and wash drawings (Figs. 1, 3) of the author.

The species is named for Mr. R. P. Coats of the Geological Survey of South Australia, who collected the holotype during field mapping of the Gardiner M.S.

Observations—The species resembles an unnamed specimen P 17670, National Museum of Victoria from Korrumburra, the stratigraphic position of which is probably comparable with that of *Protovirgus coatsi.*

ACKNOWLEDGMENTS

For the donation and loan of material the writer is indebted to Mr. A. E. Jaensch of Leigh Creek, Dr. Mary Wade, University of Adelaide, Dr. B. Daily, South Australian Museum, Mr. E. D. Gill, National Museum of Victoria, and Mr. A. Denmead, Chief Government Geologist, Queensland. Dr. D. F. McMichael kindly criticized the manuscript. The photographs were taken by Mr. B. Ruxton, Department of Lands.

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A RE-EXAMINATION OF MESEMBRIOMYS HIRSUTUS1 GOULD 1842 (MURIDAE)

BY H. H. FINLAYSON

Summary

The characters of *Mesembriomys hirsutus* Gould are re-examined with fresh material. Detailed evidence of its arboreal specialization is presented. The validity of the insular form *M. hirsutus melvillensis* Hayman is confirmed. Some aspects of the living animal, of skull and dentition, manus and pes, are illustrated.

A RE-EXAMINATION OF *MESEMBRIOMYS HIRSUTUS*[1] GOULD 1842 (MURIDAE)

by H. H. FINLAYSON

[Read 13 Oct. 1960]

SUMMARY

The characters of *Mesembriomys hirsutus* Gould are re-examined with fresh material. Detailed evidence of its arboreal specialization is presented. The validity of the insular form *M. hirsutus melvillensis* Hayman is confirmed. Some aspects of the living animal, of skull and dentition, manus and pes, are illustrated.

I owe to the kindness of my friend and former student, Wilfred Bateman, Esq., now of the Commonwealth Administration in Port Darwin, a magnificent living specimen of this great tree rat of Northern Australia, which though formerly much collected and written upon taxonomically, is still very imperfectly known.

The specimen was caught by blacks near Garden Point, Melville Island, where it is still plentiful and it occurs also on the adjoining Bathurst Island across the mile-wide Apsley Strait. Formerly it was a common animal in suitably forested country over much of the Northern Territory as far south as Daly Waters, but in recent years its numbers have declined and in many of the localities of the Daly River sector, where Knut Dahl found it plentiful in 1894-95, it seems now to be a rarity. It occurs also on Cape York Peninsula, Queensland. Dahl recorded the aboriginal names Nunjala, Dombot and Kalambo for the species and the last of these is still in use by mixed Tchingilli and Mudburra blacks at Daly Waters, though it is 20 years since the animal was seen by them there. Mr. Bateman also supplies the names Intamunga and Puturamucka as being used on Melville Island. About 60 specimens have been listed in overseas collections, but it is much less well represented in Australian museums.

The animal was flown to me from Port Darwin and the air lift of 2,000 miles, spanning a considerable climatic gap, terminated in unusually cold weather in an Adelaide spring (August) which continued for much of the period of captivity. Although it was provided with artificial warmth and much thought taken for its comfort in roomy quarters, it remained extremely secretive and could only be momentarily glimpsed by torch light. When denied its

[1] The specific name *hirsutus* was consistently used for the species through all the changes in its generic designation from *Mus hirsutus* of Gould 1842, through *Hapalotis, Conilurus, Ammomys* to *Mesembriomys*, and in the definition of its three subspecies. In recent years it has been superseded by *gouldii* of Gray 1843 on the grounds of its preoccupation by *Mus hirsutus* of Elliot 1839. The animal so named by Elliot is now known as *Golunda ellioti* Gray 1837 (fide Ellerman) and belongs to an Oriental genus whose species cannot possibly be confused with those of the Australian *Mesembriomys*. In view of these facts and of its unambiguous use for 90 years in all the formative contributions to the knowledge of the animal, there would seem to be a strong case for the conservation of *hirsutus* in *Mesembriomys*. This would make possible the continued use of *gouldii* in *Notomys*, as is done as late as 1951 by Tate.

nesting box occasionally for observation it repulsed all advances with implacable ferocity and was a difficult subject for photography, so that the attempt to gain some insight into its habits and peculiarities was largely nugatory. Dahl (1897) writes of its irritability and savage temper in the wild and the severity of its biting, and the blacks I interrogated at Daly Waters in 1953, who formerly took it by hand from hollow trees, also spoke feelingly of what they called its "cheekiness". In its frequent rages, the captive displayed considerable vocal powers of a kind quite different from the squealing and piping of more normal forms, such as *Rattus, Pseudomys, Gyomys* and *Mus,* raising its voice progressively into a sort of whirring machine-like crescendo, not unlike some of the *Phalangeridae*, such as *Petaurus breviceps.* There was no difficulty in keeping it nourished as it ate very freely of sugared biscuits of several sorts (a taste evidently inculcated by the air hostess, as his box was strewn with them on arrival), of bananas and other soft fruits and of mixed grain, but showed no interest in green vegetation nor flesh foods. Dahl records that the chief food of the species in the Daly River districts is the fruit of the local *Pandanus odoratissimus,* but the stomach of one of those examined below, which was taken on the Stewart River in North Queensland, was crammed with a gritty mass in which the shell of a fresh water mussel appeared to be the chief constituent. When examined after three months' detention, the Garden Point animal was found to be in excellent condition, weighing 670 g. and showing a smooth, well-groomed coat; no external parasites were noted. Ellerman (1941) records a life span of more than four years in captivity in London.

In checking over the characters of the species, I have used for comparison eight other specimens in the South Australian Museum representing all three of the areas from which the described geographic forms have come. Six of these were collected for the Museum in 1913-14 by Mr. W. P. Dodd, whose itinerary in the field was planned during the directorate of Sir Edward Stirling and two are donations from Mr. P. Foelsche, formerly stationed at Port Darwin. The account which follows is based primarily on my freshly chloroformed captive, which is a young adult male, and four additional examples from Melville Island, and thus represents the form *M. hirsutus melvillensis* Hayman 1936; where subspecific uniformity is departed from, it is noted in the text, and an appraisal of the validity of the described forms, as far as the material permits, is appended later.

EXTERNAL CHARACTERS

Form stout, with sturdy arms and shoulders and thick neck; the hind quarters are considerably larger than the fore, but not greatly exaggerated.

The *head* (Plate 2 and Plate 3, Fig. A) large and deep, with a strongly protuberant rhinarium and labia well developed but not pouted as in *Leporillus.* At a point one-third of the distance from the rhinarium to anterior canthus of the eye, there is a dent in the profile, the remaining curvature to the crown being moderately convex. The eye is large, black and very brilliant and is surrounded by an area of almost nude epidermis, which in turn is conspicuously ringed by a narrow band of jet black hair; the upper eye lashes are fairly well developed reaching 4 mm. in length. The ear is large, thick in substance, rather narrow and with its maximum breadth below the midpoint; it is carried well away from the head and conspicuously pricked. The epidermis of its inner surface is dusky brown with bluish pink areas showing through on the conch and the margins almost black; processes of the conch are well marked and the tragal notch deep and undivided. The cephalic *vibrissae* are strongly developed and entirely black except for the interramals which are paler at the tip. The mysticial set reach 100 mm. as a maximum, the supraorbitals 38 mm., and the genals, two of which spring from a very strongly developed papilla, 35 mm. The postoral group was not traced in adults of the Melville Island lot, but in a subadult all-black bristles on this site reached 14 mm. and in an adult female of *M.h. rattoides*, 20 mm.; the submentals reach 12 mm. and the interramals 23 mm.

The general physiognomy is distinctive and in some features sciuroid rather than murine.

The *manus* is variably developed, but is usually large in respect to the general size of the animal, and sometimes much stouter than in the example figured (Pl. 3, Fig. C). The length from base of metacarpal pads to apical pad, excluding claw, reaches 30 mm. in adults, the breadth from base of digit 5, 14 mm., yielding a breadth/length ratio of 0·47, the 3rd digit, 13 mm., and its nail 8 mm.; in two examples of the typical race in which the manus is very heavy the breadth rises to 16 mm. and the value of B/L to 0·53 as maxima. The digital formula is the normal $3 > 4 > 2 > 5 > 1$, but the pollex is unusually large and apparently functional and provided with a broad, blunt, projecting sheath-like nail; the claws of the other digits varying much in length from individual to individual, but always stout and strongly curved and unusually deep dorso-ventrally at the base; pale yellowish in colour, but slightly darkened along the dorsal curve.

The general palmar surface is lightly creased, not noticeably punctate and in life its colour is a pale slightly bluish pink with the pads and digital ridges strongly contrasted in blackish brown. The palmar aspect of the digits is quite hairless, and the ridges prominent, entire and unusually numerous; 8 or 9 on D3 and D4, but reaching 11 in one subadult of the typical race—the highest count noted on an Australian murid. The metacarpal pads are broad and obtusely oval and greatly exceed the interdigitals in area; the outer (hypothenar) much larger than the inner, which has its long axis inclined laterad towards the pollex and its distal margins well raised above the base. The lateral interdigitals are subtriangular or inverted heart-shaped, with a strongly developed satellite pad at the base of the outer, and the median pad a broad inverted pyriform; the size sequence for area is outer metacarpal > inner metacarpal > 3rd interdigital > 1st > 2nd. The palmar pads are strongly striated, the apical pads of the digits, feebly so.

The *pes* (Plate 3, Fig. B) has numerous well-marked peculiarities. Its dimensions vary, but yield several maxima which exceed all other Australian murids, except possibly the species of *Uromys*. In plantar aspect it tapers strongly from a broad interdigital area to a nude strongly constricted heel; its relative size is large, attaining in the largest examples 25 p.c. of the head and body length and a maximum breadth/length ratio of 0·30; the 3rd digit reaches 16 mm. and its nail 9·5 mm. (11 mm. in one example of *M.h. rattoides*). The digital formula is $4 > 3 > 2 > 5 > 1$, but the disproportion between the lateral and median digits is much less than that which prevails in the majority of Australian species, both the hallux and D.5 being longer in their phalanges and at the same time their bases are brought into a more anterior position on the pes, by longer metatarsals supporting them. Thus the apical pad of the hallux, which in most Australian species lies far below the level of the base of D.2, here reaches to its posterior third, and similarly that of D.5 to the anterior third of D.4. The digital ridges are strongly developed and clear cut and are entire except posteriorly, where some obscure bifurcation may be seen; all show more or less distinctly the novel feature of antero-posterior striation, but there is no scalation; they are numerous, ranging from 9-11 on the median digits in the Melville Island material and to 14 in a subadult of the typical race, which (like that of the manus) is the highest count I have obtained in an Australian rat. The claws are still stronger than in the manus and almost equally curved, and slightly darker in colour.

The plantar surface generally is soft and plump, markedly punctate, but with the creasing reduced to a minimum; the colour in life as in the manus, but with the differential darkening of the pads and digital ridges carried still further. The disposition of the *interdigital pads* is unusually symmetrical owing to the above peculiarity of the lateral digits; they are of but moderate size, but very sharply defined and well raised above cingulum-like structures, which also have margins almost as well defined as the pads which surmount them, in contrast to the rather amorphous folds of integument usually found in that site. The lateral pair are somewhat kidney shaped; the inner (I.D.1) with two rather ill-defined accessory pads at its postero-external corner and the outer (I.D.4) with a single well-defined satellite at the middle of its postero-lateral margin, and a vestige of another anterior to it; the 2nd inter-digital is obtusely oval and the 3rd inverted pyriform, and the size sequence (area) is approx. $1 = 4 > 2 = 3$.

The *metatarsal pads* are remarkably elaborated. The inner pad takes the form of a shallow crescent- or boomerang-shaped structure, concave outwards and with an overall length of 19 mm. and average width of about 2 mm., expanding to 3·5 mm. at the club-shaped upper extremity. In the example figured (Pl. 3, Fig. B) there is a well-marked antero-internal process reaching out into the centre of the sole towards a corresponding process of the opposite pad – this feature, however, is absent or only very weakly indicated in the other eight examples examined. The outer metatarsal pad is of enormous length and when undivided may span two-thirds of the interval between the heel and the 4th interdigital; it runs an almost straight line course parallel to the margin of the foot and has a maximum length of 28 mm. and average width of 2·5 mm. expanding to 4·5 mm. at the anterior extremity. It is constricted at several points in its length and in most examples splits up at these necks into a chain of from two to four separate elements with low gaps between, but entire and divided pads may occur on opposite feet of the same animal. All pads are strongly striated at right angles to their long axes, except the apicals, which are concentrically engraved.

The tail is very long and flexile, but gives no external evidence of prehensile functions; its length ranges in the Melville Island material from 108-128 p.c., but reaches 150 p.c. of the head and body length in one example from Arnhem Land; it tapers gently and uniformly to the small horny spur which forms its apex. The *scrotum* in the captive male is conspicuous and well distended to accommodate enlarged testes in November, but the condition was not checked satisfactorily in wild caught examples. The *mammae* are abdomino-inguinal only; $0\text{-}2 = 4$; in a subadult female of the typical race, they were large; the posterior about 5 mm. from the base of the genital tubercle and the anterior 11 mm. from the posterior.

EXTERNAL DIMENSIONS

Some external dimensions of nine examples are summarized in the table below. Number 4 was measured in the flesh shortly after death; number 5 is a filled skin, and the rest are alcohol preserved.

	ARNHEM LAND			MELVILLE ISLAND					NORTH QUEENSLAND
	Young Adult ♂	Sub-ad. ♂	Sub-ad. ♀	Young Adult ♂	Adult ?	Sub-ad. ♂	Sub-ad. ♂	Adult ♀	Adult ♀
	1	2	3	4	5	6	7	8	9
Head and Body	300	210	200	284	268	205 ca.	228 ca.	297 ca.	315 ca.
Tail: length	277 inc.	286	300	363	310	265 ca.	245 ca.	330 ca.	350 ca.
Tail: % H and B	–	136	150	128	115	129	108	111	111
White of Tail	—	73	85	80	82	—	—	80	107
Pes: length	67	62	62	71	64 ca.	59	58	62	64
Ear	36	36	36	38 × 18	—	31 ca.	33 ca.	35	35 ca.
Rhinarium to eye	35	30	28	36	—	28 ca.	28	35	38
Eye to ear	23	20	18	24	—	19 ca.	18	22	22

PELAGE

The type on which Hayman (1936) based his description of the pelage of *M. hirsutus melvillensis* was an animal kept in captivity in London. Although in good agreement with the material now examined, it has been thought well to supplement it in some particulars by the following observations made upon field skins of animals killed in the wild as well as on the Garden Point specimen kept in captivity here.

Coat comparatively harsh and thin; mid-dorsally there are three series. (1) An underfur of 14 mm. not slaty nor plumbeous as is usual, but very dark grey or blackish (about Ridgway's fuscous black) and not, or very obscurely, annulated. (2) Stouter hairs of 23 mm. concolorous with the underfur in the basal half, which is followed by a 5 mm. band of warm buff, and the extreme tip, black. (3) All black guard hairs to 42 mm. The general colour of the dorsum is a coarse grizzle of black and buff, paler on the nape and forequarters, but rapidly darkening to almost black on the mid-dorsum and rump, through a great increase in the number and length of the guards. A small area on the nape and prescapular area is more richly coloured than the rest, the subterminal band here being an orange buff, near Ridgway's ochraceous tawny.

The ventrum is shorter furred, and with the basal colour paler than on the dorsum, but still drab rather than plumbeous (about hair brown). The underfur of 10 mm. is overlain by a second series reaching 18 mm. with a terminal band of pale buff, and lightly sprinkled with all black hairs. The basal drab shows through strongly and the general effect is of a dull buffy grizzled grey which occupies all the ventrum and extends on to the anterior lateral surface as well. Except for the darker scrotum, the whole ventrum is very uniform. There is a narrow nude area in advance of the genital tubercle and the narrow posterior extremities of the scrotum are also nude and with the epidermis nearly black.

Crown of head, cheeks and neck grizzled like the lower foreback. Lips, rhinal and mysticial area and a ring round the eyes jet black and the muzzle also much darkened though finely grizzled. Ears densely furred jet black on the whole external surface and on the interior margins, and strongly contrasted with the crown. Outer aspect of forelimb darker than the adjacent lateral surface and becoming increasingly so distally until carpus, metacarpus and digits of manus are jet black, with no lighter markings. Hind limb also darker externally than the adjacent body surface and becoming glossy jet black on tarsus, metatarsus and digits with a similar absence of variegation. The tail strongly haired on all surfaces, largely obscuring the scales which are 8 per cm. proximally and 6 per cm. mid-dorsally, where the hairs are 5 scales long. It is jet black on all surfaces except for a variable apical portion which becomes abruptly greyish white and lengthens progressively on all surfaces to a terminal pencil of 40 mm. ca.

The Garden Point specimen, after three months captivity in Adelaide, was found to be in a different moult phase from the above, the three components of the much shorter coat averaging mid-dorsally 9, 16 and 27 mm. respectively. The coat was glossy and even but on the posterior back showed a heavily grizzled replacement coat mingling with the fuscus underfur. The second series in the London type, with a length of 35-40 mm., is much longer than in any of the local material.

THE SKULL AND DENTITION

The cranial and dental characters of the species were briefly diagnosed by Thomas (1906, 1909) and dealt with in more detail by Ellerman (1941) and Tate (1951), sometimes with conflicting results. The following notes at species level covering some additional points, are based on the skull of the Garden Point specimen, together with that of a young adult ♂ from Arnhem Land at the same stage, and a much younger male skull with unworn molars from the same area.

The skull is stout and densely ossified. The general form in dorsal aspect is narrow, with the maximum zygomatic breadth less than half the greatest length (0·44-0·48), zygomatic arch with the maximum width either median or posterior in adults and the combined outline a narrow oval somewhat flattened at the sides and in the young skull slightly concave; the anterior root of the zygoma, though massive, has little lateral development, dropping rapidly below the dorsal level. Rostrum heavy and broad, the nasals with little posterior taper and the least width at the nasofrontal suture about 28 p.c. of the length. Preorbital fossa medium in size, rather narrow from above and with the outer wall slanting inwards rather markedly. Anterior frontal region unusually broad and inflated and infringing on the orbits so that the lacrymals, which are small and rugose, are deeply imbedded between the frontals and the zygoma root and scarcely project into the orbit at all. Interorbital region strongly concave as noted by Ellerman, a distinct depression extending to or beyond the coronal suture. Brain case much longer than wide and with feebly developed temporal crests following the rather sharply angulated parieto-squamosal suture to the supraorbital ridges, which in the Melville Is. example especially, are sharp and slightly overhanging. Interparietal as given by Collett (1897); a large, broad sharply angulated element.

In lateral aspect the most conspicuous feature is the sharp division of the dorsal profile into two distinct planes meeting in an angle of ca. 155°, the junction being slightly in advance of M¹ and marking the maximum depth of the skull. The anterior margin of the zygomatic plate has a convex but somewhat sloping shoulder without spine and its lower course is variably pitched and may be the seat of racial difference (*infra*). The tympanic annulus is large, and has prominent thickened margins and the lingulate process of the squamosal overlying the petrous temporal and mastoid is developed to remarkable strength and is a conspicuous object above and behind the meatus.

The anterior palatal foramina are variable as to breadth, overall shape, position of septal suture and posterior extension—in the latter particular they fall short of the molar rows by half the length of M¹ in the Melville Island skull and almost reach them in the immature Arnhem Land specimen. Two minute (? nasopalatine) foramina are constantly developed in the premaxillae, anterior to the incisive canals and within 2 mm. of the alveolar border; they are evidently homologus with those which in *Leporillus* coalesce to form a single median aperture at the same site. The palate has been described in contradictory terms by Ellerman and Tate; in the present material, at its narrowest point between the first molars, I find that its breadth compared with that of M¹ varies from 1·7 in the heavy toothed Arnhem Land skulls to 2·1 in that of Melville Island; so measured, the palate is certainly not narrow therefore, and might be described as broad in relation to the majority of Australian species; the median spur on its posterior margin may be strongly developed or almost suppressed. The pterygoid plates are also very strongly developed and terminate bluntly without hamular processes. The bullae fall short of the molar rows in length, and in so large a skull, are relatively small. A very conspicuous feature in the palatal aspect of the skull is the great width of the mesopterygoid fossa—half as great again as that of the ectopterygoid.

The mandible is massive, has a straight inferior border and comparatively slight emargination of the posterior border above the angle; the coronoid is distinctly developed though much reduced, its relative size about as in *Mastacomys fuscus* and *Leporillus jonesi*. Within the Zyzomyid group of genera, the relative development of the coronoid appears to follow the sequence *Zyzomys* > *Laomys* > *Mesembriomys* > *Conilurus*.

The upper incisors are very large teeth with a variable angle: the Melville Island example being less opisthodont than those from Arnhem Land; in the former also the incisors are notched almost as in *Mus musculus*. In the molars the cingulum of M¹ is large and prominent anteriorly, but the accessory cuspules, two or more of which are usually claimed for the dentition, are either absent or very small and imperfect and could not justly be compared with the *Leggadina* condition. The buccal cusps vary from skull to skull and sometimes on the two sides of the same skull; T.3 of M¹ although small is generally quite distinct and separate, but T.6 and T.9 are almost absorbed by the median cusp. In M² an interesting feature in one of the mainland skulls is a very distinct though minute T.3 as in *Apodemus* and *Acomys* of the Palaearctic; it is also feebly indicated in the Melville Island individual. In the latter also (on one side only) a supplementary cusplet is crowded in between T.1 and T.4 giving the appearance of a duplication of the former. In M³ the postero-internal cusp T.7 is well developed in the two Arnhem Land skulls (which therefore have the full antero-posterior complement of nine lingual cusps), but is absent in the Melville Island example. The cusp formula of the upper molars, using the Miller notation is:—

M^1	T.1 : T.2 : T.3 T.4 : T.5 : T.6 T.7 : T.8 : (T.9)[1]	M^2	T.1 : X : X or (T.3) T.4 : T.5 : T.6 T.7 : T.8 : (T.9)	M^3	T.1 : X : X T.4 : T.5 : T.6 X or T.7 : T.8 : X

[1] ( ) = greatly reduced.

In the lower molars the posterior median supplementary cusp is strongly developed in M_1 and M_2 and feebly indicated also on M_3. In the Melville Island specimen an anterior supplementary cusp also appears on the first lamina of M_1 in a median site between the two main elements — again as in *Apodemus*.

Johnson (1952) has recorded the occurrence of supernumary upper cheek teeth in this species.

The following figures give in turn some *skull dimensions* of the young adult male from Garden Point, Melville Island; a young adult male at the same growth stage from the Northern Territory mainland, and a much younger male from the same area. Greatest length, 62·8, 63·0, 58·0; basal length, 56·7, 57·4, 50·7; zygomatic breadth, 30·2, 28·8, 26·0; interorbital breadth, 10·2, 10·5, 9·3; nasals length, 26·3, 25·1, 22·2; nasals greatest breadth, 7·3, 7·0, 6·7; palatal length, 37·0, 37·0, 33·4; anterior palatal foramina, length, 11·6, 11·9, 11·8; ditto, breadth, 4·2, 3·4, 4·0; bulla length, 9·1, 8·8, 8·9; Ms^{1-3}, 11·1, 11·3, 11·6.

SKELETAL CHARACTERS

The disarticulated skeleton of the Garden Point specimen gives the following data. Vertebrae; cervical 7; thoracic 13; lumbar 7; sacral 2; caudal 35. Possibly the element here reckoned as the first caudal would be fused to the true sacrals in later life, but there would not be four sacrals as is frequent in *rattus*. The mesosternum has 5 segments. Scapula, max. length, 36·5; ditto, max. breadth, 17·5; clavicle, length, 18·3; humerus, length, 43·0; ditto, distal breadth, 10·5; radius, length, 38·7; ditto, max. distal breadth, 4·9; ulna, length, 47·8; ulna, max. breadth (coronoid), 5·5; femur, length, 56·5; ditto, distal (inter condylar), breadth, 11·6; tibia, length, 65·4; ditto, proximal breadth (medial aspect), 11·0; maximum, combined tibio-fibular breadth, 12·5; fibula, greatest proximal breadth, 7·2; ilio-ischial length of 1 pelvic ramus, 59·4; ilium breadth ditto, 11·0; ischial breadth, ditto, 18·5.

SUBSPECIFIC DIFFERENTIATION

Two subspecies have been distinguished from the primary form of Arnhem Land, by reference to differences in such characters as general pelage colour, markings of the manus and pes, pes length, extent of white on the tail, and the relative development of the zygomatic plate in the skull, etc. Although the species is represented by considerable series in more than one European Museum, no detailed analysis of characters has so far been attempted, and until this is done and the normal range of variation in a homopatric group is determined, the real status of the described forms must remain to some extent uncertain. The material here reviewed is not sufficient to explore this field adequately, but the following comments may contribute to a partial clarification.

1. *Mesembriomys hirsutus hirsutus* Gould, 1842.

Three specimens only have been available and none is accurately localized: there is contributory evidence, however, that all three are almost certainly from Arnhem Land or the Daly River drainage of the Northern Territory.

Published dimensions might be taken to indicate that this form is larger than *M.h. melvillensis* and with a relatively longer tail, but this may be due in part at least to the lack of aged males of the latter for comparison. The data available, however, is too heterogeneous and scanty to permit of reliable deductions on this head at present.

The body form and limbs in the three examined here are somewhat stouter than in the Melville Island examples, the manus in particular being thick and heavy and with shorter claws and interdigital pads and there is a tendency for higher counts in the digital ridges, one subadult carrying 11 on D3 of the manus and 14 on D4 of the pes. The two complete tails are relatively longer than in the other examples – 136 to 150 p.c. of the head and body length as compared with a range of 108-125 p.c. in similarly immature *melvillensis*, but previously published figures do not indicate any significant difference in the tail length of adults.

The pelage in all three is less harsh and more profuse than in the island form and the general colour much paler especially on the outer aspect of the limbs. The ventral fur is creamy white to base without trace of darker ticking. The dorsum of the pes (Pl. 3, Fig. D) is strikingly variegated with blotches of cream and black in all three specimens and this is apparently almost invariably the case as there seems to be no specific record to the contrary in the literature of the 50-odd examples which have been noted. Gould's plate, however (1857), which is presumably drawn from the second specimen from Port Essington (since the type skin lacked feet) appears to have the dorsum of the feet all black. The dorsum of the manus also carries markings though less conspicuous and generally confined to a cream or buff area along the outer margin of the metacarpus and some white fringing bristles at the apical pads of the digits.

2. *Mesembriomys hirsutus melvillensis* Hayman, 1936.

This appears to me to be a well-found and even strongly differentiated insular race. Its distinctions lie chiefly in pelage characters, and Hayman based his excellent description on four examples, three of which were living at the time in the Zoological Gardens, London; the five additional specimens from Melville Island here examined are in good accord with his findings and well contrasted with both the above primary form from the Northern Territory mainland and that of Cape York Peninsula. It is a somewhat slimmer animal than *M.h. hirsutus* and with a rather harsher coat and a distinctly atrate colour scheme, which affects the head and external aspect of the limbs differentially so that they are thrown into contrast with the lighter sides and foreback. The ears are more densely furred externally and are uniformly jet black, as are also the dorsal surfaces of manus and pes, the characteristic markings of the animal from the adjacent mainland being quite suppressed. The ventral surface is quite different in appearance from that of the latter, being dark grey at the base and buffy grey externally and with a distinct admixture of all black hairs so that the general colour is a rather dark grizzled drab like the sides and totally different from the all-cream ventrum of the primary race.

Dimensions given by Hayman for the type, which is a male at about the same developmental stage as No. 4 of the table (*supra*), agree as to head and body and tail, but his pes length is lower (63 c.f. 71); Tate's remeasurement of the type, however, corrects this to 68. The local material gives widely different values for pes length in the adult ♂ and ♀ (71 c.f. 62), which is not foreshadowed in the other two groups, and is probably an individual rather than a sexual peculiarity. The ear measurement of 44 for the type is higher than in any of the four taken here from the tragal notch (44 c.f. 38 max.), but the method of measurement may be different.

Comparison of the dimensions of the three skulls here examined with those already published, suggests that there are few, if any, valid differences between the Melville Island and Arnhem Land forms. Considerably higher values have been recorded for the latter, but this is very likely due to age differences as no aged *melvillensis* skull has yet been examined. It is possible that the molar rows may be shorter in the latter (11·1-11·1 c.f. 11·3-12) and individual molars a little narrower. Tate's claim of a difference in the bulla does not stand. In non-metrical points, Hayman's opinion that there is a difference in the slope of the free margin of the zygomatic plate, seems to be confirmed and it should also be mentioned that the arching of the profile is much steeper in the Garden Point skull than in the two Arnhem Land examples. In both these latter also, the parieto-squamosal suture shows an abrupt angle of re-entrance into the squamosal, near the posterior root of the zygoma, which is much less developed in the island example. Several other minor differences are noted (*supra*), but it is unlikely that these have a geographical basis.

I am at a loss to understand Tate's statement that "the type differs little from other races"—the general level of distinction of *melvillensis* from *hirsutus* is distinctly higher than that generally accepted as justifying a trinomial in Muridae and appears to be maintained with satisfactory constancy in the nine specimens now examined. Moreover, the factor of complete geographical isolation and the considerable differential gradient attained across so small a water gap as Clarence Strait, are, as Hayman suggested, additional reasons for accepting it as a valid form.

The status of the Bathurst Island representative, separated by the still narrower Apsley Strait, remains to be determined.

3. *Mesembriomys hirsutus rattoides* Thomas, 1924.

Thomas founded this name on three specimens from Cape York Peninsula of Queensland, which were more or less intermediate between *M.h. hirsutus* and *M.h. melvillensis* in ventral pelage, being grey at base and greyish white rather than cream externally. He also considered that the foot was longer in Queensland than in Arnhem Land. Tate (1951) on re-examining the type, described the ventral fur as light grey basally and yellowish externally, which considerably reduces the distinction in this feature. He also found marked differences in pelage due to moult phase in additional specimens taken at the Pascoe River and Port Stewart in 1948, but confirmed the longer pes. It is to be noted in the latter connection, however, that the range in *M.h. melvillensis* reaches the maximum for *rattoides* (71 mm.). Hayman (1936) states that both all black and variegated feet occur in the three *rattoides* in the British Museum, but Tate does not discuss this feature in his four additional examples. His skull measurements suggest that the anterior palatal foramina average longer in *rattoides* than in *hirsutus*.

A single specimen, an adult ♀ in alcohol, collected by W. P. Dodd in 1914 on the Stewart River of the Pacific Coast of Cape York Peninsula, Queensland, has been examined for external and pelage characters only. The general coloration is nearer *M.h. hirsutus* than *M.h. melvillensis*, though the ventral pelage is intermediate and possibly somewhat nearer the latter. The ears in this specimen are nearly nude, the dorsum of manus and pes quite black, and the foot length low (64 mm.). No skull of *rattoides* has been examined here and there is no comment by Tate on his new material apart from dimensions; these might indicate that it has the largest skull of the three forms.

With this degree of overlapping it is impossible at present to assess the standing of *rattoides*, though clearly it is much less distinct from typical *hirsutus* than from *melvillensis*. There is a probability that in recent times at least the Arnhem Land and Queensland populations have been isolated; the characteristic northern Eucalyptus savannah woodland, which seems to be the chief habitat of the mainland forms is interrupted by a zone of treeless Mitchell grass downs towards the southern shore of the Gulf of Carpentaria.

ADAPTIVE MODIFICATIONS

It is remarkable that the arboreal adaptations of *Mesembriomys*, particularly in the pes, have found scant mention in the definition of the genus, but have been ousted and overlain by traditional and quite erroneous views of its terrestrial saltatory or Jerboa-like modifications.

On emergence from the early omnibus "genus" *Mus*, the two species of *Mesembriomys* were lumped with many others which are now considered very diverse, in the almost equally omnibus but purely Australian genus, *Hapalotis* of Lichtenstein, in which enlarged hind limbs, modified feet, lengthened ears and long and tufted tail were considered to indicate adaptive analogy to the Jerboas of the Old World. Analysis of this complex of species, chiefly by Oldfield Thomas, had by 1909 split Lichtenstein's *Hapalotis* into the two groups of currently accepted genera, *Zyzomys*, *Laomys*, *Conilurus sensu stricto*, and *Mesembriomys* on the one hand and *Leporillus* and *Notomys* on the other. The saltatory element in the original complex is now seen to be isolated in *Notomys* alone, but recognition of this fact was long delayed and as late as 1914 the species of *Mesembriomys* are still described in Brehm's Tierleben as "Australischen springratten" with "namentlich aber verlängerten hinter bienen".

The first references of Gould and Gray contained no mention of the habits of the animal and Gilbert, who forwarded the type to London, if he had information on this head, evidently did not transmit it. In 1871 Gerrard Krefft in Sydney, who appears to have had very sound views on the field relations of many Australian mammals, published a list of Australian rats with a broad classification into four categories, based on what was known locally of their habits. In this scheme he divided *Hapalotis* into two sections, "The Tree Rats representing the Squirrels in Australia" and the "Jerboa Rats". His allocation of some of the species to the first group would not meet with acceptance now, but *Mesembriomys hirsutus* was correctly placed there as "The Great Hapalotis or Tree Rat of North Australia". Krefft, I believe, never worked personally in the habitats of the species, but evidently had access to information on it, derived from Strange or Macgillivray or other early collectors in the North. In 1897, Knut Dahl published an excellent first-hand account of both species of *Mesembriomys* in which the tree haunting habits of *hirsutus* and its ability as a climber were well documented for the first time. These two contributions on the natural history of the animal, as noted above, made no impact on the classifications which were worked out in London, which followed severely theoretical lines, and it was not till 1951 that the arboreal character of the genus was plainly stated by Tate.

The significance of the moderately enlarged hind limb (in contradistinction to elongation and narrowing of the pes) which is found more or less developed in most of the six genera named above, is evidently not adaptive in the narrow and immediate sense, since it occurs alike in arboreal, cursorial, truly saltatory and rock-haunting forms of Australian murids and in monodelphia, in groups as different in habits as Leporidae and Sciuridae. Gray early recognised this peculiarity of the larger members of "*Hapalotis*" and coined the not altogether inappropriate name of "Rabbit Rats" for them, though it has been suggested that the ear form also had its influence in this. In the evolution of the generic concept of *Mesembriomys* it plays a diminishing part and the above statement in Brehm's Tierleben may be contrasted with that of Thomas in 1909, "form normal"—or of Longman, 1916—"legs not markedly unequal". Justification for the latter may be obtained by expressing the length of the humerus plus ulna-radius as a percentage of that of femur plus tibia, thus obtaining an approximate intermembral index which gives an estimate of the relative development of the fore and hind limb, *sans* manus and pes. In *Mesembriomys hirsutus* this is 75, *Leporillus jonesi* 73, *Rattus lutreola* 78, *R. rattus alexandrinus* 79, *Oryctolagus cuniculus* 77, and *Lepus europaeus* 85.

The pes was thought by Thomas (1909) to be long and narrow; a mistake corrected by Ellerman in 1941 and again by Tate in 1951. Its length in relation to that of head and body (max. 25 p.c.) is certainly high when compared with most Australian *Rattus* species, but is closely approached in this by several non-saltatory forms such as *Gyomys apodemoides* 25 p.c., *Leporillus conditor* and *apicalis* 24 p.c., and *Laomys pedunculatus* and *Rattus greyi* 22 p.c., and falls much below its value in saltatory *Notomys*, which in the five species measured ranges from 32-35 p.c. The hallmark of the saltatory pes, moreover, is in the low breadth/length ratio, which in the above *Notomys* spp. has the range 9-12 (11) p.c. as against the remarkably high value of 24-30 (26) p.c. in *Mesembriomys hirsutus* vars. Metrical support of terrestrial saltatory specialization is therefore lacking. Tate claimed as "scansorial" modifications, chiefly the width of the metatarsal segment of the foot and the large size and strong curvature of the claws. In view of what is now well established as to the habits and habitats of the animal, this wide term may give place to one of narrower connotation, and most of the features of the pes listed below may be regarded as evidence of arboreal adaptation, analogous to those found in other groups of tree-climbers, and including very likely, the modified type of arboreal "saltation" from branch to branch, frequent in such forms.

1. *The relatively great length of the hallux and of D5 and their more anterior position on the pes.* The former of these two conditions was recognised by Ellerman and the latter is also valid. Whether these features are to be regarded as specializations *de novo*, or rather as a retention of primitive conditions may be debated, but they certainly run counter to the trend in most Australian terrestrial genera, which (especially in subdesert areas) show a progressive reduction in the size of the lateral digits with a markedly posterior position on the pes, culminating in the extreme condition of *Notomys*, which is inescapably specialized.

The disposition of Ds. 1 and 5 on the pes of *M. hirsutus* is similar to that on some arboreal species of the Austro-Pacific genera *Cyromys* and *Uniomys*, but whether it is accompanied in life by an increase in the range of lateral movements of these digits, there is no evidence to show.

2. *High value of the breadth/length ratio of the foot.* This trend in a general way is parallel to the above, the nearest analogues amongst Australian forms being species of *Melomys* and *Uromys*, with *Notomys* again providing the opposite extreme. *Laomys pedunculatus* and some *Rattus* spp. (e.g. *lutreola*), which are not usually suspected of arboreal habits, offer partial exceptions and have very high B/L values, *Laomys*, however, may be scansorial in the sense of rock climbing.

3. *Increased size, strength and curvature of the nails of the digits.* This is a strongly marked feature shown also in the manus, and equalled by few, if any, Australian species.

4. *Increase in the number, area, and effectiveness of the plantar structures involved in frictional contact.* This is the most obvious, if not the most significant, modification of the member. It is shown in the rubber-like consistence and punctation of the general plantar surface; in the prominence and multiplication of the digital ridges and their striation; in the height and sharp sculpturing of the interdigital pads; and particularly in the enormous development of the metatarsal pads, which (especially in the outer of the two) is probably unique in Australian muridae and recalls the condition of some of the arboreal Dasyuridae.

The tail, as mentioned (*supra*), gives no evidence of prehensile powers, but it may be recalled that the long terminally tufted tail in general is by no means exclusive to terrestrial saltators like the Jerboas, but is strongly developed in such typical arboreal animals as the Tree Shrews (*Tupaia*) and *Tarsius*.

In some particulars the modifications listed above may fall short of what is found in some Austro-Pacific muridae and are certainly much inferior to those of the perfected arboreal forms of the Oriental region, such as *Haeromys* and *Chiromyscus*. Nevertheless, they probably entitle *Mesembriomys hirsutus* (in spite of the Jerboa myth) to rank at least equally with the tree-living species of *Uromys* and *Melomys*, as an Australian arboreal product.

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EXPLANATION OF PLATES

PLATE 1

Fig. A. Dorsal aspect of the skull of a young adult ♂ of *Mesembriomys hirsutus melvillensis* from Garden Point, Melville Island, Northern Territory of Australia (x 1·1).

Fig. B. Lateral aspect[1] of the same (x 1·1).

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[1] The lower profile of the bulla figured is modified by a malformation; normally it is less flattened than as shown.

Fig. C. Palatal aspect of the same (x 1·1).

Fig. D. Buccal aspect of the mandible of a young adult ♂ of *Mesembriomys hirsutus hirsutus* from the mainland of the Northern Territory of Australia (x 1·3).

Fig. E. Ditto, in an adult ♂ of *Rattus norvegicus* Erxl. for comparison with Fig. D (x 1·6).

Fig. F. Occlusal aspect of slightly worn right upper molars of the above example of *Mesembriomys hirsutus melvillensis* (x 5·0).

Fig. G. Ditto, in the above example of *Mesembriomys hirsutus hirsutus* showing the full complement of 9 lingual cusps and T3 on M2 (x 5·0).

Fig. H. Ditto, in an adult ♂ of *Apodemus sylvaticus* Linn. for comparison with Fig. G (x 14·0).

PLATE 2

The above example of *Mesembriomys hirsutus melvillensis* in captivity in Adelaide (x 0·30 ca.).

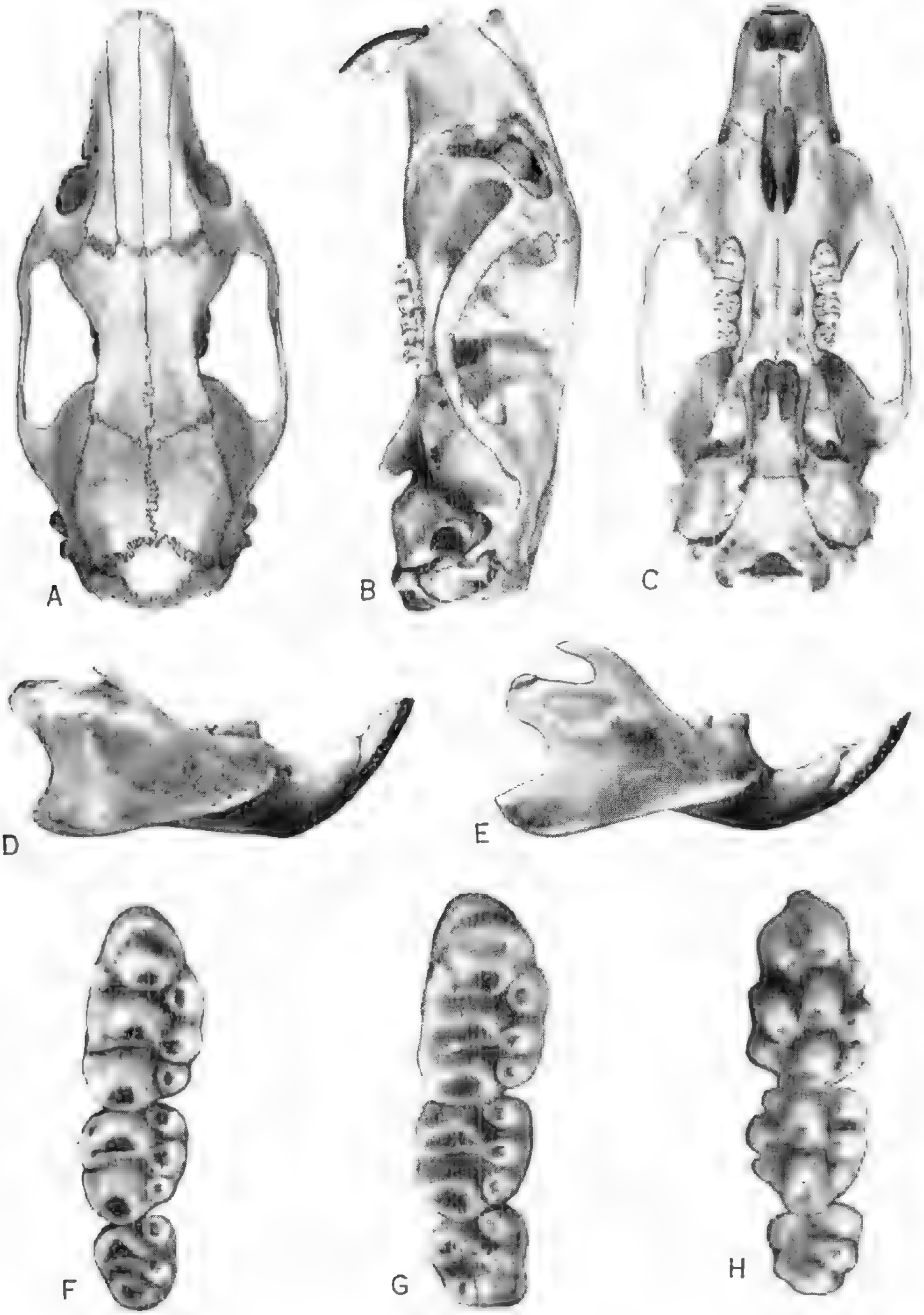
PLATE 3

Fig. A. Ditto (x 0·27 ca.).

Fig. B. Plantar aspect of right pes of the same (x 1·0 ca.).

Fig. C. Palmar aspect of right manus of same (x 1·9 ca.).

Fig. D. Dorsal aspect of right pes of the above example of *Mesembriomys hirsutus hirsutus* (x 1·5 ca.).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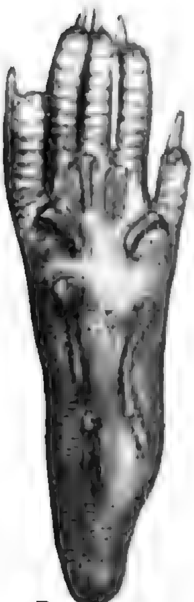
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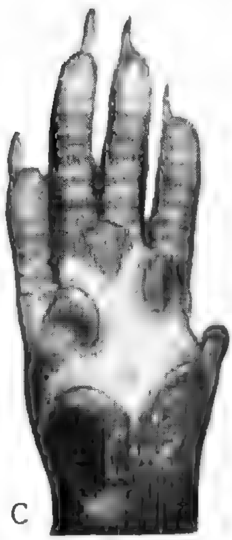
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NOTES ON THE GENUS *CAECULISOMA* (ACARINA: ERYTHRAEIDAE) WITH COMMENTS ON THE BIOLOGY OF THE ERYTHRAEOIDEA

BY R. V. SOUTHCOTT

Summary

The larva of the genus *Caeculisoma* Berlese, 1888, is defined from the rearing of a larval species *C. darwiniense* n. sp. to the nymphal stage. Larvae were captured parasitic upon the locust *Goniaea* sp. aff. *hyalina* Sjostedt at Coomalie Creek, Northern Territory. The larva, pupa I and nymph are described, and figures given. The nymph is compared with previously known adults or nymphs.
Mites answering to *Caeculisoma clavigerum* Canestrini, *1897,* are recorded from the Aitape-Wewak region of New Guinea; this is the first occasion on which this species has been possibly identified since the original record. *Caeculisoma argus* ssp. io n. ssp. is recorded from South Australia. The biology and distribution of *Caeculisoma* is discussed. It is pointed out that the wide geographical distribution of the genus is at least partly explicable on the grounds of dispersion of larvae parasitic upon locusts and grasshoppers. A comparison is made between the annual cycles of life histories of various Australian Erythraeoidea. It is shown that two broad classes are distinguishable in temperate Australia, these being the long-duration-egg class (I) and the short-duration-egg class (11). In class I the animal passes about *2/3* of the annual cycle as the egg (including deutovum), and the other instars are fairly short. The larva hatches from spring to early summer, the animal passing through successive instars to the adult stage by the summer, with oviposition in general from mid- to late summer. In class 11 the animal passes about 1/3 of the annual cycle in the egg, and the successive instars are comparatively long. Oviposition is in early summer, and the larvae occur over the autumn (March-May). Some variation occurs to the above general patterns, which are tabulated and commented upon.

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A comparison is made between the annual cycles of life histories of various Australian Erythraeoidea. It is shown that two broad classes are distinguishable in temperate Australia, these being the long-duration-egg class (I) and the short-duration-egg class (II). In class I the animal passes about 2/3 of the annual cycle as the egg (including deutovum), and the other instars are fairly short. The larva hatches from spring to early summer, the animal passing through successive instars to the adult stage by the summer, with oviposition in general from mid- to late summer. In class II the animal passes about 1/3 of the annual cycle in the egg, and the successive instars are comparatively long. Oviposition is in early summer, and the larvae occur over the autumn (March-May). Some variation occurs to the above general patterns, which are tabulated and commented upon.

INTRODUCTION

The writer has recently defined the characters of the larva of the genus *Caeculisoma* Berlese, 1888, in his monograph on the genera of the Erythraeoidea (1961). That definition was based upon the rearing of an undescribed larval Erythraeoid mite to the nymphal stage in 1943, specimens of the mite having been taken parasitic upon a species of locust at Coomalie Creek, Northern Territory. From that definition it was apparent that no previous larvae of *Caeculisoma* had been described.

In the present paper the species concerned is described as *C. darwiniense* n. sp. from the larva, pupa I and nymph. The species is compared, in the nymphal stage, with previously described adults (or possibly nymphs) of *Caeculisoma*. Some reference will be made to other species of the genus, both from the systematic and distribution aspects.

A comparison will be made between the annual life cycles of various Erythraeoidea, and the present knowledge of the durations of the various stages, and some general conclusions drawn.

DESCRIPTION* OF A NEW AUSTRALIAN SPECIES

Caeculisoma darwiniense n. sp.

Figs. 1-4

Description of Larva (Figs. 1, 2) (from the holotype ACA1062B; also supplemented where indicated from the paratype specimen ACA1062A): Colour in life, red. Length of idiosoma (unengorged), 290μ, width, 220μ; animal, 415μ long to tip of cheliceral blades. Idiosoma the usual ventrally flattened elongate spheroid.

Dorsal scutum as figured, oval with anterior margin flattened, slightly concave; anterolateral angles rounded; posteriorly produced into two flattened projections in relation to the posterior sensillae, with a shallow notch between them. Shield laterally convex; slightly concave posterolaterally at the level of the PSens.

The Standard data in micra of the type and paratype are as follow:

Specimen	ACA1062B (holotype)	ACA1062A (paratype)
AW	83·5	85
MW	87	90
PW	77	78
SBa	8	9
SBp	15	15
ASB	34	30
ISD	47	48
L	87	88
W	97	105
A—M*	19	18
A—P	44	43
AL	41	43
ML	43	46
PL	34	33
ASens	41	40
PSens	75	68
ASB/ISD	·72	·67
DS	26—51	31—55

* Distance between centres of AL and ML scutalae; equivalent to A—P, but using the second row of scutalae instead of the posterior pair.

Scutalae of medium size, lightly curved, with fine adpressed barb-like ciliations, the setae terminally blunted; AL and ML setae of about the same thickness, PL a little thinner. AL setae arise near the anterolateral angles of the shield; ML posterior and slightly lateral to AL; PL scutalae arise near the edges of the shield, and as the shield narrows posteriorad the PL scutalae are slightly medial to ML.

Scutal sensillae are fine, tapering, pointed, very lightly ciliated (under oil immersion). ASens arise a little (about 8μ) behind the ML scutalae. PSens arise about 5μ anterior to posterior end of shield.

Eyes one on each side, circular, lenses 14μ across, and situated in the unengorged specimen between the levels of the PL scutalae and the PSens.

* For the technical descriptive terms used and the definitions of the "Standard data" the writer's account (1961) should be referred to.

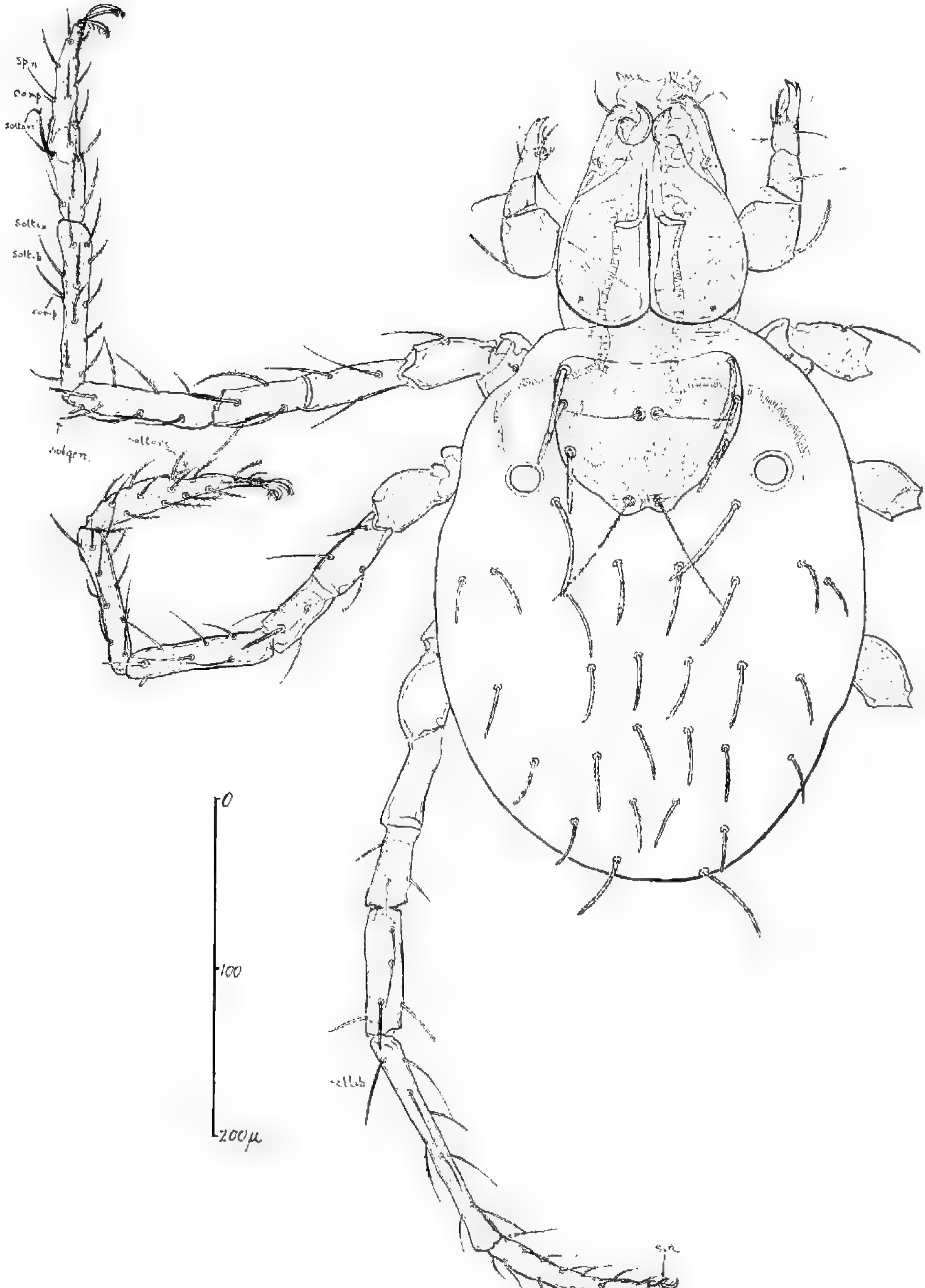

Fig. 1.—*Caeculisoma darwiniense* n. sp. Larva, dorsal view of holotype. The tracheae are also shown, and some of the internal structure of the gnathosoma. Lettering shows the sensalae of the legs: *comp.* companala, *sin.* sinuala, *solgen.* solenogenuala, *soltars.* solenótarsala, *soltib.* solenotibiala, *spin.* spinala.

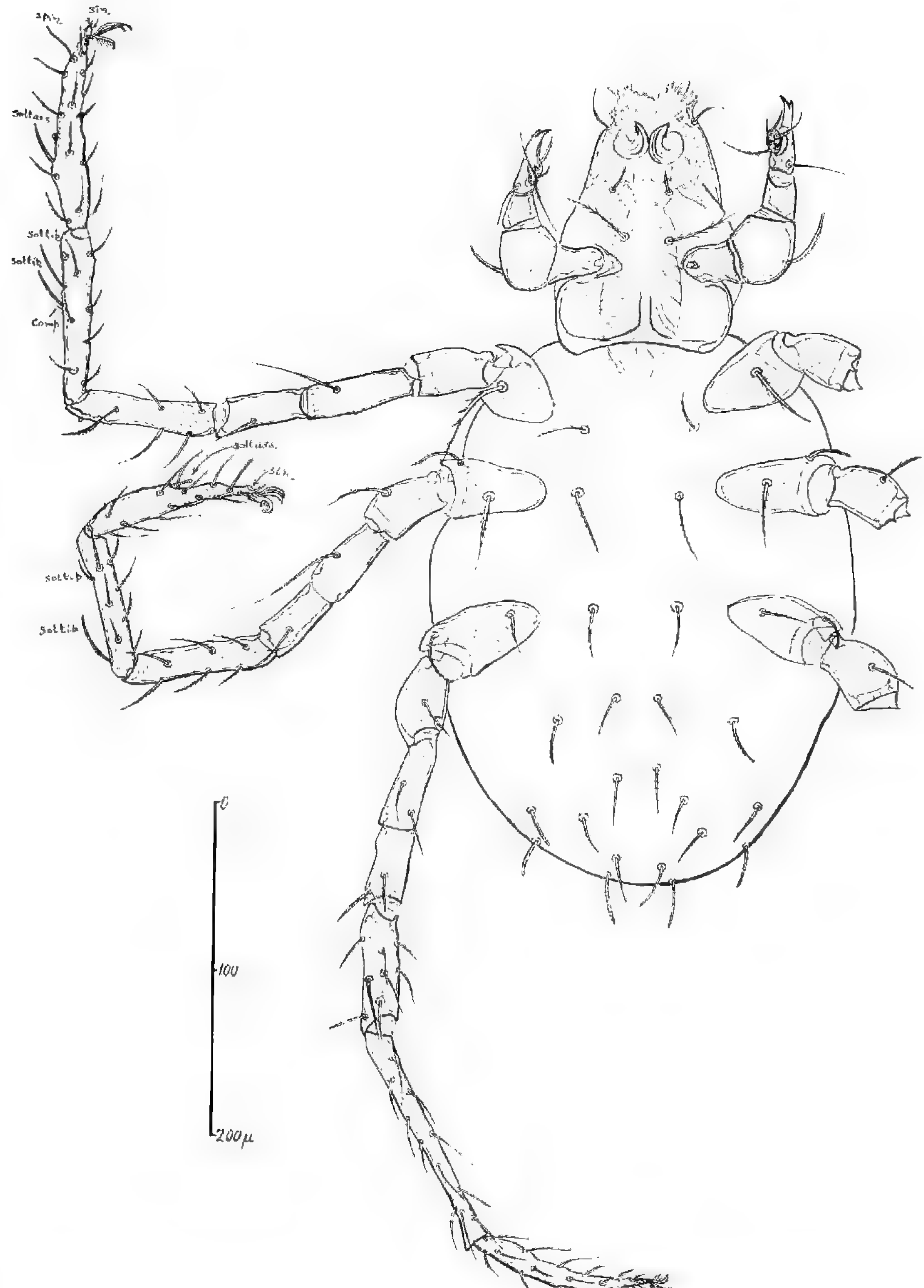

Fig. 2.–*Caeculisoma darwiniense* n. sp. Larva, ventral view of holotype. Some of the internal structure of the gnathosoma is shown. Sensalae of the legs lettered as in Fig. 1. (In general, as in previous illustrations, an effort has been made to distinguish in Figs. 1 and 2 between the dorsal and ventral setae, in the limbs as well as elsewhere, but where a seta, particularly a sensala, is so placed that its seta base is visible from both sides, it may be shown in both the dorsal and the ventral views.)

Dorsal idiosomalae similar to scutal scobalae, lightly curved, parallel-sided or slightly tapering (blunted terminally), with fine adpressed barbed ciliations along the convex side, a few more outstanding barbs being present distally along the concave side; arranged 2 (ocular row), 8, 6, 6, 4, 2; total 28. The ocular setae are the largest of the dorsal idiosomalae; the setae next in size are only 41μ long (type) or 44μ (paratype); the smallest dorsal setae are the 5 lateral setae down each side (see Fig. 1).

Venter: between coxae I a pair of scobalae (sternalae), fairly short, pointed, ciliated, 30μ long; between coxae II a similar pair, but stronger and longer, 36μ long; between coxae III a similar pair, 31μ long; behind coxae III, on the ventral opisthosoma, are similar setae, which gradually change in character posteriorad, to approximate those of the posterior pole of the idiosoma dorsally, arranged 4, 2 + 5 + 2, 1 + 2 + 1; 22-30μ long.

Coxal formula 1, 2, 2. Coxala I strong, pointed, ciliated, 40μ long. Medial coxala II pointed, slightly ciliated, 32μ long; lateral coxala II curved, blunted, ciliated, 20μ long. Medial coxala III similar to II, 28μ long; lateral coxala III curved, somewhat pointed, ciliated, 20μ long. Supracoxala present to coxa I, normal, peg-like, 4μ long.

Legs normal for family: I 520μ long, II 455μ, III 535μ (all lengths including coxae and claws). Each trochanter with one seta (trochanterala, a scobala). Tarsi tapering, with irregularities, as figured. The femur-tibia segments more or less cylindrical. Tarsus I 104μ long (excluding claws and pedicle) by 18μ high. Tibia I 102μ long. Tarsus III 104μ long (without claws and pedicle) by 15μ high. Tibia III 143μ long.

On the legs the following is the arrangement of the specialized setae:

	trichobothrialae (sensillae)	solenoidalae (solenidia)	spinalae (eupathidies)
genu I	0	1	0
genu II	0	0	0
genu III	0	0	0
tibia I	0	2	1 (comp.*)
tibia II	0	2	0
tibia III	0	1	0
tarsus I	0	1	4 (1 dorsal 1 subterminal 1 comp. 1 ped.**)
tarsus II	0	1	1 (ped.**)
tarsus III	0	0	1 (ped.)

* companula, accompanying the posterior solenoidala.

** the spinala alongside the pedicle. This has been named the pretarsala in the trombiculid system of nomenclature. Newell (1957 p. 407) finds this term unacceptable, "a misnomer". Possibly "sinuala", here proposed, is an acceptable term; these setae are characteristically sinuous.

The scobalae of the legs do not in general show a high degree of differentiation. Trochanteral formula 1, 1, 1; basifemoral 4, 4, 2; telofemoral 5, 5, 5.

Tarsal claws: anterior strong, nearly straight with strong terminal ventrally directed hook, unciliated; middle claw falciform, more slender; posterior claw strong, falciform, with long ventral ciliations.

Gnathosoma as figured. Chelae bases ("mandibles") form a compact cordate mass, with finely punctate chitin. Cheliceral blades rounded, simple, hook-like, without barbs but with a concave cutting edge. Galeala (galeal seta) curved, pointed, lightly ciliated, 20μ long. Hypostomal lip present, delicate, fimbriated. Anterior hypostomala simple, pointed, curved, 17μ long. Posterior hypostomala pointed, ciliated, 46μ long.

Palpal setal formula 0, 0, 1, 1, 3, 7, i.e. no palpal coxala or trochanterala. Palpal supracoxala present, 3μ long. The claw of the palpal tibia bifid, curving ventromedially, the ventromedial tooth the stronger.

Description of Pupa 1 (from ACA1060B, supplemented from ACA1060A). Colour red. General shape typical for the erythraeoid pupa I, ovoid, flattened ventrally, notched anteriorly, and with various protuberances, as normal. Length 1200μ, width 1000μ (estimated from the preserved cast skin). The pupa, particularly over the dorsal surface, is provided with a bristly coating of typical pupal setae, mostly projecting posteriorad. Setae 56-130μ long, slender, stiff, nude, swordlike, gradually tapering except in terminal part, which then tapers abruptly to a slightly blunted point; setae provided with the normal papillate basal socket.

Description of Nymph (Figs. 3, 4) (from ACA1060A, freshly emerged, unfed, then dried, finally mounted in polyvinyl alcohol, and possibly slightly compressed from above; also supplemented from ACA1060B). Colour in life red. Length of body to tip of mouthparts (hypostomal lip) 1360μ, width 930μ. External appearance normal for genus, with the usual squarish and lumpy outline.

The standard data are (in micra):

ASens	PSens	SBa	SBp	ISD	DS
118	ca 150*	12	24	490	80—160

* From ACA1060B

Cristal sensillae long, thin, pointed, nude. Anterior end of crista with ovoid boss, about 125μ long by 95μ across; anterior point of boss 86μ ahead of centres of ASens. Boss provided with about 18 scobalae, long, tapering, pointed, with slender projecting barbed ciliations, these being longest basally; setae 160-200μ long. Anterior sensillary area enclosed by the forking anterior arms of the crista, which separate at an angle of about 60°. Posterior sensillary area encloses a transverse ovoid roughened boss.

Eyes 1 + 1, 57μ across, placed well behind mid-cristal point (MCP, or midpoint between centres of bases of ASens and PSens; distance from eye level to MCP 170μ).

Dorsal idiosomalae long, tapering, curved, slender, often sinuous in the slide mount, quite ciliated (more marked basally), 80-160μ long. Setae dense, forming a hairy covering over the body. Venter of idiosoma with similar setae.

Legs as figured, with the normal somewhat beaded and irregular appearance of the genus. Leg I 1345μ long, II 790μ, III 965μ, IV 1470μ (all measured from the distal point of the coxa to the tips of the tarsal claws). Tarsus I 245μ long by 89μ high, tibia I 319μ long. Tarsus IV 153μ long by 72μ high, tibia IV 352μ long. Tarsi with scopulae. Tibial tuberosities present, normal, situated a little beyond middle of segment in tibia I, II, III, but in IV about 3/5 along length of segment. Clear areas with a punctate appearance to the chitin are placed distally and dorsally on some leg segments (such as Vitzthum (1926)

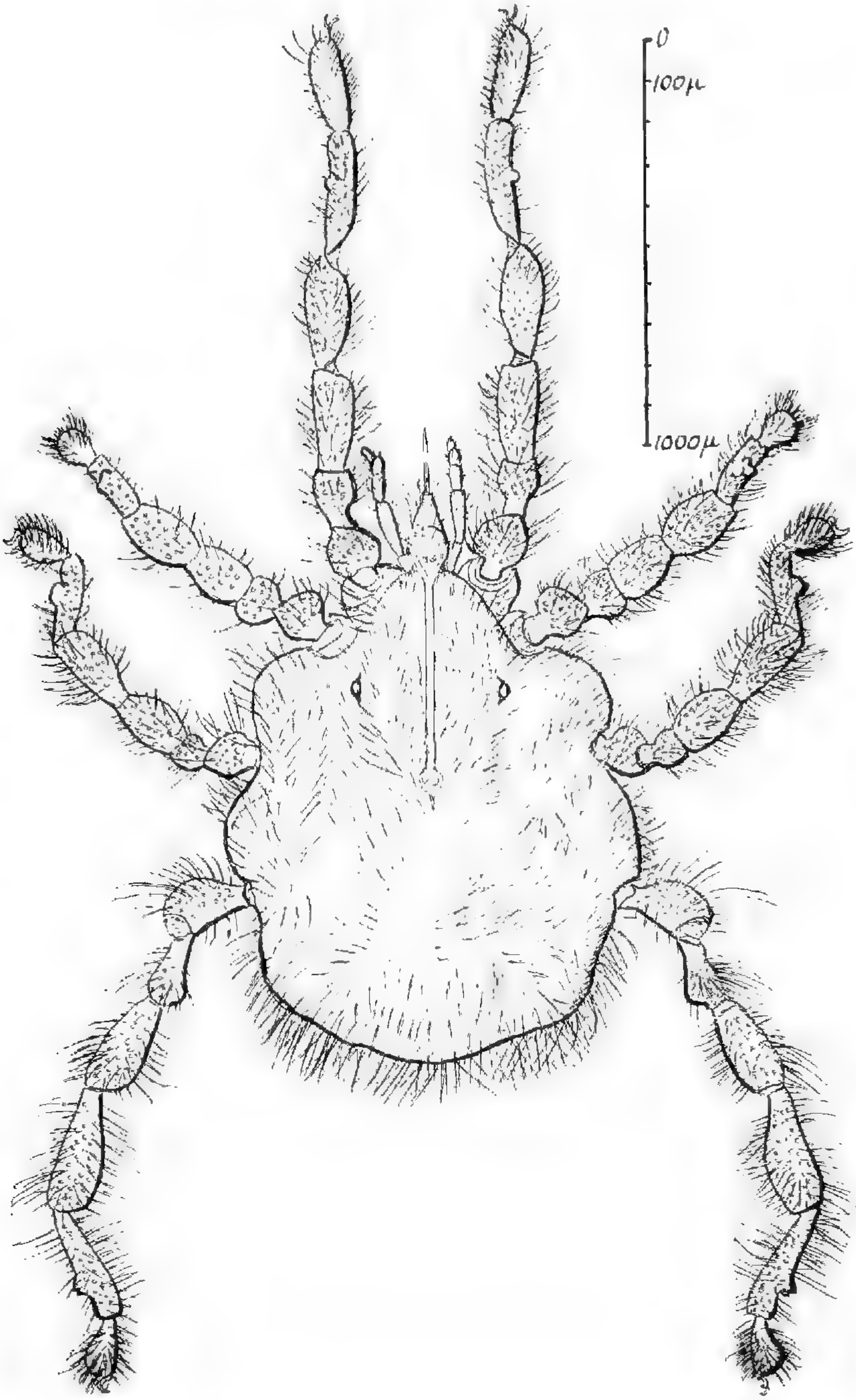

Fig. 3.—*Caeculisoma darwiniense* n. sp.. Nymph, entire, dorsal view.

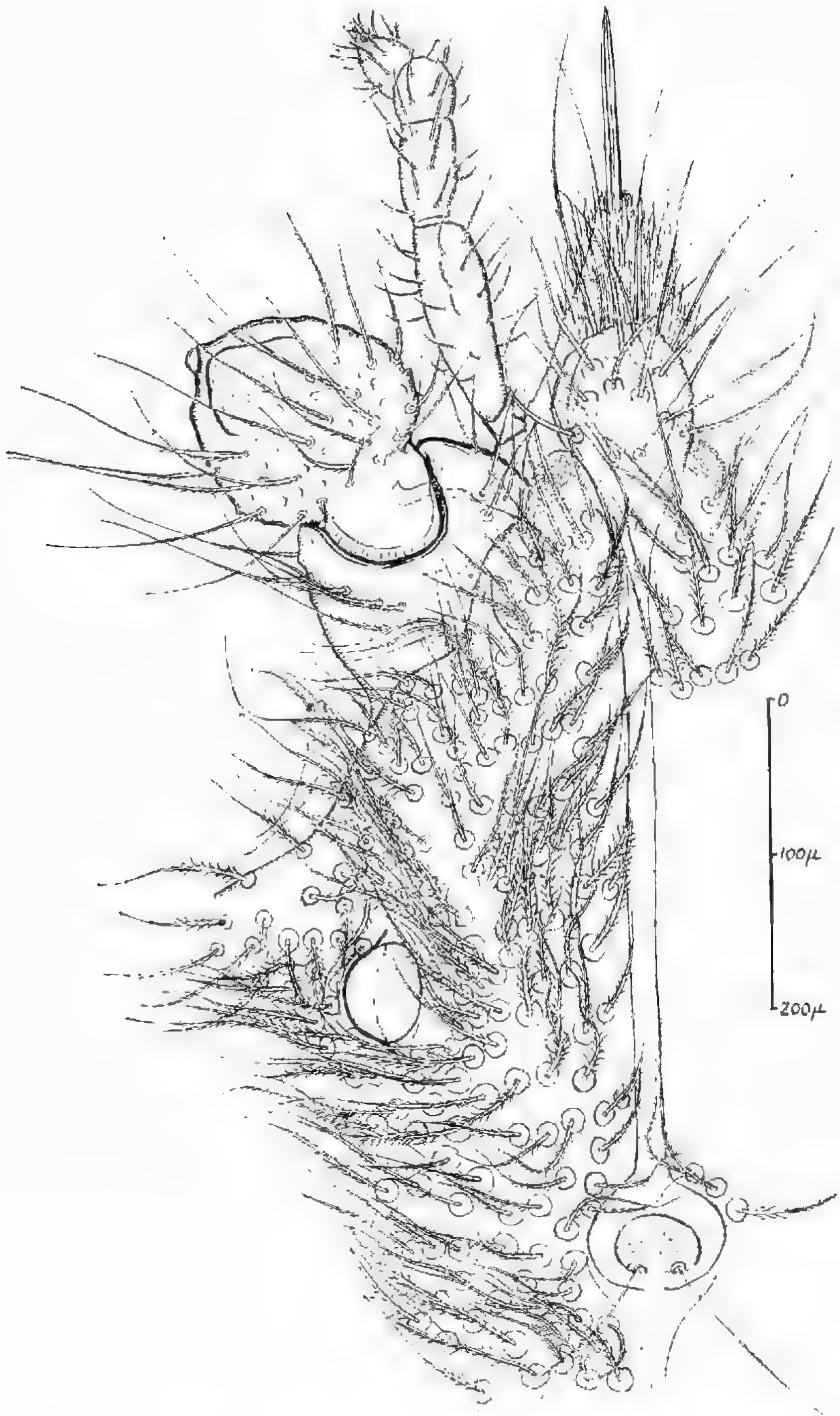

Fig. 4.—*Caeculisoma darwiniense* n. sp. Nymph. Part of propodosoma, including crista and left eye, and adjacent structures.

describes and figures for *C. argus* Vitzthum, 1926, and *C. infernale* Vitzthum, 1926, and Cooreman (1958) figures for *C. afrum* Cooreman, 1958; they are present also in other species of *Caeculisoma* and *Callidosoma* examined by the writer). One such of these is figured dorsodistally upon the trochanter I of the nymph in Fig. 4.* Tarsal claws 2, normal, strong, falciform, simple. Legs thickly covered with setae, the scobalae similar to those on the idiosoma.

Gnathosoma normal, as figured. Palpi as figured, characteristic of the genus (see redefinition by the writer (1961)).

Locality. (1) The type (ACA1062B) and paratype (ACA1062A) were two larvae, captured ectoparasitic upon the external surface of the right hindwing of a locust, in hilly country about 3-4 miles south of Coomalie Creek, Northern Territory, 13 June, 1943 (R. V. Southcott). The host has been identified as *Coniaea* sp. aff. *hyalina* Sjöstedt, ♂, by Dr. K. H. L. Key, Division of Entomology, C.S.I.R.O., Canberra (pers. comm. 11 Nov., 1957).

(2) Another batch of 6 larval mites (ACA1060) was obtained from the same locality, 7 May, 1943, attached to hindwings of a ♀ specimen of *Coniaea* sp. aff. *hyalina* (identified by K. H. L. Key, as above) (R. V. Southcott). All specimens of mites were attached by their mouthparts to veins of the wings, except one specimen which was recorded as "sitting astride a cell" of the wing. This latter specimen could, of course, have been dislodged from some other situation by the trauma of capture and handling.

Biology. The mites were detached from their host in each case, and the host preserved. The mites were transferred individually to clean, dry tubes. Of the eight specimens two subsequently underwent ecdysis to pupa I and nymph. The details of these two successful rearings are as follow:

Specimen	ACA1060A	ACA1060B
Captured and removed	7 May, 1943	7 May, 1943
Became immobile	10 May	7 May
Skin split off	12 May	11 May
Nymph emerged	27 May	22-25 May
Survived until	7-11 June	2-10 June

No attempt to feed the nymphs thus obtained was made. During the experiment the tubes were kept as cool as possible, i.e. by being kept in the shade, but without any special facilities or procedures.

REMARKS ON SYSTEMATICS

(1) Larvae

The definition of the larva of *Caeculisoma* Berlese, 1888, has been given by the writer elsewhere (Southcott, 1961). That definition was based on the species described above, *C. darwiniense* n. sp., and its experimental rearing from larva to nymph. From a study of those larval Callidosomatinae that have previously been described it is apparent that no larvae of *Caeculisoma* have been described hitherto. The species *C. darwiniense* n. sp. is based upon the larva as type, but as there are no other published accounts of larval *Caeculisoma* its systematic position within the genus must depend upon the characters of the nymphal stage reared (see below). The writer has seen a number of unde-

* The tibial tuberosities have the same punctate chitin and it is apparent that the tibial tuberosities are homologous structures. Probably they serve as chemical sense organs, and not as organs of ocular function, as Vitzthum suggested.

scribed species of larvae of *Caeculisoma* and other genera of the Callidosomatinae ectoparasitic upon Australian locusts, grasshoppers and other insects, which it is hoped to describe formally later, and to make appropriate comparisons.

(2) Adults and Nymphs

Cooreman (1958) has reviewed the species of *Caeculisoma* of the world, listing the important systematic characters of each species. Including his *C. afrum* Cooreman, 1958, the total of described adults (or possibly nymphs) amounted to 10 species. Among these 10 species the dorsal idiosomal setae are of diverse character, e.g. having been recorded as expanded, clavate, cylindrical, asparagus-tip-like, etc., but in none does the dorsal setation resemble that of *C. darwiniense* n. sp., where such setae are of a single kind, uniform in character over the dorsum, being long, flexible, pointed, tapering and ciliated.

There is, however, one species of the genus which has been recorded from Indonesia and New Guinea, *Caeculisoma sulcatum* (Canestrini, 1898),* where some further comment is required. Of *C. sulcatum* Cooreman (1958, p. 45) states: "Les poils de l'idiosoma sont de deux types: les uns portent quelques ramifications latérales, les autres sont simples, lisses et rigides, quoique progressivement effilés distalement; ces derniers sont d'ailleurs aussi plus longs que les autres". Originally Canestrini had described a species *Rhyncholophus sulcatus* in 1898 and 1899.* His description of the setae (1898, p. 481) was: "Corpo vestito di setole cigliate; arti pure coperti di setole cigliate, fra le quali se ne osservano alcune rare assai sottili e semplici che sono piantate sull'arto ad angolo quasi retto". The specimen came from Erima, Astrolabe Bay, New Guinea. Unfortunately the remainder of the description is also brief, and Canestrini provided no figures. Vitzthum (1924, pp. 357-9) redescribed this species from Krakatau Island, Sunda Islands, Indonesia, placing it in *Belaustium* (sic). In 1926 (pp. 168-9) he referred again to this species, placing it in *Caeculisoma*, and again stated (p. 169) his belief that his specimen from Krakatau was identical with Canestrini's species: "Auch heute noch glaube ich an der Identität der Art mit Canestrinis *Rhyncholophus sulcatus*. Denn Canestrinis Beschreibung passt Wort für Wort auf sie. . . ." (apart from one point

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* Some doubt attaches to the dates 1898 and 1899 of Canestrini's two articles. These dates will be used here as given by the writer in his monograph on the genera of the Erythraeoidea (1961), following Vitzthum (1924, 1926). The writer has not seen the second of these two papers by Canestrini ("1899"). Vitzthum (1924, 1926) had, however, seen both papers, referring to the pagination of the second paper from a reprint. As Vitzthum provides (1924, p. 357) a translation of Canestrini's description in Italian into German, corresponding to Canestrini (1898) as used here, the present writer assumes that his "1899" paper contains at least no further descriptive material relating to his *Rhyncholophus sulcatus*. (N.B.: In 1924 Vitzthum dated both of these papers as "1898".) A minor further point is that it is possibly surprising that Canestrini did not place *Rhyncholophus sulcatus* immediately in *Caeculisoma*, since he had earlier (1897) described a species of mite from New Guinea as *Caeculisoma claviger* Canestrini, 1897. Cooreman (1958) has amended the specific name to *clavigerum*, presumably correctly, since Canestrini was probably using *claviger* as an adjective and not as a substantive, and has remarked that *C. clavigerum*, which was unfortunately originally very briefly described without figures, has not been recorded subsequently. However, the present writer has in his own collection five specimens of *Caeculisoma* from the Aitape-Wewak area of New Guinea which answer to Canestrini's description. Locality records of these are: 3 specimens, Babiang, 22 December, 1944 (ACA1619, 1620, 1621); 2 specimens, Suain, 15 February, 1945 (ACA1622, 1623). All specimens were collected in leaf-litter and humus on the forest floor, near the coast (R. V. Southcott). Possibly two species are present among these five specimens. It is hoped to refer to this material further in a later paper.

in the description of the palp where he believed Canestrini was in error). The present writer believes that this viewpoint of Vitzthum on the identity of the species may be accepted.

Vitzthum (1924, p. 359) stated of the setation of his Krakatau specimen "Die Behaarung des Rumpfes die in der Abbildung [of Vitzthum] weggelassen ist, ist sehr dicht and besteht in feinen, weichen, massig kurzen, beiderseits spärlich gefiederten Haaren, die den gefiederten Haaren der Beine durchaus gleichen. Einen besonderen Radiationspunkt, wie in der Gattung *Leptus* Latreille, 1795,* zeigen diese Rumpfhaare nicht". As he stated, he did not figure the dorsal idiosomal setae, but he did figure (his Fig. 4 on p. 359) the leg setae, which were mostly similar to the dorsal idiosomal setae, but included also some more outstanding simple spiniform setae. It is apparent that Cooreman has taken these latter as being present also upon the idiosoma, which is in fact not stated by Canestrini or by Vitzthum. Womersley (1934, p. 241) in his key to the genus *Caeculisoma* has made a similar error.

Neither Canestrini or Vitzthum gave any measurements of the lengths of the dorsal idiosomal setae in *C. sulcatum*, although Vitzthum (1924) described them as short. On a comparative basis the present writer would consider the dorsal idiosomalae of *C. darwiniense* as long, which is a fair description of setae 80-160μ long among the Erythraeoidea and Trombidioidea. The ciliated leg setae of *C. sulcatum*, as described and figured by Vitzthum (1924), and which he states are the same as the dorsal body hairs of the same species, are obviously different in character from those of the *C. darwiniense* nymph. Those of *C. sulcatum* are from Vitzthum's Fig. 4 fairly short, and carry only 4-6 ciliations throughout their length. In *C. darwiniense* nymph the dorsal idiosomalae are long, tapering gradually, heavily ciliated, particularly basally, and the usual leg scobalae have the same character.

There are also other differences which may be noted between *C. darwiniense* and *C. sulcatum* (Canestrini) Vitzthum. In the two nymphs of *C. darwiniense* available the posterior projection of the crista behind the posterior sensillary area appears to be comparatively short, but unfortunately pigment within the specimens prevents much study of that feature. In *C. sulcatum* the posterior process is of great length, being almost as long in Vitzthum's specimen as the remainder of the crista (see 1924, p. 358, including his Fig. 3). However, this point is not stressed here, since this feature is not necessarily comparable between a nymph and an adult (Vitzthum stated his specimen was an adult). Another difference between these two species, undoubtedly of specific significance, lies in the leg structure, going on Vitzthum's Fig. 3 (1924, p. 358). Thus in *C. darwiniense* the legs are more irregular in outline, and the tarsi of the legs comparatively shorter, at least in leg II.

REMARKS ON THE BIOLOGY AND GEOGRAPHICAL DISTRIBUTION OF *CAECULISOMA*

Adults or nymphs of this genus are terrestrial predators, being found in humus, leaf-litter, under bark and other similar situations. The larva recorded in this paper was taken parasitic upon a locust, and the writer has seen other Australian larval species of *Caeculisoma*, at present undescribed, taken ectoparasitic from other Australian locusts and grasshoppers.

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* Accepted now as 1796. See Southcott (1961).

At the present time, recorded specimens of the genus are distributed geographically as follows:

South America - - -	*C. tuberculatum* (Berlese, 1888).
Marquesas Islands - -	*C. cordipes* Vitzthum, 1935.
Africa - - - - -	*C. afrum* Cooreman, 1958.
New Guinea, Sunda Islands -	*C. sulcatum* (Canestrini, 1898).
New Guinea - - -	*C. clavigerum* Canestrini, 1897.
Sumatra - - - -	*C. argus* Vitzthum, 1926.
	C. infernale Vitzthum, 1926.
Australia - - - -	*C. montanum* (Rainbow, 1906).
	C. nasutum Hirst, 1928.
	C. johnstoni Womersley, 1934.
	C. darwiniense n. sp.
	C. argus ssp. *io* n. ssp.*

This wide geographical distribution of the genus has been commented on by previous writers; most recently by Cooreman (1958), who has pointed out that all specimens recorded so far have come from the southern hemisphere, between 0° and 40° S. latitude. Such a wide geographical dispersion could at least in part be explained on the hypothesis that they are spread, or have been, by larvae parasitic upon hosts which themselves have considerable powers of dispersion, e.g. by flight or other means. It would appear that locusts and grasshoppers could fulfil such a requirement. The extent to which these larval mites are host-specific requires further study. Some Erythraeoid larvae have so far been found only upon a restricted host range, while others have a wider range. Thus *Smaris* (Smarididae) larvae have so far been found only upon Psocoptera, while within one genus, e.g. *Erythrites* (Erythraeidae), one species may be restricted, thus *Erythrites osmondensis* (Southcott, 1946) has been found only upon Thysanoptera, while other species, such as *Erythrites reginae* (Hirst, 1928) and *Erythrites urrbrae* (Womersley, 1934) will parasitize a wide range of insects (Womersley and Southcott (1941); Southcott (1946, 1960)).

REMARKS ON THE LIFE HISTORY OF THE ERYTHRAEOIDEA

It is proposed to make some comparisons of the durations of the stages in the life histories of various Erythraeoidea. Such data are now available for a number of Australian species of both the families Erythraeidae and Smarididae. Details of the durations are given in Table 1.

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* Based upon a specimen from Glen Osmond, South Australia, January, 1934 (R. V. Southcott) and recorded by Womersley (1934, p. 238) as *C. argus* Vitzthum. A restudy of that specimen shows that it has considerably shorter setae than *C. argus* f. p. from Sumatra and the following new subspecific name is proposed for it: *C. argus* ssp. *io* n. ssp. In *C. argus io* the dorsal idiosomal setae are 20-136μ long and the scobalae of the anterior sensillary area are 76-131μ long, as against the figures given by Vitzthum of 35-190μ for the idiosomalae and 190μ for the scobalae of the anterior sensillary area in *C. argus* f. p.

My field notes for the type specimen (ACA1641) of *C. argus io* record it as being collected "very early in January, probably 1st" January, 1934 "on surface of water in a horse [and cattle] trough (Trough A)" at Glen Osmond. That trough was one of the three upon which specimens of *Speleognathus australis* Womersley, 1936, were collected by myself over 1934-1941, as noted elsewhere (Southcott, 1957). The map reference for the site of Trough A is 656808 Map Adelaide 1:63360 No. 810 Zone 6 Sheet South 154M/ IV SE & SW. The trough has now been removed for several years. Over the years it was under study it was placed in contact with the ground, under the shade of a sugar gum, *Eucalyptus cladocalyx*, one of some rows that had been planted in about 1895, according to Gill (1905, p. 5). It was found that frequently insects, such as flies, hymenoptera, and collembola, were blown onto the water surface or otherwise occurred there, also mites, etc. Presumably most of these came from the surrounding vegetation. It would appear probable that the *Caeculisoma* was blown in from the foliage of the *Eucalyptus cladocalyx* above.

An inspection of Table 1 indicates that over the instars pupa I to pupa II, as well as the immobile stage immediately before pupa I, the durations of the stages or instars are broadly comparable over the species studied in the two families. These data have all been obtained with Australian Erythraeoidea in experiments conducted by the writer, all being in the Adelaide region of South Australia with the exception of *Caeculisoma darwiniense*, which was conducted in the Darwin region of the Northern Territory. No comparable data exist for other Erythraeoidea elsewhere in the world, and in fact for the fauna of other parts of the world only fragmentary data on life-history are available (see Southcott, 1961).

TABLE 1.

Durations of the stages of Erythraeoidea, in days.

	Prepupal immobile stage	Pupa I	Nymph	Pupa II
*Erythrites reginae**	2, 3, 2	12, 13, 12	21	15
*Erythrites osmondensis**	2	9		
*Erythrites pilosus**	3-4	11-12		
*Erythrites urrbrae**	2, 2, 4, 2, 1-2, 1-2, 1-2, 1-2, 1	13, 15, 14, 12, 15-16, 14-15, 15-16, 16	39, 11+, 21+, 13+, 25	16, 15
*Erythroides clavatus**	7, 3	12		
*Rainbowia imperator***	6, 4, 6, 4, 4, 4, 6, 5, 5	28, 27+, 58, 45, 25-26, 23-24, 22, 26, 27, 18		
*Callidosoma womersleyi**	4, 2	9, 12		
Caeculisoma darwiniense	2, 4	15, 11-14		
Pollux sp.* (ACA882B)	6	9		
*Smaris prominens****	3-7, 7-9, 4-5	27-30, 21-24, 35, 31-51+	80+	

* Data from Southcott (1946)
** Data from Southcott (1961)
*** Data from Womersley and Southcott (1941).

A closer inspection of Table 1 shows, however, that two main groups can be separated, thus:

Class I, the "fast group". These have a prepupal immobile stage of in general 1-3 days, a pupa I stage of the order of 9-16 days. The group includes species listed belonging to the genera *Erythrites*, *Erythroides*, *Callidosoma*, *Caeculisoma* and *Pollux*.

Class II, the "slow group", have a prepupal stage of the order of 4-6 days (the range extending occasionally over 3-9 days) and a long pupa I stage lasting on an average about 30 days, and ranging over 18-58 days. This group so far includes only *Rainbowia imperator* (Hirst, 1928) (family Erythraeidae) and *Smaris prominens* (Banks, 1916) (family Smarididae).

We may then ask whether these two classes correspond to other biological features in the Erythraeoid mites. Table 2 shows a table of the seasonal incidences of the various instars of mites of the Erythraeoidea where there is sufficient knowledge available to list the seasonal incidences of these instars. This last condition restricts the table to species occurring in temperate Australia, in fact, most of it is derived from observations made by the writer on the fauna in the Adelaide region of South Australia (using the same sources as given in the footnote to Table 1, and in addition Southcott (1960)).

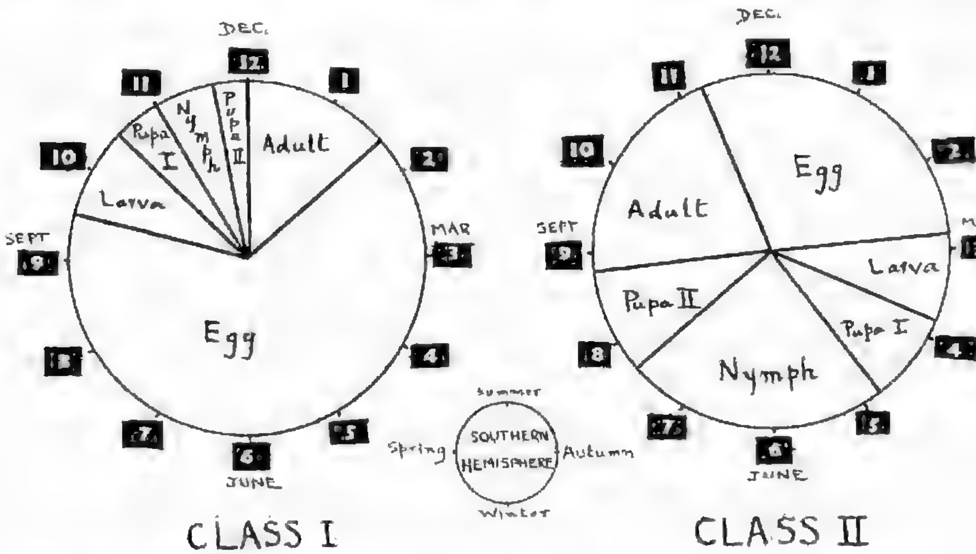

Fig. 5.—Diagram to illustrate the two broad classes of life history in the Erythraeoidea. The numbers represent the months of the year, by their ordinal number. For class II the diagram is interpretative for pupa II, as precise data are not available for that instar.

As will be observed from the data in Table 2, the larvae have in each case a limited seasonal distribution. Inspection of the seasonal distributions of the larvae shows that they are classifiable into two groups: those occurring over September to February (exceptionally into March), i.e. spring-summar larvae (genera *Erythroides, Erythrites, Callidosoma, Pollux*), on the one hand, and on the other those with larvae occurring in March to June (*Smaris, Sphaerotarsus, Rainbowia*).

Thus it is found that again we have segregated the same genera as by our previous classification of the durations of the instars and stages. The following two classes may therefore be proposed:

Class I: the long-duration-egg group, with spring larvae and summer adults, the non-egg developmental stages being passed through quickly. About 2/3 of the annual cycle is passed in the egg. Examples *Erythrites, Erythroides, Callidosoma, Caeculisoma, Pollux, Microsmaris* (all family Erythraeidae).

Class II: the short-duration-egg group, with autumn larvae and spring adults, the non-egg developmental stages being passed through more slowly. About 1/3 of the annual cycle is passed in the egg. Examples *Rainbowia* (family Erythraeidae), *Smaris, Sphaerotarsus* (family Smarididae).

TABLE 2.

Table of seasonal incidences of Erythraeoidea instars and species for temperate Australia.

Mite	Adult	Egg	Larva	Pupa I	Nymph	Pupa II
Smaris prominens	All year, maximal Apr.-June	Mar.-(May)	Mar.-May	Apr.-June	Apr.-Oct., maximal Apr.-May	
Sphaerotarsus leptopilus	Dec.-Mar.	Feb.-Apr.	Apr.-June			
Rainbowia imperator	July to early Dec.	Oct.-Mar.*	Mar.-May	Apr.-May	May-Sept.	
Erythroides clavatus	Aug.-Jan., especially Nov.-Jan.**		Nov.-Dec.	Nov.-Dec.	Nov.-Dec.	
Erythrites reginae	Nov.-Mar.	Dec.-Mar., exceptionally Sept.-Nov.	Sept.-Nov.	Nov.-Dec.	Nov.-Dec.	Dec.-Jan.
*Erythrites osmondensis****			Sept.-Nov.	Nov.	Nov.-Dec.	
*Erythrites guttatus****	Nov.-Jan	Jan.				
Erythrites pilosus	Jan.-Aug., mainly autumn	May Dec.	Nov.-Mar.	Nov.-Dec.	Dec.**** Apr.-May	
Callidosoma womersleyi	Dec.		Dec.-Feb.	Dec.-Jan.	Dec.-Jan.	
Pollux sp. or spp.	Nov.-Feb.*****		Nov.-Dec.	Nov.-Dec.	Nov.-Dec.	

* Based on the time of emergence of the larvae.
** Assuming that *Erythroides clavatus* is the larva of either *E. neoserratus* or *E. serratus*, which is probable.
*** Probably conspecific.
**** Based on experiment ACA863 (see Southcott 1946).
***** Assuming, as appears probable, that the adults and nymphs previously classified as *Microsmaris* are the adults of *Pollux* (see Southcott 1946, 1961).

Although there are variations from the basic classification proposed, e.g. in the fact that adults of *Smaris prominens* may be found throughout the year, or that *Erythrites pilosus* adults appear over January to August and the eggs over May-December, it is apparent that there is a broad separation into the two classes proposed. An attempt to show these two broad groups in a generalized way is made in Fig. 5, where the months of the year are represented by their ordinal numbers as in a conventional 12-hour clockface, thus January by 1, February by 2, and so on. For the southern hemisphere, therefore, summer will be represented at the top of the circle and winter at the bottom. Autumn will be at about 3 o'clock and spring at about 9 o'clock. In the northern hemisphere the reverse would be the case by the same clockface convention.

In Table 2 the details of *Caeculisoma darwiniense* were not shown, since the species has so far been recorded only from northern Australia, and only limited collecting could be done there over May-June, and no information is available as to the possible seasonal occurrence of the species in other months; furthermore, the seasonal temperature differences over the year are different from those of southern Australia, there being no cold season.

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* Principal references only are given here. A full bibliography of the genus *Caeculisoma* is given by Cooreman (1958) and Southcott (1961), the latter containing a full bibliography of the Erythraeoidea.

LIST OF LECTURES GIVEN AT MEETINGS DURING THE YEAR 1959-60

Summary

LIST OF LECTURES GIVEN AT MEETINGS DURING THE YEAR 1959-60

Oct., 1959. Mr. V. J. Boscher: "Missile Testing at Woomera".

Nov., 1959. Mr. T. R. N. Lothian: "Plant Collecting in Central Australia". This was delivered as a Presidential Address.

Apr., 1960. Prof. J. H. Bennett: "The Rôle of Heredity in Human Disease".

May, 1960. Mr. R. C. Sprigg: "Oil Search in Australia".

June, 1960 Dr. T. D. Campbell, Dr. P. Miles, Dr. R. Specht and Mr. I. M. Thomas: "A Symposium on the University of Adelaide's Expedition to Pearson Island".

July, 1960. Mr. B. C. Newland: "From Game Laws to Fauna Protection in South Australia. Evolution of an Attitude".

Aug., 1960. Mr. E. J. Symons: "Production of Uranium Oxide at Port Pirie".

Sept., 1960. Mr. G. B. Sharman: "Reproduction in Marsupials".

BALANCE SHEET

Summary

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED)

REVENUE ACCOUNT

Receipts and Payments for Year ended 30th September, 1960.

	£	s.	d.	£	s.	d.
To Balance, 1/10/59				554	13	1
„ Subscriptions				333	18	10
„ Government Grant				1,750	0	0
„ Sale of Publications, etc.				315	9	11
„ Rent of Rooms				3	0	0
„ Interest—						
Endowment Fund	£259	19	10			
Savings Bank	65	9	4			
				325	9	2
				£3,282	11	0

				£	s
By Printing and Publishing Volume 83, Reprints, etc.				1,622	1
„ Library Assistants				116	
„ Printing and Stationery				65	1
„ Postages and Duty Stamps				117	
„ Cleaning and Polishing				119	1
„ Insurance				122	
„ Lighting				45	
„ Shelving				118	
„ Binding				308	
„ Publications Purchased				26	
„ Hire of Keys				21	
„ Sundries				8	1
„ Balance—					
Savings Bank of S.A., Rundle St.	£634	10	5		
Less Outstanding Cheques	43	19	4		
				590	1
				£3,282	1

Audited and found correct.

F. M. ANGEL } Hon.
N. S. ANGEL, A.U.A. Com. } Auditors.

F. MITCHELL,
Hon. Treasurer.

Adelaide, 6th October, 1960.

ENDOWMENT FUND

Receipts and Payments for Year ended 30th September, 1960.

	£	s.	d.	£	s.	d.
To Balance, 1/10/59				6,110	0	0
„ Walter Howchin Bequest—Received from Public Trustee—						
Commonwealth Inscribed Stock	£810	0	0			
Gas Co. Bonds	200	0	0			
S.A. Inscribed Stock	150	0	0			
Cash—Since Invested in Inscribed Stock	2,400	0	0			
Balance Interest	1	14	9			
				3,561	14	9
„ Investment Interest—						
Inscribed Stock	251	17	7			
Gas Co.	6	7	6			
				258	5	1
				£9,929	19	10

				£	s.
By Revenue A/c Transfer				259	1
Balance—					
Commonwealth Inscribed Stock	9,220	0	0		
S.A. Inscribed Stock	150	0	0		
S.A. Gas Co. Bonds	300	0	0		
				9,670	(
				£9,929	1

Audited and found correct. The Stock has been verified by certificates and the Gas Co. Bonds l been inspected in the hands of the Treasurer.

F. M. ANGEL } Hon.
N. S. ANGEL, A.U.A. Com. } Auditors.

F. MITCHELL,
Hon. Treasurer.

Adelaide, 6th October, 1960.

AWARDS OF THE SIR JOSEPH VERCO MEDAL

Summary

AWARDS OF THE SIR JOSEPH VERCO MEDAL

1929 Prof. Walter Howchin, F.G.S.
1930 John McC. Black, A.L.S.
1931 Prof. Sir Douglas Mawson, O.B.E., D.Sc., B.E., F.R.S.
1933 Prof. J. Burton Cleland, M.D.
1935 Prof. T. Harvey Johnston, M.A., D.Sc.
1938 Prof. J. A. Prescott, D.Sc., F.A.C.I.
1943 Herbert Womersley, A.L.S., F.R.E.S.
1944 Prof. J. G. Wood, D.Sc., Ph.D.
1945 Cecil T. Madigan, M.A., B.E., D.Sc., F.G.S.
1946 Herbert M. Hale, O.B.E.
1955 L. Keith Ward, I.S.O., B.A., B.E., D.Sc.
1956 N. B. Tindale, B.Sc.
1957 C. S. Piper, D.Sc.
1959 C. G. Stephens, D.Sc.
1960 H. H. Finlayson.

LIST OF FELLOWS

AS AT 30th SEPTEMBER, 1960.

Those marked with an asterisk (*) have contributed papers published in the Society's Transactions. Those marked with a dagger (†) are Life Members.

Any change in address or any other changes should be notified to the Secretary.

Note.—The publications of the Society are not sent to those members whose subscriptions are in arrears.

Date of Election	Date of Honorary Election	Honorary Fellows
1895	1949	*Cleland, Prof. J. B., M.D., Dashwood Road, Beaumont, S.A.—*Verco Medal,* 1933; *Council,* 1921-26, 1932-37; *President,* 1927-28, 1940-41; *Vice-President,* 1926-27, 1941-42.
1913	1955	*Osborn, Prof. T. G. B., D.Sc., St. Mark's College, Pennington Terrace, North Adelaide—*Council,* 1915-20, 1922-24; *Vice-President,* 1924-25, 1926-27; *President,* 1925-26.
1912	1955	*Ward, L. K., I.S.O., B.A., B.E., D.Sc., 22 Northumberland Street, Heathpool, Marryatville, S.A.—*Council,* 1924-27, 1933-35; *Vice-President,* 1927-28; *President,* 1928-30.

Date of Election	Fellows
1946.	*Abbie, Prof. A. A., M.D., D.Sc., Ph.D., Department of Anatomy, University of Adelaide, North Terrace, Adelaide, S.A.
1958.	*Abele, K., Dr. Phil. (Marburg), Dr.Phil.Nat. (Tartu-Dorpat), M.Sc. (Riga), 42 Kildonan Road, Warradale Park, S.A.
1959.	Aitken, P., B.Sc., South Australian Museum, North Terrace., Adelaide, S.A.
1927.	*Alderman, Prof. A. R., Ph.D., D.Sc., F.G.S., Department of Geology, University of Adelaide, North Terrace, Adelaide, S.A.—*Council,* 1937-42, 1954-57.
1951.	*Anderson, Mrs. S. H., B.Sc., 31 Lakeman Street, North Adelaide, S.A.
1935.	*Andrewartha, H. G., M.Ag.Sc., D.Sc., Zoology Dept., University of Adelaide, North Terrace, Adelaide, S.A.—*Council,* 1949-50; *Vice-President,* 1950-51, 1952-53; *President,* 1951-52.
1935.	*Andrewartha, Mrs. H. G., B.Agr.Sc., M.Sc. (nee H. V. Steele), 29 Claremont Avenue, Netherby, S.A.
1929.	*Angel, F. M., 34 Fullarton Road, Parkside, S.A.
1939.	*Angel, Miss L. M., M.Sc., 2 Moore Street, Toorak, Adelaide, S.A.
1960.	Archbold, R. T., South Australian Museum, North Terrace, Adelaide, S.A.
1945.	*Bartlett, H. K., L.Th., 2 Abbotshall Road, Lower Mitcham, S.A.
1958.	Bauer, F. H., Department of Geography, University of California, Riverside, California, U.S.A.
1950.	Beck, R. G., B.Ag.Sc., R.D.A., Lynewood Park, Mil-Lel, via Mount Gambier, S.A.
1932.	Begg, P. R., D.D.Sc., L.D.S., Shell House, 170 North Terrace, Adelaide.
1928.	Best, R. J., D.Sc., F.A.C.I., Waite Institute (Private Mail Bag, No. 1), Adelaide.

Date of Election

1956. **Black, A. B., A.S.A.S.M., M.I.M.M., 36 Woodcroft Avenue, St. Georges, S.A.**
1934. Black, E. C., M.B., B.S., Magill Road, Tranmere, S.A.
1950. Bonnin, N. J., M.B., B.S., F.R.C.S. (Eng.), F.R.A.C.S., 19 Marlborough St., College Park, S.A.
1945. **†*Bonython, C. W., B.Sc., A.A.C.I., Romalo House, Romalo Avenue, Magill, S.A.**
1940. Bonython, Sir J. Lavington, 263 East Terrace, Adelaide, S.A.
1945. ***Boomsma, C. D., M.Sc., B.Sc.For., 6 Celtic Avenue, South Road Park, S.A.**
1947. *Bowes, D. R., Ph.D. (Lond.), D.I.C., F.G.S., Department of Geology, University, Glasgow, Scotland.
1957. *Brookes, Miss H. M., Dept. of Entomology, Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1957. Buick, W. G., B.A., c/o Country Lending Service, Public Library, South Australia.
1944. *Burbidge, Miss N. T., M.Sc., C.S.I.R.O., Div. Plant Industry, P.O. Box 109, Canberra, A.C.T.
1958. Buring, I., 51 Richmond Road, Westbourne Park, S.A.
1922. *Campbell, Prof. T. D., D.D.Sc., D.Sc., 24 Lynington Street, Tusmore, S.A.—*Council*, 1928-32, 1935, 1942-45; *Vice-President*, 1932-34; *President*, 1934-35.
1960. Candler, C., 2 Harris St., Glenelg, S.A.
1959. Carrodus, B. B., R.D.Oen., 26 Dequettville Terrace, Kent Town, S.A.
1953. Carter, A. N., B.Sc., 8 Scott St., Maroubra Bay, N.S.W.
1960. Catley, D. E., 8 Cudmore Terrace, Whyalla, S.A.
1957. *Chippendale, C. M., B.Sc., Lindsay Avenue, Alice Springs, N.T.
1929. Christie, W., M.B., B.S., 7 Walter Street, Hyde Park, Adelaide, S.A.—*Treasurer*, 1933-38.
1955. Clothier, E. A., Hydroelectric Commission, Hobart, Tas.
1949. Colliver, F. S., Geology Department, University of Queensland, St. Lucia, Brisbane, Q.
1929. *Cotton, B. C., F.R.Z.S., J.P., South Australian Museum, North Terrace, Adelaide—*Council*, 1943-46, 1948-49; *Vice-President*, 1949-50, 1951-52; *President*, 1950-51; *Programme Secretary*, 1959-.
1956. Crawford, A. R., B.Sc., Mines Department, 169 Rundle St., Adelaide, S.A.
1956. Daily, B., Ph.D., South Australian Museum, North Terrace, Adelaide, S.A.—*Programme Secretary*, 1957-59.
1951. Davidson, A. L. C., Ph.D., B.Sc., c/o Messrs. Simpson & Brookman, 35 Grenfell St., Adelaide, S.A.
1950. Deland, C. M., M.B., B.S., D.P.H., D.T.M., 29 Gilbert Street, Goodwood, S.A.—*Council*, 1952-.
1930. Dix, E. V., Box 12, Aldgate, S.A.
1957. Doull, K. M., M.Ag.Sc., Waite Institute (Private Mail Bag, No. 1), Adelaide.
1959. Dunlop, P. R. G., B.Sc., 13 Walton Ave., Clearview, S.A.
1944. Dunstone, S. M. L., M.B., B.S., 170 Payneham Road, St. Peters, S.A.
1931. Dwyer, J. M., M.B., B.S., 105 Port Road, Hindmarsh, S.A.
1933. *Eardley, Miss C. M., M.Sc., F.L.S., Department of Botany, University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1943-46.
1945. *Edmonds, S. J., B.A., M.Sc., Ph.D., Zoology Department, University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1954-55; *Programme Secretary*, 1955-56; *Secretary*, 1956-57.
1902. *Edquist, A. G., 19 Farrell Street, Glenelg, S.A.—Council, 1949-53.
1956. *Eichler, H., Dr.rer.nat., State Herbarium, Botanic Garden, North Terrace, Adelaide, S.A.
1959. Fielder, D. R., B.Sc., Dept. of Zoology, University, North Terrace, Adelaide, S.A.
1927. *Finlayson, H. H., 305 Ward St., North Adelaide—*Verco Medal*, 1960; *Council*, 1937-40.
1951. Fisher, R. H., 21 Seaview Road, Lynton, S.A.
1958. *Forbes, B. G., Ph.D., F.G.S., 9 Flinders Road, Hillcrest, S.A.
1958. Ford, A. W., F.I.C.S., A.C.C.S., 380 South Terrace, Bankstown, N.S.W.
1959. Forde, N., Dip.For., C.S.I.R.O., Canberra, A.C.T.
1954. Gibson, A. A., A.W.A.S.M., Mines Department, 169 Rundle St., Adelaide, S.A.
1953. *Glaessner, M. F., D.Sc., Geology Department, University of Adelaide, North Terrace, Adelaide, S.A.—*Council*, 1953-54; *Vice-President*, 1958-59.
1935. †Goldsack, H., Coromandel Valley, S.A.
1959. Green, Miss L. M. A., B.A., M.Sc., Dept. of Anatomy and Histology, University of Adelaide, North Terrace, Adelaide, S.A.
1948. Gross, G. F., M.Sc., South Australian Museum, Adelaide—*Secretary*, 1950-53.
1944. Guppy, D. J., B.Sc., c/o W.A. Petroleum Co., 251 Adelaide Terrace, Perth, W.A.

Date of Election

1922. *Hale, H. M., O.B.E., 25 Rochester St., Leabrook, S.A.—*Verco Medal*, 1946; *Council*, 1931-34, 1950-53, 1956-; *Vice-President*, 1934-36, 1937-38; *President*, 1936-37; *Treasurer*, 1938-50, 1953-56.
1949. Hall, D. R., Tea Tree Gully, S.A.
1930. †Hancock, N. L., 3 Bewdley, 66 Beresford Road, Rose Bay, N.S.W.
1953. *Hansen, I. V., B.A., Queen Elizabeth School, Crediton, Devon, England.
1946. *Hardy, Mrs. J. E. (nee A. C. Beckwith), M.Sc., Stewart Ave., Salisbury, S.A.
1944. Harris, J. R., B.Sc., c/o Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1960. Harrison, J., 7 McQuillan Ave., Renown Park, S.A.
1958. Hayball, J. F., B.Sc., 68 Pleasant Avenue, Glandore, S.A.
1960. Hayman, D. L., Ph.D., Genetics Department, University of Adelaide, North Terrace, Adelaide, S.A.
1944. Herriot, R. I., B.Agr.Sc., 49 Halsbury Avenue, Kingswood, S.A.
1951. Hocking, L. J., 46 Kauri Parade, Seacliff, S.A.
1959. Horwitz, R. C. H., D.Sc., 6 Vardon Street, Seacombe Gardens, S.A.
1924. *Hossfeld, P. S., Ph.D., 132 Fisher Street, Fullarton, S.A.
1944. Humble, D. S. W., M.P.S., J.P., 238 Payneham Road, Payneham, S.A.
1947. *Hutton, J. T., B.Sc., A.S.A.S.M., 10 Bellevue Place, Unley Park—*Council*, 1957-.
1928. Ifould, P., 14 Wyatt Road, Burnside, S.A.
1960. Ingham, L. J., 31 Florence St., Fullarton, S.A.
1945. *Jessup, R. W., M.Sc., Division of Plant Industry, C.S.I.R.O., P.O. Box 109, City, Canberra, A.C.T.
1950. *Johns, R. K., B.Sc., Department of Mines, 169 Rundle St., Adelaide, S.A.
1957. Johnson, B., B.Sc.Agr., Ph.D., Waite Institute (Private Mail Bag, No. 1), Adelaide.
1958. *Johnson, W., B.Sc. (Hons.), 33 Ryan Avenue, Woodville West, S.A.
1954. Keats, A. L., B.E., 44 LeFevre Terrace, North Adelaide, S.A.
1939. †Khakhar, H. M., Ph.D., M.B., F.R.G.S., Khakhar Buildings, C.P. Tank Road, Bombay, India.
1949. *King, D., M.Sc., c/o Commercial Bank of Australia, King William St., Adelaide, S.A.
1933. *Kleeman, A. W., Ph.D., Dept. of Geology, University of Adelaide—*Secretary*, 1945-48; *Vice-President*, 1948-49, 1950-51; *President*, 1949-50.
1960. Kuchel, R. H., Roseworthy Agricultural College, Roseworthy, S.A.
1941. *Langford-Smith, T., B.A., M.Sc., Ph.D., Dept. of Geography, University of Sydney, Sydney, N.S.W.
1922. Lendon, G. A., M.D., B.S., F.R.C.P., c/o Elder's Trustee and Executor Co. Ltd., 37 Currie Street, Adelaide, S.A.
1958. Lindsay, H. A., 110 Cross Road, Highgate, S.A.
1948. Lothian, T. R. N., N.D.H. (N.Z.), Director, Botanic Garden, Adelaide, S.A.—*Treasurer*, 1952-53; *Council*, 1953-57; *Vice-President*, 1957-58, 1960-61; *President*, 1958-60.
1931. *Ludbrook, Mrs. N. H., M.A., Ph.D., D.I.C., F.G.S., Department of Mines, 169 Rundle St., Adelaide, S.A.—*Council*, 1958-59; *Vice-President*, 1960-61.
1953. Maelzer, D. A., B.Sc. (Hons.), Waite Institute (Private Mail Bag, No. 1), Adelaide.
1939. Marshall, T. J., M.Agr.Sc., Ph.D., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide—*Council*, 1948-52.
1959. Martin, Miss H. A., 43 Dunrobin Road, Brighton, S.A.
1950. Mayo, G. M. E., B.Ag.Sc., Ph.D., 29 Angas Rd., Lower Mitcham, S.A.
1920. Mayo, Sir Herbert, LL.B., Q.C., 19 Marlborough Street, College Park, S.A.
1948. McCulloch, R. N., M.B.E., B.Sc., B.Agr.Sc., Roseworthy Agricultural College, Roseworthy, S.A.
1945. †*Miles, K. R., D.Sc., F.G.S., 11 Church Road, Mitcham, S.A.
1952. Milne, K. L., F.C.A., 14 Burlington Street, Walkerville, S.A.
1939. Mincham, V. H., 30 Wainhouse Street, Torrensville, S.A.
1958. Mirams, R. C., B.Sc., 5 Myrtle Rd., Seacliff, S.A.
1951. *Mitchell, F. J., South Australian Museum, North Terrace, Adelaide, S.A.—*Treasurer*, 1959-.
1933. Mitchell, Prof. Sir M. L., M.Sc., c/o Elder's Trustee and Executor Co. Ltd., 37 Currie Street, Adelaide.
1925. †Mitchell, Prof. Sir W., K.C.M.G., M.A., D.Sc., Fitzroy Terrace, Prospect, S.A.
1936. *Mountford, C. P., 25 First Avenue, St. Peters, Adelaide.
1957. *Mumme, Ivan A., B.Sc. (Hons.), Department of Mines, 169 Rundle St., Adelaide, S.A.
1944. Murrell, J. W., Engineering and Water Supply Dept., Victoria Square, Adelaide.
1944. Ninnes, A. R., B.A., R.D.A., 62 Sheffield Street, Malvern, S.A.
1945. *Northcote, K. H., B.Agr.Sc., A.I.A.S., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide, S.A.

Date of Election

1930. OCKENDEN, G. P., B.A., 68 Holbrooks Rd., Flinders Park, S.A.
1956. O'DRISCOLL, E. S., B.Sc., 9 Vinall Street, Dover Gardens, S.A.
1937. *PARKIN, L. W., M.Sc., A.S.T.C., Department of Mines, 169 Rundle St., Adelaide, S.A.—*Secretary*, 1953-56; *Vice-President*, 1956-57, 1958-59; *President*, 1957-58.
1949. PARKINSON, K. J., B.Sc., 91 Stuart St., Hillcrest, S.A.
1929. PAULL, A. G., M.A., B.Sc., 10 Milton Avenue, Fullarton Estate, S.A.
1926. *PIPER, C. S., D.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide—*Verco Medal*, 1957; *Council*, 1941-43; *Vice-President*, 1943-45, 1946-47; *President*, 1945-1946.
1948. POWRIE, J. K., B.Sc., Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1925. *PRESCOTT, PROF. J. A., C.B.E., D.Sc., F.R.A.C.I., F.R.S., 82 Cross Road, Myrtle Bank, S.A.—*Verco Medal*, 1938; *Council*, 1927-30, 1935-39; *Vice-President*, 1930-32; *President*, 1932-33; *Editor*, 1955-.
1957. *PRINGLE, MISS L. A. B., Box 876G, G.P.O., Adelaide.
1945. *PRYOR, L. D., M.Sc., Dip.For., 32 La Perouse Street, Griffith, Canberra, A.C.T.
1950. *RATTIGAN, J. H., M.Sc., Newcastle University College, Tigh's Hill, 2N, N.S.W.
1944. RIGEMAN, D. S., M.Sc., B.Agr.Sc., C.S.I.R.O., Division of Biochemistry, Adelaide.
1947. RIEDEL, W. R., B.Sc., c/o Scripps Institution of Oceanography, Dept. of Palaeontology, University of California, La Jolla, California, U.S.A.
1947. RIX, C. E., 42 Waymouth Avenue, Glandore, S.A.
1953. ROGERS, PROF. W. P., Ph.D., F.A.A., M.I.Biol., Zoology Dept., University of Adelaide, North Terrace, Adelaide, S.A.
1951. ROWE, S. A., 22 Shelley Street, Firle, S.A.
1950. RUDD, PROF. E. A., B.Sc., A.M., University of Adelaide, North Terrace, Adelaide, S.A.
1951. RUSSELL, L. D., c/o Adelaide Boys' High School, West Terrace, Adelaide, S.A.
1945. RYMILL, J. R., Old Penola Estate, Penola, S.A.
1933. SCHNEIDER, M., M.B., B.S., 175 North Terrace, Adelaide, S.A.
1959. SCHODDE, R., Division of Land Research and Divisional Survey, C.S.I.R.O., Canberra, A.C.T.
1951. *SCOTT, T. D., M.Sc., S.A. Museum, North Terrace, Adelaide, S.A.—*Programme Secretary*, 1953-54, 1956-57; *Secretary*, 1957-58.
1957. SHARMAN, G. B., B.Sc., Department of Zoology, University, North Terrace, Adelaide, S.A.
1925. *SHEARD, H., Port Elliot, S.A.
1936. *SHEARD, K., D.Sc., C.S.I.R.O., Division of Fisheries and Oceanography, University of W.A., Nedlands, W.A.
1954. SHEPHERD, R. C., B.Sc., c/o Department of Mines, 169 Rundle St., Adelaide, S.A.
1959. SHEPLEY, MISS E. A., M.Sc., 97 North Terrace, Kensington Gdns., S.A.
1934. SHINKFIELD, R. C., 57 Canterbury Avenue, Trinity Gardens, S.A.
1925. †SMITH, SIR TOM BARR, Kt., B.A., 25 Currie Street, Adelaide.
1941. *SOUTHCOTT, R. V., M.D., B.S., D.T.M. & H., 13 Jasper Street, Hyde Park, S.A.—*Council*, 1949-51, 1952-53, 1957-60; *Treasurer*, 1951-52; *Vice-President*, 1953-54, 1955-56; *President*, 1954-55, 1960-61.
1936. SOUTHWOOD, A. R., M.D., M.S. (Adel.), M.R.C.P., 170 North Terrace, Adelaide, S.A.
1947. *SPECHT, R. L., Ph.D., Botany Department, University of Adelaide—*Council*, 1951-52, 1958-60; *Programme Secretary*, 1952-53.
1936. †*SPRIGG, R. C., M.Sc., 5 Baker Street, Somerton Park.
1949. *SPRY, A. H., M.Sc., Geology Department, University of Tasmania, Hobart, Tas.
1947. SPURLING, M. B., B.Ag.Sc., Horticultural Branch, Department of Agriculture, Box 901 E, G.P.O., Adelaide, S.A.
1951. STEADMAN, REV. W. R., 8 Blairgowrie Road, St. Georges, S.A.
1938. *STEPHENS, C. G., D.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide—*Verco Medal*, 1959; *Council*, 1952-54; *Vice-President*, 1954-55, 1956-57; *President*, 1955-56.
1955. SWAINE, C. D., M.B., B.S., 220 Esplanade, Largs North, S.A.
1932. SWAN, D. C., M.Sc., Waite Institute (Private Mail Bag, No. 1), Adelaide—*Secretary*, 1940-42; *Vice-President*, 1946-47, 1948-49; *President*, 1947-48; *Council*, 1953-58.
1951. SWIRSKI, P., M.Ag.Sc., 13 Derwent Ave., Rostrevor, S.A.
1960. SYMONS, E. F., Uranium Treatment Plant, Port Pirie, S.A.
1934. SYMONS, I. G., 35 Murray Street, Lower Mitcham, S.A.—*Editor*, 1947-55; *Council*, 1955-58.
1958. TAYLOR, D. J., Dept. of Entomology, Waite Institute (Private Mail Bag, No. 1), Adelaide, S.A.
1959. TAYLOR, D. J., 23 Westbourne St., Prahran East, Vic.

Date of Election

1929. *TAYLOR, J. K., B.A., M.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide—*Council*, 1940-43, 1947-50; *Librarian*, 1951-52; *Vice-President*, 1952-53, 1954-55; *President*, 1953-54; *Council*, 1955.

1955. THATCHER, D., B.Sc., Department of Mines, 169 Rundle St., Adelaide, S.A.

1948. *THOMAS, I. M., M.Sc. (Wales), M.I.Biol., Department of Zoology, University of Adelaide—*Secretary*, 1948-50; *Council*, 1950-53; *Vice-President*, 1955-56, 1957-58; *President*, 1956-57; *Assistant Editor*, 1958-.

1938. *THOMAS, MRS. I. M. (nee P. M. Mawson), M.Sc., Department of Zoology, University of Adelaide, North Terrace, Adelaide, S.A.

1957. THOMAS, J., B.Sc., Woodleigh Road, Blackwood, S.A.

1940. *THOMPSON, CAPT. J. M., 135 Military Road, Semaphore South, S.A.

1959. THOMSON, B. P., M.Sc., 33 Oaklands Road, Parkholme, S.A.

1923. *TINDALE, N. B., B.Sc., South Australian Museum, North Terrace, Adelaide, S.A.—*Verco Medal*, 1956; *Secretary*, 1935-36; *Council*, 1946-47; *Vice-President*, 1947-48, 1949-50; *President*, 1948-49; *Librarian*, 1952-.

1955. *TUCKER, B. M., B.Sc., C.S.I.R.O., Division of Soils (Private Mail Bag, No. 1), Adelaide, S.A.

1959. TWIDALE, C. R., Ph.D., M.Sc., Dept. of Geography, University of Adelaide, North Terrace, Adelaide, S.A.

1959. *TYLER, M. J., Dept. of Physiology, University of Adelaide, Adelaide, S.A.

1960. TYNAN, A. E., c/o Australian Mineral Development Laboratories, Flemington St., Parkside, S.A.

1950. VEITCH, J. T., Box 92, Port Lincoln, S.A.

1953. WATERMAN, R. A., B.A., M.A., Ph.D., Wayne State University, Detroit, Michigan, U.S.A.

1954. WEBB, B. P., M.Sc., Department of Mines, 169 Rundle St., Adelaide, S.A.

1954. WELLS, C. B., B.Ag.Sc., Broadlees, Waverley Ridge, Crafers, S.A.

1959. WHELAN, PROF. R. F., Department of Physiology, University of Adelaide, North Terrace, Adelaide, S.A.

1946. *WHITTLE, A. W. G., M.Sc., c/o Australian Mineral Development Laboratories, Parkside, S.A.

1950. WILLIAMS, L. E., "Dumosa," Meningie, S.A.

1946. *WILSON, PROF. A. F., D.Sc., Dept. of Geology, University of Queensland, St. Lucia, Brisbane, Qld.

1938. *WILSON, J. O., 42 Wilson Terrace, DaCosta Park, Glenelg, S.A.

1933. *WOMERSLEY, H., F.R.E.S., A.L.S. (Hon. causa), South Australian Museum, North Terrace, Adelaide—*Verco Medal*, 1943; *Secretary*, 1936-37; *Editor*, 1937-43, 1945-47; *President*, 1943-44; *Vice-President*, 1944-45; *Rep. Flora and Fauna Protection Committee*, 1945; *Treasurer*, 1950-51, 1956-59.

1954. *WOMERSLEY, H. B. S., D.Sc., Botany Department, University of Adelaide, North Ter-Adelaide, S.A.

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Names printed in italics as separate entries indicate that the forms are new to science.

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