Journal

OF

The Royal Society of Western Australia.

Vol. XII.
1925-1926.

The Authors of Papers are alone responsible for the statements and the opinions expressed therein.

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THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

Patron: His Majesty the King.
Vice Patron: His Excellency Sir William Campion, K.C.M.G.

OFFICERS, 1925-26.

President:

A. Gibb Maitland, F.G.S.

Vice-Presidents:

W. M. Carne, F.L.S.; W. A. Saw.

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Secretaries:

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For Natural Science:

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Assistant Librarian:

L. Glauert, F.G.S.

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F. E. Allum, G. Spencer Compton, B.Sc., A.I.M.M., Miss M. Creeth, C. A. Gardner, W. Catton Grasby, F.L.S., A. Montgomery, M.A., F.G.S., Mrs. M. A. Shelton, E. S. Simpson, D.Sc., B.E., F.C.S.

Owing to an error the above list of Office Bearers appeared in Vol. XI as if holding office for the year 1924-1925, the correct list of officers for which may be found in Vol. X, p. xiv.

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LIST OF MEMBERS.*

As at July 1st, 1926.

Honorary Members:

Bird, Mrs. A. M., The Old Farm, Albany, W.A.

Cooke, Prof. W. E., M.A., F.R.A.S., The Observatory, Sydney.

Dakin, Prof. W. J., D.Sc., F.L.S., F.Z.S., The University, Liverpool.

Diels, Dr. Ludwig, Director of Botanical Gardens and Museum, Berlin-Dahlem, Germany.

French, Charles, F.L.S., F.R.H.S., Government Entomologist, Melbourne.

Pritzel, Dr. E., Str.4, Han Sachs, Berlin-Lichderfelde.

Hancock, W. J., M.Inst.C.E., M.Inst.E.E., D.Sc., 47 Forrest Avenue, Perth.

Corresponding Members:

Alexander, W. B., M.A., Prickly Pear Laboratory, Sherwood, via Brisbane.

Cheel, Edwin, National Herbarium, Sydney.

Hedley, Charles, F.L.S., c/o Museum, Brisbane.

Herbert, D. A., M.Sc., Department of Biology, University of Queensland.

Ordinary Members:

Alexander, L., J.P., Malcolm Street, Perth.

Allen, F. B., M.A., B.Sc., The Technical School, Perth.

Allum, Miss Enid, The Royal Mint, Perth.

Allum, F. E., The Royal Mint, Perth.

Anderson, Joseph, Government Stores, West Perth.

*Members are requested to notify the Hon. Secretary for Physical Science of any change of address.

LIST OF MEMBERS—*continued.*

Ordinary Members—continued.

Baker, F. G., 12 Warwick House, St. George's Terrace, Perth.
Barnesby, A. J., Aberdeen Street, Albany.
Baron-Hay, G., B.Sc. (Agric.), Department of Agriculture, Perth.
Battye, J. S., LL.B., D.Litt., The Public Library, Perth.
Bennett, W. E., D.M.D., Victoria Parade, Claremont.
Bennetts, H. W., B.V.Sc., Dept. of Agriculture, Perth.
Blackall, W. E., M.B., Ch.B., F.R.C.S., L.R.C.P., View Street, Cottesloe.
Blain, A., 448 Beaufort Street.
Blatchford, T., B.A., 2 Lyall Street, South Perth.
Bonnerup, P. M., A.S.A.S.M., A.M.P. Chambers, Perth.
Boultbee. G. F., Commercial Union Chambers, Perth.
Brearley, Major N., D.S.O., M.C., C/o Airways Ltd., A.M.P. Chambers, Perth.
Buckeridge, Walter, F.I.O.O., F.S.M.C., D.B.O.A., 263 Murray Street, Perth.
Burbury, D. C., A.B.S.M., Royal Mint, Perth.
Calanchini, M. J., Mines Department, Perth.
Campion, W. E., Forests Department, Mundaring, W.A.
Carne, W. M., F.L.S., Department of Agriculture, Perth.
Christie, W. B., C/o Civil Service Club, Perth.
Clark, J., F.L.S., Department of Agriculture, or 54 Jewell Street, Perth.
Clarke, E. de C., M.A., The University, Perth.
Clifton, A. R. C., Department of Agriculture, Perth.
Clubb, Wallace, B.A., Education Department, Perth.
Compton, G. Spencer, B.Sc., 87 Second Avenue, Inglewood.
Coombe, Sir Thomas M., Kt., Prince of Wales Chambers, Murray Street, Perth.
Couch, James K., M.D., 1314 Hay Street West, Perth.
Creeth, F. B., Avonmore Terrace, Cottesloe Beach.
Creeth, Miss M., 38 Wilson Street, West Perth.
Curtis, Miss Alice, B.A., Victoria Avenue, Claremont.
Dale, Hylton B., 8 Wilson Street, Perth.
Dale, Mrs. H. B., 8 Wilson Street, Perth.
Dale, J., O.B.E., M.D., B.Sc., M.R.C.S., L.R.C.P., Public Health Department, Perth.
Doye, A. G., Parker Street, Bassendean.
Drummond, J. M., Irvine Street, Cottesloe.
Dwyer, J. J., 121 Barrack Street, Perth.
Edwards, Ernest, Whitfield Street, Bassendean.
Esson, A. G. D., M.A., Garrett Road, Bayswater.
Farquharson, R. A., M.A., M.S., F.G.S., Geological Survey, Perth
Feldtmann, F. R., Geological Survey, Perth.

LIST OF MEMBERS—*continued.*

Ordinary Members—continued.

Fox, A. C., M.A., The University, Perth.
Fyfe, W. V., 27 Longroyd Street, Mt. Lawley.
Gardner, Charles A., Agricultural Department, Perth.
Garner, W. B., King's Park Road, Perth.
Gatherer, R. E., Royal Mint, Perth.
Gibson, F. E., 112 High Street, Fremantle.
Glauert, L., F.G.S., The Museum, Perth.
Grasby, W. Catton, F.L.S., C/o "West Australian," Perth.
Gray, H. J., M.B., B.S., 25 Richardson Street, West Perth.
Gray, H. R., B.A., Forests Dept., Perth.
Gulley, F. P., J.P., M.P.S., 262 Railway Parade, West Leederville.
Hadley, F. G., F.R.C.S., "Adelaide House," St. George's Terrace, Perth.
Hayman, Wm. G. I., B.Sc., The Technical School, Perth.
Hedges, William N., Esplanade Mansions, Perth.
Hislop, J. Gordon, M.B., Ch.B., M.R.C.P., Children's Hospital, Perth.
Holmes, H. D., Salvado Street, Cottesloe.
Hoskins, J. S., 19 Bedfordale Avenue, Subiaco.
Jackson, Horace B., Forrest Street, Cottesloe.
Joyner, A. E., 13 Rheola Street, West Perth.
Kennedy, Peter, M.I.E.E., Assoc. A.I.E.E., State Engineer, G.P.O., Perth.
Kessell, S. L., B.Sc., Forestry Department, Perth.
Kierath, A. R., C/o Telephone Exchange, Murray Street, Perth.
Kirby, Harry, 832 Hay Street.
Klem, Carl A., Longroyd Street, Mt. Lawley.
Knapp, A., M.W.A.O.A., Barrack Street, Perth.
Knapp, Mrs. A., 14 Altona Street, West Perth.
Lapsley, R. G., B.S . (Agric.) Judd Street, South Perth.
Larcombe, C. O. G., D.Sc., School of Mines, Kalgoorlie.
Law, R. O., Colin Street, West Perth.
Lefroy, H. Maxwell, Survey Department, Perth.
Le Souef, E. A., B.V.Sc., The Zoological Gardens, South Perth.
Lipfert, O. H., The Museum, Perth.
Limb, John M., A.A.C.I., 48 Fourth Avenue, Maylands.
Lotz, H. J., F.R.C.S., D.P.H., L.R.C.P., Perpetual Trustee Buildings, St. George's Terrace, Perth.
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Lovekin, The Hon. A., M.L.C., 9 Colin Street, West Perth.
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Lunnon, J. H., D.B.O.A., F.I.O., Bruce Street, Nedlands.
Maitland, A. Gibb, F.G.S., Geological Survey, Perth.

LIST OF MEMBERS—*continued.*

Ordinary Members—continued.

Maitland, Mrs. A. G., Charles Street, South Perth.
Male, Arthur, Broome, W.A.
Marr, H. V., C/o Plaimars, Ltd., Perth.
McDonald, Miss J., South Perth.
McMillan, The Hon. Sir Robert, Kt., View Street, Cottesloe.
McVicar, Douglas, Forestry Department, Perth.
Michelides, P., 116 William Street, Perth.
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Montgomery, Mrs. A., 28 First Avenue, Mt. Lawley.
Morgans, A. E., 81 St. George's Terrace, Perth.
Murray, J. G., 1 Bennett Street, East Perth.
Nathan, C. S., 1 Malcolm Street, Perth.
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Nicholls, Prof. G. E., D.Sc., A.R.C.Sc., F.L.S., The University, Perth.
Nicholls, Mrs. G. E., Suburban Road, South Perth.
Nicholson, Lt.-Col. E. J. H., C.M.G., D.S.O., V.D., 7 Victoria Avenue, Claremont.
Nicholson, The Hon. John, M.L.C., Surrey Chambers, St. George's Terrace.
Nunn, George M., L.S., 92 Thomas Street, West Perth.
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Robinson, R. T., K.C., "Killowen," Mt. Lawley.
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LIST OF MEMBERS—*continued.*

Ordinary Members—continued.

Rosenstamm, B., 8 Bellevue Terrace.
Ross, Prof., A. D., M.A., D.Sc., F.R.A.S., F.R.S.E., F.Inst.P., The University, Perth.
Sandover, Alfred, Mount Street.
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Smith, Mrs. L. Russell, M.A., 112 Helena Street, Guildford.
Southern, B. L., A.A.C.I., Government Analyst's Office, Perth.
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Stephenson, The Hon. H. A., 56 Ord Street, West Perth.
Stuart, H. Ackroyd, M.Inst.M.E., "Akroydon," Claremont.
Sutherland, W. G., C/o Fremantle Trading Coy., Fremantle.
Sutton, G. L., Department of Agriculture, Perth.
Talbot, H. W. B., C/o Surveyor-General's Department, Perth.
Thomas, Charles O. A., Brook Street, Bassendean.
Thompson, James B. E., M.Inst.C.E., "Rostrever," Esplanade, Cottesloe.
Thompson R. D., M.A., M.Sc., F.R.A.S., A.Inst.P., The University, Perth.
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Wackett, W., C/o F. H. Faulding and Co., Ltd., Murray Street.
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Watkins, A. O., A.R.S.M., F.G.S., The Royal Mint, Perth.
Webster, A., M.D., 229 St. George's Terrace.
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Williamson, A. F., Public Works Dept., Perth.
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Wood, J. A., 15 Chester Street, Subiaco.
Wright, Miss J. G., Ph.D., The University, Perth.
Yeates, G. E., M.W.A.O.A., 37 Barrack Street, Perth.

LIST OF MEMBERS—*continued.*

Associate Members:

Adams, A. B., Agricultural Adviser, Bunbury.
Allen, T. G. B., 38 Colin Street, West Perth.
Anderson, Miss S., 253 St. George's Terrace, Perth.
Anderson, Miss Maggie, 253 St. George's Terrace.
Anderson, Miss Henrietta, 9 Mitchell Street, Mt. Lawley.
Armstrong, Miss Florence, The Rectory, Victoria Park.
Atkins, R. W., Forests Department, Perth.
Benham, Miss L., Malcolm Street.
de Burgh, Miss, C/o Mrs. Charles Harper, 60 Mount Street.
Campbell, J. G. C., B.Sc., Department of Agriculture, Suva, Fiji.
Campbell, W. D., A.K.C., F.G.S., A.M.Inst.C.E., L.S., Office 33, 273 George Street, Sydney.
Carne, Mrs. W. M., York Street, South Perth.
Cass-Smith, W. P., B.Sc., (Agric.) C/o J. T. Mosey, 35 Barrack Street.
Clarke, Mrs. E. de C., 8 Charles Street, South Perth.
Cleland, Prof. J. B., M.D., Ch.M., The University, Adelaide.
Conning, Miss A. W., Victoria Street, Bunbury.
Creeth, Mrs. F. B., Avonmore Terrace, Cottesloe Beach.
Cummins, J. E., B.Sc., 110 Outram Street, West Perth.
Davy, Miss Margaret, 83 Broome Street, Cottesloe.
Edmiston, Miss Margaret E., B.Sc., 71 Outram Street, West Perth.
Fairweather, Miss Margaret, B.A., 137 Hammersley Road, Subiaco.
Frearson, Miss O., Tuart Street, Applecross.
Galbraith, A. R. M.Inst.C.E.I., L.R.I.B.A., A.M.I.E.A., City Engineer, Christchurch, N.Z.
Gribble, Rev. E. R., C/o A.B.M. Office, Cathedral Chambers, Perth.
Hall, Albert J., 9 Ruby street, North Perth.
Hancock, Mrs. W. J., 47 Forrest Avenue.
Hayward, Miss L. A., B.Sc., C/o Professor Ross, University, Perth.
Henderson. T., B.Sc., The Grammar School, Guildford.
Hinckley, Miss C., 47 Forrest Avenue.
Hughes, T. R., 20 Tower Street, Leederville.
Hosking, Miss L., University, Perth.
Jackson, Miss Nina Florence, Forrest Street, Cottesloe.
Lambourne, Miss E., B.Sc., C/o Fire Station, Irwin Street.
Le Mesurier, C. J. R., 39 St. George's Terrace.
Lobstein, J. L., Technical School, Perth.
Lovegrove, Mrs. F., Dumbleyung, W.A.
Neville, A. O., Department of North-West, Perth.
Newton, Miss E. A., The University, Perth.
Norman, Mrs. Hugh, 5 Esplanade Mansions, Perth.
Parr, Miss Kate, B.Sc., 689 Beaufort Street, Perth.

LIST OF MEMBERS—*continued.*

Associated Members—continued.

Paterson, J. W., 34 Suburban Road, South Perth.
Paton, Mrs. D. D., C/o Dr. Paton, 68 St. George's Terrace.
Pearson, H. E., B.A., B.Sc., The Modern School, Subiaco.
Pelloe, Mrs. T., 22 Mount Street.
Phillips, Mrs. L. W., 10 Queen's Crescent, Mt. Lawley.
Prisk, Miss Joyce, 24 Hamersley Road, Subiaco.
Prisk, Mrs. Olive, 24 Hamersley Road, Subiaco.
Quilty, J. F., District High School, Geraldton.
Richardson, K. C., 25 Charles Street, South Perth.
Ross, Mrs. A. D., B.Sc., Ventnor Avenue, West Perth.
Robertson, Mrs. A. A., 1029 Wellington Street.
Rotenberg, Miss Dora, B.Sc., 8 Bulwer Street.
Sanderson, A. E., Meadow Street, Guildford.
Serventy, D. L., Railway Parade, East Cannington.
Shelton, Miss K., 20 Kershaw Street, Subiaco.
Shelton, Mrs. Wm. E., C/o W. E. Shelton, Modern School, Subiaco.
Shields, Miss, 42 Swanbourne Terrace, Cottesloe Beach.
Simpson, Mrs. E. S., "Carlingford," Mill Point, South Perth.
Simpson, Miss Mary, The University, Perth.
Le Soeuf, Miss Mildred H., B.Sc., The Zoological Gardens, South Perth.
Spicer, M. P., C/o Elder Smith and Co., Ltd., Perth.
Spicer, Mrs. M. P., 10 Queen's Crescent, Mt. Lawley.
Steedman, H., Suburban Road, Victoria Park.
Sterne, Miss Ilma R., M.Sc., Presbyterian Ladies College, Cottesloe.
Stremple, Miss Edna M., The University, Perth.
Sutton, Miss N. E., Ellesmere Road, Mt. Lawley.
Terelinck, Miss Rose F., The University, Perth.
Thompson, Mrs. R. D., 61 Highway, Nedlands.
Tothill, Miss, 62 Ord Street, West Perth.
Watson, E. M., B.Sc., University, Perth.
Wellwood, Miss M., 32 Mount Street, Perth.
Williams, F. A., B.Sc., Royal Mint, Perth.
Wood, W. E., Inspecting Engineer's Office, Railway Department, Perth.
Wright, A. R. L., L.R.I.B.A., Public Works Department, Perth.

Student Member:

Builder, G.

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR ENDING 30th JUNE, 1926.

Ladies and Gentlemen:

Your Council begs to submit the following report for the year ending 30th June, 1926:—

Membership: As from 1st July, there are 243 members on the roll, of whom 7 are honorary members, 4 corresponding members, 157 ordinary members, 74 associate members, and one student member.

During the year 7 ordinary members and 7 associate members have been elected, while 9 ordinary members and 5 associate members have resigned. The election of one member has been declared void in accordance with Rule 10.

The Council records with regret the deaths of Mr. J. H. Maiden, honorary member, and of Dr. R. C. Merryweather, ordinary member of the Society.

The number of members and associate members for every year since the foundation of the Society is as follows (with the exception of the year 1921, for which no list of members was published in the Journal):—

Year . . .	1914	1915	1916	1917	1918	1919	1920	1922	1923	1924	1925	1926
Members .	—	47	59	64	64	76	75	76	89	172	161	157
Associates	—	29	19	20	19	24	27	31	40	63	72	74
Total . . .	112	76	78	84	83	100	102	107	129	235	233	231

Finances: The grant of £75 received during the year from the Government has placed the finances of the Society on a far more satisfactory footing than was the case last year. But it is to be noted that while the Financial Statement shows a credit balance of a little over £70, yet it is estimated that a further sum of at least £80 will be required to complete the publication of the current volume. Thus it would appear that a grant of £75 at the present time enables the Society just to meet the costs of printing, and does not provide for the increased expenditure urgently needed in other directions. It has therefore been decided to approach the Government with a view to securing an increased grant for the coming year.

Publications: Up to the present 7 numbers of Volume XII. of the Journal have been published at a cost of about £70. However, as 10 or 11 further contributions have been received, or are in course of preparation, and as these are accompanied by a number of plates and text-figures, the final cost of Volume XII. will be at least £150.

The following table shows the space occupied by the subject matter of the 7 numbers of Volume XII. so far published:—

	Number of papers.	Number of pages.	Number of plates.
Botany	2	31	6
Geology	3	19	—
Zoology	2	12	1

In addition, there are 3 papers on geology, and 8 on zoology now in course of publication.

Four lectures of a popular character, and not intended for publication, have been given before the Society during the year.

Library: The Honorary Librarians report as follows:—

(1) *Reorganisation of the Library*: During the year, considerable time has been given to the work of re-arranging the library. This was found to be necessary as the congestion of journals on the shelves rendered usage of the library difficult and had led to some confusion. All "short series" of journals, together with some 200 volumes on natural history, have been removed from the shelves and placed in less accessible positions. This has provided sufficient shelving space for incoming journals for another two years. The general arrangement of the Library now is as follows:—The Proceedings of Royal and other scientific societies are in the lecture room, while in the library, sections have been set aside for geology, botany, agriculture, physics, mathematics and chemistry. It is hoped that this will be of greater assistance to members than the old geographical arrangement.

(2) *New shelving*: During the work of re-arranging the library, it was found that the shelving along the north wall had become infested with white ants. This has been taken down, and replaced by new shelving made of jarrah.

(3) *Binding*: During the year 80 volumes have been bound at a cost to the Society of £28 17s. 6d. This represents merely the most urgent work. The list of journals that require binding is formidable, and, if possible, £50 should be set aside each year for binding. This would enable all the incoming journals to be bound, and allow for the arrears of binding to be dealt with gradually.

(4) *Donations to the Library*: Donations of scientific journals have been made to the Society by Mr. A. Montgomery, M.A. These have been of great use in completing certain series of journals. Dr. Hancock has also donated a set of the volumes of this Society.

(5) *Exchange List*: Three additions to the exchange list were made during the year. The following table gives the countries, type of institution, etc., to which the journal is forwarded free:—

Country	Scientific Societies	Govt. Depts.	Univers-ities.	Museums. Libraries	Total.
Australia	8	12	3	12	35
England	3	1	—	5	9
South Africa	2	—	—	2	4
India	1	2	—	1	4
New Zealand	—	—	1	1	2
Canada	1	1	—	—	2
Europe	4	1	5	8	18
United States	2	1	10	9	22
South America	2	1	—	—	3
Java	—	1	—	—	1
Totals	23	20	19	38	100

(6) *Catalogue*: A catalogue of the library is urgently required, and it is hoped that, during next year, funds will be made available for cards and boxes, so that a card catalogue can be prepared.

Reports of Committees: (1) During the year a committee consisting of the President, Messrs. Carne, Catton Grasby, Glauert, Saw, and the Hon. Secretary for Natural Science, was appointed to seek the co-operation of all bodies and individuals interested in the preservation of the unique flora and fauna of Western Australia. Two matters have been dealt with by the committee:—(a) *Re-dedication of South Perth Reserve No.* 5574. A Bill was framed, but not proceeded with, having as its object the re-dedication of portion of this reserve originally set aside for the establishment of Botanical Gardens. The committee drew the attention of the Chief Secretary to the importance of reserving a suitable site for this purpose, and proferred assistance should the re-dedication of the South Perth reserve necessitate the selection of another area for the Botanical Gardens. (b) *Swan View National Park, Reserve No. A.* 7537. The committee's efforts to have this park gazetted a flora and fauna reserve have so far secured the proclamation of the park as a reserve for native game. Means for the protection of he flora are being considered.

(2) A report from the "Salinity in Soils" committee is appended.

(Signed) A. GIBB MAITLAND,
President.

R. D. THOMPSON,
Joint Hon. Secretary.

ROYAL SOCIETY OF WESTERN AUSTRALIA.

STATEMENT OF RECEIPTS AND EXPENDITURE for the Year ending 30th June, 1926.

RECEIPTS.

	£ s. d.	£ s. d.
Balance on July 1st, 1925.		
In bank, Medal Fund	3 16 9	
General Fund	81 4 4	
Cash	2 19 0	
		88 0 1
Subscriptions—		
1923-24	3 13 6	
1924-25	17 6 6	
1925-26	157 10 0	
Students	1 15 0	
		180 5 0
Reprints		8 4 7
Profit on Excursion		1 1 6
Books Sold		10 0
Government Grant		74 19 11
Exchange		6
Interest on Banking A/c		2 4 8
		£355 6 3

In addition to the Expenditure shown in this statement a debt of about £80 for the rest of Vol. XII has been incurred.

EXPENDITURE.

	£ s. d.	£ s. d.
Printing Journals—		
R. S. Sampson, Vol. XI	96 5 0	
R. S. Sampson, Vol. XII	64 8 0	
Art Photo Engravers, for blocks	10 1 10	
		170 14 10
Annual Meeting		11 4 0
Govt. Print. for Cards, etc.		12 11 4
Museum, free for Cleaning		14 14 0
Bookbinding		28 17 6
Petty Cash, Postage, etc.		26 16 5
Shelving		7 10 0
Launch Hire		5 0 0
World List of Publications		2 2 0
		£279 10 1
Balance on June 30th, 1926.		
Medal Fund	3 16 9	
Ordinary Fund	69 14 10	
Cash	2 4 7	
		75 16 2
		£355 6 3

Examined and found correct.

F. D. CREETH, }
G. F. BOULTBEE, } Auditors.

10th July, 1926.

ENID ALLUM,
Hon. Treasurer.

REPORT OF "SALINITY IN SOILS" COMMITTEE TO 30th JUNE, 1926.

Two meetings of the Committee have been held since the last Report, the second meeting being on the 24th instant.

The work during the past year has consisted chiefly in carrying on the investigations on the salinity of rain. The results up to March, 1926, when the analyses for the first period of twelve months were completed, were disappointing for the reason that the winter season of 1925 was exceptionally dry in most districts, and that storms were usually weak and the routes they travelled not well defined.

The Committee therefore decided at its meeting on March 5th, 1926, to continue the tests for another twelve months, in the hope of obtaining a more reliable set of data. Shortly afterwards a letter dated March 8th, 1926, was received from the Commonwealth Meteorologist conveying the same conclusions, and asking the Committee to continue the Chlorine Survey in Western Australia for another twelve months. The letter mentioned further that out of approximately 600 analyses of rain received during the preceding twelve months over fifty per cent. were from the five capital cities and Darwin, leaving the other twenty-five recording stations with less than ten records each. Also in very few cases did observations at neighbouring stations synchronise.

The data are therefore as yet insufficient to justify definite conclusions, but from such as are available the following provisional deductions may be drawn:

1 The variability of the salt content in rain collected at different localities is marked, but this variability is much more pronounced near the sea coast than inland.

2 The salt content is much greater in rain collected near the coast than in that collected inland.

3 In rain collected at Perth the salt content increases as the wind veers from north-west through west to south-west.

A Sub-Committee has been appointed to examine data relating to the salt content of rain, and it is hoped that by comparing the estimations of chlorine with the records of the Weather Bureau it will be possible to determine the nature of the storms that bring most salt on to the land in Western Australia, their frequency, and the area traversed.

When satisfactory conclusions in the above directions have been reached, the Committee will be better equipped to study the main problem for which it was appointed, namely, the effect, if any, of deforestation on the salinity of the soil.

(Signed) N. T. M. WILSMORE,
Chairman.

EXHIBITS DURING THE SESSION, 1925-26.

(Only those exhibits are noted of which details have been furnished by the member making the exhibit.)

August, 1925.

Dr. E. S. SIMPSON—*Rutile* from Coodardy. Large black crystals twinned on (101), the two largest weighing 500 and 350 grammes. *Aragonite* from Lake Barlee and Lake Ballard. Finely fibrous botryoidal masses. *Calcite* from Lake Austin. Finely fibrous, botryoidal masses, probably pseudomorphous after aragonite.

Mr. E. de C. CLARKE—The following *Jurassic fossils* collected in June at Newmarracarra, near Geraldton, and tentatively identified by Dr. F. W. Whitehouse: *Dorsetensia etheridgei*, *D. edwardiana*, *Emileia australia*, *E.* cf. *brockesi*, *E. semiornata*, *Epubsceites*, *Lytoceras*, *Otoites affsausiae*, *O. depressus*, *Teloceras*. This assemblage appears to confirm the middle Bajocian age previously suggested for these beds by Whitehouse (Jour. Roy. Soc., W.A., vol. XI. (1924), p. 12). An ammonite from the Gingin Chalk tentatively identified by Dr. Whitehouse as *Parapuzosia* cf. *daubrei*.

Mr. W. M. CARNE—Specimens of *Cordyceps* from Plavin's Siding, Hotham River Railway, collected by H. Lansdell, June, 1925, parasitic on larvae of a hepialid moth. The species is probably *C. gunnii* Berk, though the specimens are larger than any yet recorded. Specimens are being forwarded to C. G. Lloyd, U.S. America, for determination. This is the first record of *Cordyceps* occurring in Western Australia.

Mr. L. GLAUERT—A female specimen of *Paranebalia longipes* Willem. Suhm., a species first discovered by the "Challenger" in the West Indies, and since recorded from many very distant localities, including Torres Strait.

October, 1925.

Mr. W. E. SHELTON—Specimens of *Orobanche cernua*, showing the nature of the attack of its parasitic roots upon hosts belonging to the natural orders leguminosae, compositae and gramineae.

Mr. W. M. CARNE—Specimens of the sterile (*Xylostroma giganteum*, Fries) stage of undetermined polyporoid fungi taken from Karri, Jarrah and Tuart logs. Also a specimen of *Trametes lilacino-gilvo*, Berk, from an unidentified Eucalyptus log at Marvel Loch, showing both fructification and Xylostroma stages.

Mr. L. GLAUERT—A Red Tailed Tropic Bird *Phaethon rubricaudus* shot at Gingin Brook by Mr. V. Jones in August last. This bird breeds in the Abrolhos Islands, where it generally arrives in November. Its presence at Gingin in August is, therefore, all the more remarkable. This is the first record of the Tropic Bird in the Swan River district as defined by Mr. W. B. Alexander in his paper to "the Emu" in 1921. Mr. Gregory Mathews' statement that the bird occurs on Rottnest is due to a confusion of that Island with Rat Island in the Houtman's Abrolhos, where specimens were collected by Mr. V. H. Lipfert in 1894. A fresh-water sponge, probably *Ephydatia multiformis* so common in many of the lakes and swamps near Perth. The specimens exhibited were found in water pipes conveying de-aerated water. Presented to the Museum by the Chief Engineer for Water Supply. The presence of this sponge in water mains is of economic importance, as much trouble has been caused by similar growths in the water mains of "water works" in Britain, America, France, Holland and Germany.

December, 1925.

Mr. A. GIBB MAITLAND—Glaciated pebbles, collected by Mr. H. W. B. Talbot from the Poole Range, to the south of Xmas Creek, between Mount Synnot and Light Jack Hills. The horizon is about 80 feet thick, and is well above the base of the formation, for a bore has been put down to about 2300 feet below it. Two photographs of Kimberley geological formations taken by Mr. T. Blatchford.

Mr. C. A. GARDNER—Botanical specimens collected by himself and Dr. W. E. Blackall—(a) from summit of Middle Mt. Barren, S.W. of Ravensthorpe—*Hakea Hookeriana, Acacia cedroides, Boronia albiflora*; (b) West of Ravensthorpe—*Bossiaea calycina, Casuarina acuaria, Nematolepis phebalioides, Calycopeplus marginatus.*

Mr. W. M. CARNE—Specimens of wheat affected with a bacterial disease *Pseudomonas tritici*, Hutchinson, in association with an attack of Ear Cockle, *Tylenchus tritici* (Stein) Bast. Field evidence here supports the finding of Fahmy and Mikhail in Egypt (Agric. Jnl. Egypt N.S. 1. 1., 1923) that *Pseudomonas tritici* is incapable of producing infection in nature without the assistance of the nematodes. The specimens came from a farm at Yelbeni, where the disease had been first noted by the owner in 1923. *Pseudomonas tritici* has been previously recorded only in India and Egypt. Its occurrence in Western United States of America has recently been reported to the exhibitor by Mr. C. M. Hutchinson, Imperial Bacteriologist in India.

March, 1926.

Mr. D. L. SERVENTY—A specimen of the oriental Dottrel (*Charadrius veredus*, Gould), which he took at Lake Jandakot on January 14, 1926. The exhibitor mentioned that this appeared to be the first record of the species from the South-west of the State, none apparently having been observed or collected further south than Pt. Cloates. The bird, he pointed out, was stated to breed in S.E. Mongolia, though the nest and eggs were yet unknown to science. Three members of its genus, however, were permanent residents of, and bred in the State—th Black fronted Dottrel (*C. melanops*, Vieillot), the Red-capped Dottrell (*C. ruficapillus* Temminck et Laugier), and the Hooded Dottrel (*C. cucullatus*, Vieillot).

Mr. G. A. SUTTON—Four varieties of wheat, Gluyas Early, Nabawa, Merredin and Florence, which were grown in Kalgoorlie during the past season when 349 points of rain fell during the growing period. This exhibit is interesting in that it represents wheat from some trial plots conducted at Kalgoorlie in order to determine the possibilities of wheat growing in that district. The acre yields obtained were:—

	Bus.	Lb.
Gluyas Early	5	17
Nabawa	5	0
Florence	3	15
Merredin	1	54

Despite the low rainfall during the growing period the grain was of excellent quality, and showed no effect of drought conditions. It is interesting to note that, apart from a good fall of rain (121 points) after planting, the falls which occurred up to the time the grain matured were of a very light nature, the three heaviest being 37 points on 10th September, 33 points on 20th May, and 31 points on 30th June. The other falls were mainly below 10 points. The trial is also interesting because, owing to the character of the rainfall, it provided an opportunity to study the drought resistance of the different varieties, which showed that the two highest yielding varieties, i.e., Gluyas Early and Nabawa, have the character of drought resistance to a considerable extent. The ground for these trials could not be prepared during the usual fallowing period of June, July and August of the preceding year. Preparation had to be delayed until after the first useful rains, which fell on the 10th September of that year. Very useful rains were, however, recorded in the following February, when 344 points fell.

AUTHORS OF ADDRESSES AND ORIGINAL PAPERS DELIVERED DURING THE 1925-1926 SESSION.

Carne, W.M.—Brown rot of citrus in Australia caused by *Phytophthora hibernalis*, sp. nov.

Clark, J.—Australian Formicidae.

Clarke, E. de C.—Natural Regions in Western Australia.

Clarke E. de C., and Williams, F. A.—The geology of physiography of two small areas in the Darling Range near Perth.

Gardner, C. A.—A new species of Eucalyptus (*E. Deilsii*) from Salmon Gums district, and a new poison plant (*Gastrolobium densifolium*) from Kukerin and Dudinin districts.

Glauert, L.—(1) Further notes on Gingin chalk.

(2) The Aborigines of Australia.

Grasby, W. Catton—National parks, and flora and fauna reserves.

Maitland, A. Gibb—(1) Thomas Huxley and Sir Ferdinand von Mueller.

(2) The Mezozoic and Tertiary Geological History of the South-West of Western Australia.

(3) Western Australia's contribution to earth history (Presidential Address).

Marr, H. V.—(1) Essential oils of the mallees of the eastern wheat belt.

(2) Details of an experimental distillation of the wood of the cypress pine of the North-West.

(3) Australian sandalwood and some details regarding the essential oils.

Nicholls, G. E.—(1) *Protocrangonyx fontinalis*—a new blind fresh-water amphipod from Western Australia.

(2) *Neoniphargus obrieni*, a new blind amphipod from Victoria.

(3) *Neoniphargus setosa*, a new Western Australian gammarid.

(4) Description of a new species of *Uroctena* from South-Western Australia.

(5) Description of a new genus and two new species of blind fresh-water amphipods from Western Australia.

(6) Description of two new phreatoicids.

Nicholls, G. E., and Jackson, Ada—Three new species of *Megascolex* from South-Western Australia.

A New Species of Spoon-winged Lacewing (family Nemopteridae, order Neuroptera planipennia) from Western Australia, by

R. J. Tillyard, M.A., Sc.D. (Cantab), D.Sc. (Sydney), F.R.S., F.N.Z.Inst., F.L.S., F.G.S., F.E.S., C.M.Z.S., Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.

(*Communicated by L. Glauert*, October 13, 1925. *Published* November 30, 1925.)

The family Nemopteridae includes the Spoon-winged Lacewings (sub-family Nemopterinae) and the Thread-winged Lacewings (sub-family Crocinae) which are the most remarkable insects in the whole Order Neuroptera. They range from the Mediterranean Region down to South Africa and across to India, with an extension to Western Australia and across to the dry inland parts of Queensland. Only a single species, *Croce attenuata* Frogg., is so far known to reach to Queensland; but Western Australia possesses species of both sub-families, the Nemopterinae being represented there by the fine species *Chasmoptera hutti* Westwood, found around Perth and Guildford.

The Spoon-winged lacewings have their hindwings of most extraordinary form. The basal portion is narrowed and lengthened into a slender stalk provided with only three main veins, Sc., R. and M. Distally, this stalk widens out into an irregularly dilated area with oblique lateral veins on either side; at some point within this area, Rs comes off from R, being marked by a stout oblique vein, and junctions with M, continuing straight on below R_1. The dilatation is usually constricted near the middle so as to form two distinct lobes of more or less irregular form, and the narrow piece between them is generally more or less twisted round upon itself, so that the two expanded portions do not lie in the same plane.

A magnificent new species of the genus *Chasmoptera*, discovered at Cunderdin, W.A., has been sent me for description through the kindness of Mr. L. Glauert, Biologist of W.A. Museum, Perth. It is distinguished from *Ch. hutti* Wwd., by its much larger size, paler colouration, and particularly by the immense length of the hindwings, which measure 40 mm. as against about 25 mm. for *Ch. hutti;* this latter species, however, has larger dilatations. The unique specimen of the new species is almost complete, but its antennae and portions of its legs are missing; the hindwings have been broken off level with the end of the abdomen and again at the constrictions between the two expanded portions, the apical part of one of them being absent. The specimen is mounted on its side, on cardboard, with the hindwings glued down in line with the abdomen; in order to save space in figuring, the distal portion has been figured as if cut off and placed between forewing and stalk of hind. In glueing down the middle broken portions, these parts have evidently become turned over, as a careful examination of the venation shows that the apparently anterior portion of the first dilatation contains the veins M and Rs, while the apparently posterior portion contains Sc. This part has, however, been left as mounted in the figure, the veins being labelled. The amount of twisting between the two lobes cannot be stated, owing to the break at the constriction and the flattening down of the lobes when mounted.

As this wonderful insect is probably attracted by light, further specimens ought to be obtained if a careful look-out were kept for it in and around Cunderdin. Unfortunately the date of capture is not given.

Chasmoptera superba n.sp.

(FIG. 1.)

Total length of body 16.5 mm.; *forewing* 22 mm., *hindwing* 40 mm.

Head black above; *rostrum* black with creamy patch at base; *eyes* grey; *ocelli* prominent; basal segment of *antenna* black, (rest missing); *genae* and sides of rostrum creamy; *palpi* blackish.

Thorax black above, creamy on sides; spiricles and lateral suture of mesothorax black; breast greyish. *Legs* pale testaceous, with black hairs; tibiae brownish above; tarsi five-segmented, seg. 1 very long; segs. 2-4 very short; seg. 5 as long as 2-4 taken together; claws large, curved, black (distal portions of middle and hind legs missing).

Wings.—Forewing hyaline except for a tiny patch of fuscous at beginning of pterostigma above the distal fusion of Sc and R_1. Veins mostly black, but Sc, R, R_1, stalk of Cu_1, short basal piece of Cu_2, 1A, 2A and basal portion of posterior margin are much paler, as are also the following cross-veins:—first five and anterior parts of next three below R from base outwards; first three between M and Cu_1; the three between stem of Cu_1 and Cu_2; first two between 1A and 2A or margin. Costal veinlets 22 in number. After fusing distally, Sc and R_1 run obliquely to a little below apex, leaving a rather wide pterostigmatic area above them. Rs has four descending branches, Cu_1a five; Cu_1b has two branches. Below Cu_2+1A is a single series of eleven veinlets.

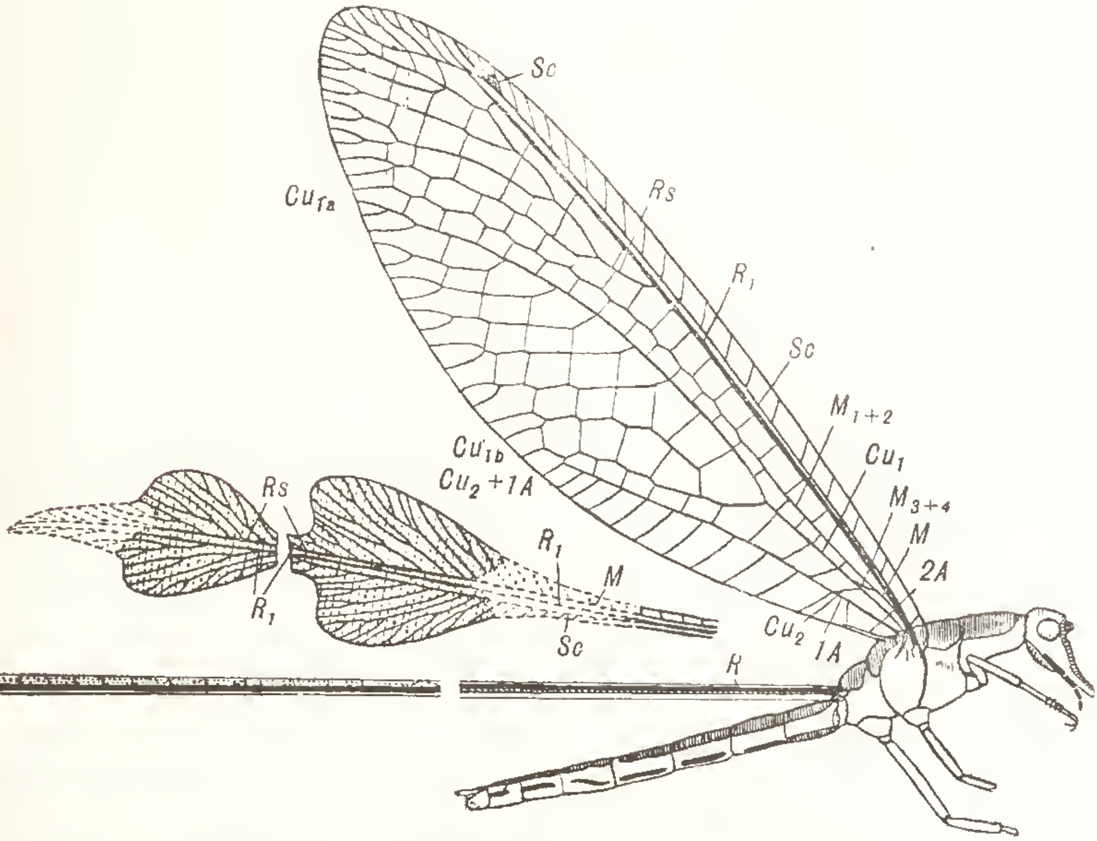

FIG. 1.—*Chasmoptera superba* n.sp., male lateral view (forewing 22 mm.). Distal portion of hindwing detached and placed between forewing and stalk of hind. The actual breaks in hindwing are shown at level of end of abdomen and also between the two dilatations; the portion including first dilatation has been mounted with anterior and posterior margins reversed and is so shown in figure. 1A, 2A, first and second anals; Cu_1, first cubitus, with its branches Cu_1a, Cu_1b; Cu_2, second cubitus; M, media, with its branches M_1+_2, M_3+_4; in forewing, the former continues free, but the latter fuses with Cu_1; R, radius; R_1, its main stem; Rs, radial sector; Sc, subcosta. Creamy portions of hindwing indicated by dotted lines.

Hindwing excessively long (40mm.) and slender, the stalk occupying the first 26 mm. Basal part for 10 mm. hyaline with black veins; for the next 12 mm. the membrane is blackish; distal part of stalk and a sagittal portion of the base of the first dilatation creamy (marked in text-fig. 1 by dotted lines). Main portions of both dilatations dark fuscous with black veins, and shaped as in text, fig. 1; apex pointed, slightly nodding, pale creamy (indicated by dotted lines in text-fig. 1).

Abdomen slender, cylindrical; colour black above, with sutures finely outlined in creamy; sides pale orange, underside creamy; segs. 2-8 with elongated latero-ventral band of black, interrupted between the segments (text-fig. 1); seg. 9 creamy with black in suture.

Appendages 1·2 mm., very hairy, forcipate, creamy with black band above.

Habitat—Cunderdin, W.A.

Types—*Holotype male* (unique), Specimen No. 1386, in W.A. Museum Collection, Perth. Label:—Cunderdin, W.A., 1914 (name of collector and month of capture not given).

Easily distinguished from *Ch. hutti* Wwd. by its much larger size, paler colouration, and, in particular, by the very long hindwings with much smaller dilatations than on *Ch. hutti;* in the latter, the hindwings are entirely blackish except for a touch of creamy at apex and along midrib of first dilatation; appendages of male of *Ch. hutti* are about half as long as in the new species.

Printed for the Royal Society of Western Australia by R. S. Sampson, 971-973 Hay Street, Perth.

Further Notes on the Gingin Chalk, by **L. Glauert,** F.G.S., in charge of geological collections, Western Australian Museum, Perth.

(*Read* October 13, 1925. *Published* November 30, 1925.)
(Communicated by permission of the Trustees.)

The present paper is mainly intended as a record of the definite identification of the Gingin series at Dandarragan, some fifty miles north of Gingin, during a short visit to "Kayanaba" Dandarragan rendered possible through the kindness of Messrs. C. Roberts and C. L. E. Orton to whom I gratefully express my indebtedness.

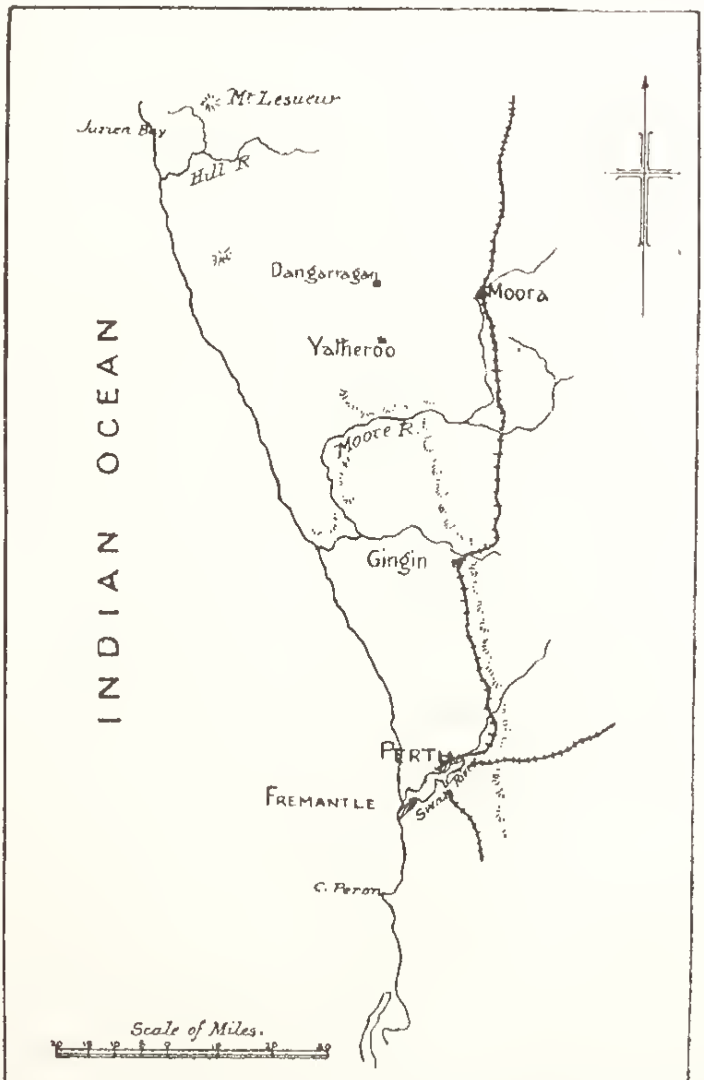

FIG. 1.—Map showing position of Dandarragan, Gingin, etc.

The presence of Chalk in the vicinity of Dandarragan and Yatheroo has long been suspected. Gregory's map of 1860*, published in 1861, shows patches of "Chalk" and Sandstone containing flints and Cretaceous fossils" at Gingin and Yatheroo. H. Y. L. Brown in his General Report of 1873 refers to "the white chalky limestone of Gin Gin, Yatheroo and Dandarragan" of Mesozoic age.

In 1907 Mr. W. D. Campbell examined "the Phosphatic Deposits near Dandaraga (1907), in his report he mentions a series of limestone hills capped with laterite and describes two patches of limestone. Loc. 1137 near Emu Hill and Locs. 823, 867 (Whitfields), a few miles to the south of Emu Hill, but beyond comparing "the characteristics of the bone bed series with the ferruginous sandstones of Greenough River district which contain Jurassic fossils" makes no reference to the probable age of the limestone and its associated beds.

Three years later, Campbell states (1910, p 64) "the Dandaraga ferruginous Sandstones are probably......of Jurassic age, while the Limestones eastward and northward from there are possibly Cretaceous."

In 1912 Dr. E. S. Simpson proved the "bones" of Campbell's bone beds to be pieces of fossil wood "provisionally classed as *Cedroxylon*," (1912 p 36).

Mr. T. Blatchford's report on "the Possibility of obtaining Artesian Water in the vicinity of Moora," (1912 p. 60), contains the statements "Samples collected from these deposits (the limestones at Dandarragan and Yatheroo) show the presence of fossil shells which are identical with those found in similar limestone beds of Gingin, and it seems certain that they are of the same geological age, i.e. Cretaceous, and in fact are a continuation of the same beds. A specimen of the rock collected from near Yatheroo homestead, on close examination was found to contain the following:—Fragments of *Inoceramus* shells, rounded black nodules, and green specks and stains. The remnants of the *Inoceramus* shells occur in small flat fragments resembling somewhat tubular secondary minerals. They are very frequent in their occurrence in the Gingin series, where they have been found almost complete," and (ib. p 61) "Two specimens collected from a limestone hill near Kajamba (Kayanaba) and presented by Mr. E.

* For a Bibliography of the Gingin Chalk prior to 1910 see Glauert, "The Geological Age and Organic Remains of the Gingin Chalk" in Geol. Surv. W.A. Bulletin 36. Palaeontological Contributions III., Art VIII., 1910. A list of more recent publications dealing with the subject and others referred to in the text, is appended to this paper.

Roberts, junr., showed some fine fossil remains of *Ostrea*.... These fossil remains resemble in every characteristic such as are found in the Chalk deposits of Gingin.''

Mr. A. Gib'. Maitland (1924 p 39) sums up the position as follows:—''In the neighbourhood of Dandarragan is a belt of white chalky limestone......which there seems some sound reason for believing to be the northern extension of the Gingin beds.'' Mr. Mailtand's caution is fully justified for lithological characters and such vague palaeontological evidence as ''fragments of *Inoceramus*'' and ''specimens of *Ostrea*'' do not warrant a more definite statement .

The Gingin series at Dandarragan occupies a strip of country several miles in width running in a northerly direction from Yatheroo. It consists of horizontally bedded chalk, ''greensands,'' marls, clays, etc., with occasional bands of more resistant ferruginous sandstone and compacted layers of phosphatic nodules, and is covered in places with the remnants of an uncomformable lateritic capping.

As a result of irregular denudation, two series of low hills have been developed, the westerly ridge, according to Campbell, being capped with sandstones, whilst the undulating eastern series, in the district that I examined, are in part protected by lateritic material.

The rich black soil resulting from the disintegration of the chalk and the gravelly residue of the weathered laterite usually obscure the underlying rocks on the hill sides, but the steep gullies so characteristic of the ''limestone country'' often present interesting sections. In a short gully on the northern side of Round Hill, ''Kayanaba'' an exposure of chalk bearing fragments of *Inoceramus* was considered suitable for further investigation, I therefore selected a site and made an interesting collection from a band of approximately twelve inches in thickness, situated about three feet above the base of th exposure. As the relationship of this exposure to the chalk as a whole is not determined, the position of the ''zone'' is also uncertain.

Great care was taken whilst the collection was being made and, though a number of small forms were lost, because of the strong wind that was blowing, these, fortunately, were mostly recognised as belonging to the commoner species. The specimens obtained include the common *Trigonosemus, Magadina, Magas, Mytilus, Inoceramus, Camptonectes* as well as *Uintacrinus, Marsupites*, Echinid spines, etc

No special search was made for Microzoa, such as Foraminifera and Ostracoda, but about twenty Foraminfera were obtained belonging to the genera *Frondicularia, Nodosaria and Cristellaria.*

Up to the present no specimens of *Serpula pyramidalis* (Eth. fil.) * so plentiful at Gingin, has been found at Round Hill.

Ammonites and Fish remains also seem to be absent from the zone.

The Round Hill fauna, as far as known at present, is briefly discussed below and a list has been prepared in which the faunas of the various Gingin outcrops and of Round Hill, Dandarragan, are tabulated side by side.

Peronidella globosa (Eth fil)

Peronella (?) globosa, Eth. fil.(1913), p. 10, pl IV figs. 1 and 2.

A single specimen of a sponge which seems to be identical with Etheridge's species was obtained at Round Hill, it has been sent to the British Museum for confirmation.

Porosphaera globularis (Phil)

Millipora globularis. Phillips (1829) Pl. 1, fig. 12.

One specimen of this curious little organism was collected, it agrees in every respect with specimens in the W.A. Museum from Sussex, England.

Cidaris sp.

Cidaris sp. Etheridge junr. (1913). p 11, Pl. 1, figs. 9-15a.

Many Echinid spines similar to those figured by Etheridge are in the collection. No plates were seen.

Uintacrinus sp.

Uintacrinus sp. Withers (1924). P. 15, pl. III, figs. 4-10.

Seven fragments undoubtedly belong to this very characteristic genus.

Marsupites sp.

Marsupites sp. Glauert (1925).

One corroded plate, similar to some of those exhibited before the Society in August last, was found at Round Hill.

**Serpula pyramidalis*=*Tubulostium pyramidale,* Etheridge junr., 1913 p. 21, Pl. III, figs. 3a-3c. This may prove eventually to be identical with *Serpula turbinella,* J. de C. Sowerby, Mineral Conchology of Great Britain, Part CXI, 1844, p 54, Pl 635 fig6.

Serpula ampullacea Sow.

Serpula ampullacea Sow. (1829), p. 199, pl. DXCVII, figs 1-5.

Spirulaea gregarea. Eth. fil, (1913), p. 13, pl. I, figs. 1-7.

A single specimen of the sub-conical variety was obtained. When compared with the Cretaceous Annelids in the Tennant Collection, now in the Western Australian Museum, its resemblance to a specimen of *S. ampullacea* was so marked that identity was suggested at once. The specimens of Etheridge's *S. gregarea* from Gingin were then compared with the English specimens and found to fall within the range of variation recognised in that species.

Terebratulina ovata Eth fil.

Terebratulina ovata. Eth. fil. (1913), p. 14, pl. II, figs. 18-19.

Three specimens of this small shell were obtained, the collection also contains several larger individuals with simple echinate costae which may prove to be the adults of this species.

Magadina cretacea (Eth fil).

Magasella cretacea. Eth. fil. (1913), p. 16, figs. 9-12.

Magadina cretacea. Thomson (1915), p. 400, figs. 9a-c.

This is the commonest fossil at Round Hill, it is, if anything even more abundant than at Gingin, and is usually present in a perfect state of preservation.

Trigonosemus acanthodes Eth fil.

Trigonosemus acanthodes. Eth. fil. (1913), p. 15, pl. II, figs. 1-4.

After the preceding this is the most plentiful Brachiopod in the zone on Round Hill, the specimens are generally in good condition.

Magas mesembrinus Eth fil.

Magas mesembrinus. Eth. fil (1913), p. 15, pl. II, figs. 5-8a.

Rather rare, but more abundant than at Gingin.

Undetermined Brachiopods.

These include several forms not yet met with in the chalk at Gingin The abundance of Brachiopoda in the zone on Round Hill would almost warrant the designation Brachiopod Band.

Ostrea sp "b"

Ostrea sp "b." Eth. fil. (1913), p. 17, pl. II, figs. 19-21.

Remains of small *Ostrea* spp. are very common, they are usually fragmentary. One or two specimens seem to resemble Etheridge's species "a" (ib. p. 17, pl. IV, figs. 8-9).

Gryphaea vesicularis Lamk

The series from Round Hill contains two more or less imperfect very globose, auriculate shells with the lower umbo truncated, these shells are considerably larger than the specimens of the Gingin *Pycnodonta ginginensis* of Etheridge in the Museum collection and closely resemble English speimens of *Gryphaea vesicularis.*

Camptonectes ellipticus Eth fil.

Camptonectes ellipticus. Eth. fil. (1913), p. 19, pl. I, figs. 16-16a.

This shell is very abundant but on account of its very delicate nature is very difficult to remove intact.

Pecten spp.

Several fragmentary Pectens, quite distinct from the preceding, were obtained, at least two species seem to be represented.

Inoceramus sp.

The characteristic tabular fragments of *Inoceramus* shells are common in the zone.

Mytilus piriformis Eth fil.

Mytilus piriformis. Eth. fil. (1913), p. 21, pl. II, figs. 22, 23.

Small intact valves of this species are not rare, eight are in the collection.

Calantica (Scillaelepas) ginginensis (Eth fil).

Pollicipes (?)ginginensis. Eth. fil. (1913), p. 13, pl. III, figs. 4, 5.

Calantica (Scillaelepas) ginginensis Withers (1913), p. 64, pl. I.

Three valves, presumably belonging to this species, were obtained at Round Hill, together with two others which seem to me to belong to a different genus, they have been sent to Mr. T. H. Withers of the British Museum for examination.

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FAUNA OF THE GINGIN CHALK (excluding Foraminifera and Ostracoda).

	One Tree Hill Gingin.	Mo e Cap Hill Gingin.	Moorgup Slope Gingin	Yatheroo.	Round Hill Dandarragan.
Peronidella (?) globosa (Eth. fil.)	1	—	—	—	1
Porosphaera globularis (Phil.)	—	—	—	—	1
Coelosmilia (?) ginginensis (Eth. fil.	2	—	—	—	—
Echinid spines (?) Cidaris sp.	C	C	C	—	C
Cidaris comptoni Glauert	R	R	—	—	—
Uintacrinus sp.	M	M	?	—	7
Marsupites sp.	R	R	R	—	1
Serpula ampullacea Sow	C	M	?	—	1
Serpula fluctuata J. de C. Sow	1	—	—	—	—
Serpula pyramidalis (Eth. fil.)	C	C	?	—	—
Spirorbis sp.	R	R	—	—	—
Terebratulina ovata Eth. fil.	M	M	—	—	3
Magadina cretacea (Eth. fil.)	V.C.	V.C	C	—	20
Trigonosemus acanthodes Eth. fil.	M	M	?	—	16
Magas mesembrinus Eth. fil.	M	M	?	—	5
Brachiopods, several new forms	R	R	?	—	20
Ostrea sp. a	R	R	?	?	2
Ostrea sp. b	M	M	?	?	9
Gryphaea vesicularis Lamk = ?	—	—	—	—	2
Pycnodonta ginginensis Eth. fil.	C	C	?	—	—
Camptonectes ellipticus Eth. fil.	M	R	?	—	V.C
Pecten spp.	R	—	—	—	4
Inoceramus spp.	VC	VC	C	M	VC
Mytilus piriformis Eth. fil.	C	C	?	—	8
Ammonite remains	M	—	—	—	—
Calantica (Scillaelepas) ginginensis (Eth. fil.)	R	R	?	—	5
Cirripede valves	—	—	—	—	2
? Elytrum of Beetle	1	—	—	—	—
Teeth of Shark	R	M	—	—	—
Teeth, Scales, etc. of Fishes	M	M	?	—	—

R=rare. M=moderately common.
C=common. V.C.=very common.

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A Brown Rot of Citrus in Australia (Phytophthora hibernalis n.sp) by **W. M. Carne,** F.L.S., Economic Botanist and Plant Pathologist, Dept. of Agriculture, W.A.

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The pathogen herein described is believed by the writer to be responsible for the disease known as Citrus Brown Rot in Australia, which in the past has been attributed to *Pythiacystis citrophthora*, Sm. & Sm. *P. citrophthora* is the cause of a similar disease in California, but the writer has failed to find any definite evidence of its occurrence in Australia. It has been recorded without drawings or cultural notes from Queensland, Victoria, South and Western Australia. Examination of many hundreds of affected fruits in Western Australia has resulted in the finding of the new species *Phytophthora hibernalis*, and that only. A typical brown-rotted orange forwarded by Samuel from South Australia proved to be affected with the same fungus. Unfortunately neither specimens or cultures have been obtainable from the other States. The remarkable similarity of the published symptoms of the disease occurring in Victoria with that in South and Western Australia makes it highly probable, in the absence of cultural evidence to the contrary, that the causes are identical.

P. citrophthora was described from California in 1906 (29). Later records from Florida, Cuba and the Isle of Pines have since been admitted to be in error, owing to confusion with *Phytophthora terrestris* Sherb. (13). Brown Rot diseases of citrus fruit occur in Spain, Italy and Portugal. From the work of Moniz da Maia (20) it appears that the rot of citrus fruit in Portugal is due to a *Phytophthora* (not identified) identical with the one herein described. Moniz da Maia also considers that the orange disease known as ''aquado'' in Spain is due to his *Phytophthora* though previously attributed to *Pythacystis citrophthora* on symptomatic evidence only. This may also apply to the Italian citrus disease. Moniz da Maia also considers that this *Phytophthora* is probably indigenous to Mediterranian countries. As Australia has long been an importer of lemons from the Mediterranean it is probable that the disease has been brought in on lemons or even on citrus plants which have occasionally been brought into Australia from the same region in past years. There remain only two records of the occurrence of *P. citrophthora* on citrus fruits outside California, namely in New Zealand (9) and South Africa (12). In both cases cultural details have not been published. No definite statements, in the absence of detailed information, can be made on these records. From the description of the New Zealand disease, which occurs only on lemons, it would appear to be of different origin to the Australian rot. The drawings given of the conidia of the South African disease appear to be definitely of *Pythiacystis citrophthora.*

Citrus Brown Rot was noted in the files of the Department of Agriculture of Western Australia as early as 1916, but the first published record was made in 1923 by Fawcett (15) who stated that in 1917 he was informed by Dr. F. Stoward, then Plant Pathologist to the Western Australian Department of Agriculture that he had isolated *P. citrophthora* from lemons affected with Brown Rot. It may be here stated that the writer has examined fruit from every citrus area in the State during the past three seasons, and has found the pathogen responsible for Brown Rot to be *Phytophthora hibernalis.* The record of *P. citrophthora* from Western Australia was undoubtedly the result of mistakes in identification.

Brittlebank recorded citrus Brown Rot due to *Pythiacystis citrophthora* in oranges received in Victoria from Queensland in 1918, and in Victorian orchards later in the same year (4 and 26). A detailed account of the field symptoms in Victoria was given by Cole in 1921 (10). These symptoms agree identically with those occurring in Brown Rot outbreaks in Western Australia, and differ considerably from those resulting from *Pythiacystis citrophthora* in California. In South Australia, G. Samuel recorded *Pythiacystis* Brown Rot in 1922 (26), but pointed out that the symptoms somewhat differed from those recorded in California. An orange with typical infection forwarded by him in 1925 proved to be affected with *Phytophthora hibernalis* and not with *Pythiacystis.*

In 1917 Darnell-Smith writing to Fawcett (15) stated that *Pythiacystis* had been found associated with gummosis of citrus trees from Norfolk Island. No details were given but there is no doubt that this record must be classed with other records of gummosis quoted by Fawcett (15) as due to *Pythiacystis-like* fungi.

From the foregoing it is obvious that *Pythiaccytis citrophthora* is known with certainty only from California, that it is possible that it also occurs in South Africa and New Zealand, but that there is no definite evidence of its presence in Australia.

OCCURRENCE OF BROWN ROT IN WESTERN AUSTRALIA.

Brown Rot is the most serious parasitic disease of citrus in the State. Though known as early at 1916 it has of late come into greater prominence especially since 1921.

As the disease is very closely associated with climate and soil moisture, a short review is given of the conditions under which citrus trees are grown. The total area of commercial citrus orchards in the State was 4,069 acres in 1924. They may be conveniently divided into two principal groups. The first and larger consists of isolated orchards or groups of orchards on the coastal plain from the neighbourhood of Perth south to Harvey, the centre of greatest acreage. The second area occupies strips of good soil in the western valleys and foothills of the Darling Ranges. The annual rainfall in both areas varies from about 35 to over 40 inches, falling principally between April and October. Summer rain is erratic and unreliable, and on the average does not exceed 8 to 10 per cent. of the total. The wettest months are June and July. An occasional summer irrigation (about three from January to April) is essential in most commercial orchards. In consequence they are mainly confined to areas where water can be obtained by pumping, or by gravitation from private storage dams. At Harvey there is a public irrigation scheme.

On the Range area natural drainage is usually good, or the orchards can be readily drained artificially into the valleys. At the same time as they occupy the valley sides and bottoms the actual water coming into the soil naturally, owing to seepage and springs, much exceeds the rainfall. During the winter months the soil is often at the point of saturation for days and even weeks.

On the coastal area natural drainage is poorer and more difficult to secure artificially. Here again there is an accumulation of water by soakage from higher levels, causing the water table to rise close to soil level during wet periods before drainage can cope with the incoming supply. River and creek side orchards are, of course, subject to occasional partial inundations for short periods. In both areas winter temperatures rarely fall to 27° F. Summer temperatures over 90° are common.

Citrus picking commences about June, and extends into the summer, the ripening thus coinciding with the wet season. Oranges grown on the coastal plain are typically orange-yellow when ripe with fine smooth skins. Those on the ranges ripen later, have courser skins, and are a rich orange-red. They have distinctly better keeping qualities than the coastal plain oranges, which are rather liable to mould (*Penicillium spp.*).

Brown Rot occurs more commonly in the Range area than on the coastal plain. During the past three seasons, when it has been under the writer's observation, it has appeared in the Ranges shortly after the first heavy winter rains in May or June. Fresh outbreaks then follow each wet spell diminishing and practically ceasing after a week or two of fine dry weather. The maximum attack develops towards the end of August or early in September continuing into October, or to the advent of the dry season.

On the coastal plain, with the exception of one or two orchards so situated that effective drainage is practically impossible, the disease is relatively much less important, and is in most places of little consequence before August.

The difference in the importance of the disease in the two areas appears to be related to sunshine and wind. The hill orchards most affected are those which, owing to their positions in valleys, are sheltered by hills, and consequently have a shorter daily exposure to direct sunlight, and more protection against wind. In support of the latter statement it may be noted that the occurrence of blemishes due to rubbing, thorn scratches, etc., is much greater on the coastal plain than on the ranges. Exposed orchards on the Ranges suffer relatively little from the disease.

The economic loss varies greatly in different orchards, and in different seasons. Those badly affected one year are not necessarily badly affected the next. In the same orchard some portions suffer more than others, but the same portions are not necessarily the most affected each season. In general the orchards in sheltered situations, with good natural water supplies in the form of permanent streams and soakages, are the most affected. Cases have been noted where the disease has been almost confined to the limits of an overflow from a stream.

Few, if any, citrus orchards escape the disease in average seasons. In many cases the damage is confined to the dropping of a few leaves. In badly affected areas fruit, leaves and twigs are affected. At the worst trees are more or less totally defoliated and suffer considerably from loss of vitality. Actual death from this cause alone has not been observed, except in the case of yearling seedlings. The direct loss of fruit is the most obvious effect of the disease. It may reach 75% of the crop of individual trees and exceed 50% of the crop of quite considerable portions of orchards. The indirect loss due to leaf and twig blighting may, however, be quite as great, as badly affected branches bear little or no fruit in the succeeding season, and take several seasons to return to normal cropping.

TREES AFFECTED.

All varieties of oranges including mandarins and lemons grown in this State are affected. Other varieties of citrus such as grape fruit, citron, etc., are not grown commercially and their behaviour to the disease has not been observed. Late varieties of oranges suffer less from the fruit rot than the early ones. Mandarins are particularly subject to both leaf and fruit infection. Lemons appear to be less subject to fruit rot and to be more susceptible to leaf infection.

SYMPTOMS OF BROWN ROT IN WESTERN AUSTRALIA.

The symptoms of Brown Rot in Western Australia were described by the writer in 1924 (6). Affected oranges and mandarin fruits develop a dull dark brown area, usually on one side, which spreads until the whole fruit may be involved. The rot is not a soft one, and is accompanied by a very penetrating and easily recognisable odour, quite distinct from those usually associated with rotting and mouldy citrus fruit. When free or relatively so from secondary infections the affected areas become dark, dry, and eventually sunken. The whole fruit eventually shrinks to a dry hard mummy. Under normal conditions in the orchards, however, secondary infections closely follow Brown Rot in the vast majority of fruit. The principal secondary organisms observed have been *Penicillium digitatum*, Sacc., *P. italicum* Wehn, P. *spp.*, *Colletotrichum gloeosporoides* Penz., *Cladosporium herbarum* (Pers.) Link., *Fusarium sp.*, *Phoma sp.*, *Rhizopus sp.*, *Oospora citri-aurantii* (Ferr.) Sacc. & Syd., and *bacteria*, the first four and bacteria predominating.

During wet conditions in the orchard or when placed under a bell-jar a fine short growth of white mycelium develops on and around the lesions.

Apparently-sound fruits in contact with affected fruits are almost invariably affected also. Varieties which, like the common orange, carry their fruit in bunches are in consequence liable to heavy infection. The first fruits affected are usually near to or in contact with the soil, but once the disease has become well evident in an orchard, affected fruits may be found at any height on the trees even at the very top.

Affected parts of lemon fruits develop a straw colour showing in contrast against the brighter yellow of the sound skin. The skin appears to be distended making it smooth and somewhat glossy in contrast to the rougher surface of the sound fruit. The affected areas eventually turn brown. As with oranges in the absence of secondary contamination affected fruits shrink and dry. This is, however, rare with lemons owing to secondary infection by the organisms which attack oranges with the difference that *Oospora citri-aurantii* predominates even over *Penicillium spp.* During wet weather *Oospora* is very active producing a slimy wet rot. Under such conditions it is not uncommon to see lemons on the trees become so soft that they elongate and eventually fall in a soft rotten mass. The strong sour smell induced by *Oospora* frequently masks the characteristic smell of Brown Rot. In other ways the disease develops as on the orange.

Affected leaves of lemons as well as oranges and mandarins develop dark water-soaked areas usually at the tips, but not infrequently extending in from the edges. Portion of the leaf margin is usually involved, though occasionally the disease may develop centrally on a leaf. Affected leaves curl somewhat and fall readily while still green over the greater part of their surfaces. Leaf attack is usually the first indication of the presence of the disease and is sometimes the only form of the disease to develop. The presence of the disease in mild or early attacks is best seen by observing the fallen leaves on the ground. Lower leaves are usually first infected but later they may be found at any level. On oranges and mandarins leaf dropping may go on until more or less complete defoliation of part of the tree may result. With the exception of a few cases of complete defoliation the affected portion involves almost entirely a strip running vertically from bottom to top, extending laterally from two or three feet to the entire width of a tree (Plate I). These severe infections occur on the side of the trees most sheltered from the sun or from wind. In the majority of cases it is confined to the Eastern and Southern side. On lemon trees the leaf infection is similar to that of the orange tree but is more general, and not confined to portions of the tree. In 1924 a number of large lemon trees were seen at Maddington (Plate I) which were completely defoliated, the large crop of fruit remaining sound on the trees.

Leaf blight without fruit rot is not uncommon in mild cases with oranges. Heavy leaf infection is invariably associated with fruit infection. On lemons, however, as in the case already mentioned, leaf infection may be plentiful without the fruit being attacked.

The recognition of an unknown pathogen causing leaf blight was made by the writer before he realised that all cases of Brown Rot were due to the same cause and not to *Pythiacystis citrophthora* (7).

TWIG BLIGHT.

Accompanying severe leaf defoliation the smaller twigs and branches are killed. As a consequence fruit bearing in the following season on the affected portion is largely or entirely prevented.

SYMPTOMS OF BROWN ROT DUE TO PHYTOPHTHORA HIBERNALIS COMPARED WITH THOSE OF PYTHIACYSTIS BROWN ROT.

Brown Rot in California due to *Pythiacystis citrophthora* was described by R. E. & E. H. Smith as essentially a lemon fruit disease occurring less frequently on oranges, mandarins, pomelos, etc., (29 & 30). In a letter to the writer Professor H. S. Fawcett, of the Citrus Experiment Station, University of California stated "we sometimes find the *Pythiacystis* fungus attacking the leaves, but this is not so frequent as the attack of the fruits, especially lemon fruits, although oranges are also attacked when the weather is very moist and there is a medium temperature over a considerable period." *Pythiacystis* Brown Rot would therefore appear to be essentially a lemon fruit disease attacking oranges less frequently and citrus leaves even less. *Phytophthora hibernalis* on the other hand in Western Australia attacks leaves more frequently than fruit, and orange and mandarin fruits more frequently than lemons. There are undoubtedly great resemblances between the two diseases. It may be mentioned that oranges were infected by the writer with pure cultures of *Pythiacystis citrophthora* and *Pytophthora terrestris* Sherb. [probably a form of *P. parasitica* Dast. (1 & 17)] developed Brown Rot not distinguishable from that due to *P. hibernalis.* These two cultures were obtained from California through the courtesy of Professor Fawcett. Though *P. terrestris* causes a citrus stem gummosis in Florida and elsewhere (15) it has not, so far as the writer is aware been found in nature on citrus fruits. A further resemblance between the Californian and the Australian diseases is to be found in the fact that both develop under conditions of high soil moisture content, especially in wet weather, in low wet situations and on the lower and sheltered portions of the trees. Further differences may be noted which cannot be related to the climatic differences in the two countries. *Pythiacystis* Brown Rot remains active throughout the summer where the ground is wet according to Smith (30). This is unknown in Australian Brown Rot, even in orchards alongside perennial streams. The Australian disease is essentially one of cool-moist weather. Heavy defoliation, twig blight and consequent failure to bloom and fruit are not recorded in California. *Pythiacystis* Brown Rot spreads readily in packed fruit. With the Australian disease, infection spreads slowly, and only under very favourable conditions. No loss is experienced from this cause in Western Australia, though this appears to be the most important feature in the American rot. So far comparisons have been made only with the symptoms of *Pythiacystis* Brown Rot as stated to occur in California.

Published descriptions by Cole (10) of the symptoms of *Pythiacystis* Brown Rot in Victoria agree exactly with those of the *Phy-*

tophthora disease in Western Australia, with the exception that lemons are stated to be apparently immune. Seville oranges, grape fruit, and cumquats not investigated in Western Australia are also attacked. The statement by Cole that in an advanced state of this disease a sticky growth develops on the fruit is probably due to confusion with the common secondary Sour or Greasy Rot due to *Oospora citri-aurantii*.

Samuel's articles on Brown Rot in South Australia (26 & 27) refer only to it attacking oranges. This disease as already stated is now known to be due to *Phytophthora hibernalis. Pythiacytis* Brown Rot in New Zealand is recorded only on lemons (9) attacking the fruit, leaves, laterals and even larger branches. Affected leaves turn brown, but remain hanging on the trees. This disease appears to be distinct from that in Australia, and even from that in California. In South Africa, Brown Rot has been recently recorded only on orange fruits in March and April, 1925, a year of exceptional rainfall (12).

From the foregoing it is evident that the disease in Victoria agrees in field symptoms more closely with the Western and South Australian disease than it does with the Californian. In the absence of any detailed mycological evidence to the contrary the writer considers that he is justified in regarding all citrus Brown Rot in Australia as being due to *P. hibernalis*.

ISOLATION OF PATHOGEN IN WESTERN AUSTRALIA.

In September, 1923, in company with Dr. E. J. Butler, of the Imperial Bureau of Mycology, and Mr. J. G. C. Campbell, a visit was made to an infected orchard at Bickley in the Darling Ranges. The day was wet. Specimens of affected leaves and twigs showing faint indications of superficial fungal growth were secured. Under microscopic examination these proved to be spore clusters of a Phycomycete. Previous to this date it was believed, following American experience with *Pythiacystis*, that the pathogen did not fruit on the trees. It was at once evident that the fungus differed from *Pythiacystis*. Over one hundred different successful attempts have been made during 1923, 1924 and 1925 to develop the pathogen from diseased tissues in water, liquid media or on agar. In every case the organism has been the same. *Pythiacystis* has never been found.

Cultures have been submitted to Dr. E. J. Butler, Director of the Imperial Bureau of Mycology, who also isolated the same organism in England in 1924 from West Australian oranges. He reported in 1925 that he was convinced that the organism was a new species distinct from *Pythiacystis*. Cultures were also forwarded to Mr. W. L. Waterhouse, Sydney University, who compared them with his type cultures, and stated that besides differing from *Pythiacystis*, "it differed markedly culturally from *Phytophthora cactorum*, *P. infestans*, *P. erythroseptica*, *P. fagi* and *P. parasitica*." The writer has also been able to compare it with cultures of *Pythiacystis citrophthora* and *Phytophthora terrestris* received from Professor Fawcett, of the Citrus Experiment Station, University of California, and with cultures of *Pythiacystis terrestris* received from Mr. Waterhouse and has found it to be readily distinguishable.

After the discovery of the pathogen in 1923, and after the difficulties of isolation had been overcome the season for the disease closed. It was found however, that the organism developed on affected twigs and leaves in water, but rarely, if ever, on affected fruits under the same conditions; that spores were developed in nature on all affected parts of citrus trees during or immediately following wet weather in the winter; that spores in water germinated either as zoosporangia or conidia. Few attempts at infection were made. Successful infection of oranges by spores was secured in one case.

The pathogen was definitely determined from oranges, mandarins and lemons grown at various parts of the hill and coastal plain areas. At Harvey a case was noted where lemon seedlings grown for stocks were more or less defoliated, and many killed.

During the summer of 1923-1924 the cultures died.

On 19th June, 1924, diseased fruits were obtained from Bickley, and the organism again isolated. The first winter rains had commenced in the early part of May, one inch being recorded on 10th-12th. The disease was in evidence until the end of October, and was again found on all varieties of citrus, both on leaves and fruit and in all commercial citrus areas. Isolations were made from orange and mandarin leaves and fruit, the pathogen being identical with that found the previous year. Young orange trees were infected by spore suspensions in water and the pathogen recovered from typically affected leaves.

During the summer of 1924-25 the cultures were maintained alive by storing in closed Mason jars in a cool safe (Coolgardie safe) with hessian sides kept wet by a constant supply of water and placed in a draught. The organism was found to be very susceptible to heat and to drying out. Sub-cultures could be made to grow during the summer only at the reduced temperatures of the cool safe which rarely exceeded 65°F.

On 29th May, 1925, the disease was again found at Maddington near Perth on orange leaves and fruit. The first winter rains had commenced on 19th and 20th May with a fall of 1.83 inches at Perth.

The disease was last noted active early in September.

During the season it was again recorded from all citrus areas, though owing to the exceptionally dry winter the losses in general were lighter than those of 1924.

The same pathogen as in the two previous seasons was again isolated many times from lemon leaves and fruit as well as from the leaves and fruit of oranges and mandarins. It was also isolated from an orange from South Australia. Infection of oranges and lemons was secured from the 1924 isolations from orange leaves. Oranges and lemons were infected from cultures from each other and from leaves. Definite evidence was secured that Brown Rot on oranges and lemons and their leaves in Western and South Australia were due the same cause. Investigations carried out late in the season of 1924 had seemed to indicate that the lemon diseases were due to different pathogens (6). This was found to be incorrect.

METHODS OF ISOLATION.

Successful results have been obtained by spreading a water suspension of spores from affected tissues on potato dextrose agar plates and picking off germinating spores. Usually, however, isolation has been obtained by washing small pieces of affected leaves in corrosive sublimate solution (1-1000) for one to three minutes, followed by three washings in sterile tap water, and then placing on potato dextrose agar plates. Some fruit isolations were made in the same way after first washing the fruit in water, and then with alchohol, and cutting out with a sterile scapel small portions of the surface tissues at or just beyond the edges of the evident lesions. Best results were obtained by inverting these pieces of tissue so that the surface of the fruit came in contact with the agar. Pieces taken beyond the edges of the lesions gave the lowest contaminations. After two or three days the mycelium could be easily recognised by its characteristic dense branching, when examined under a low power through the underside of the petri dish. Apparently clean growth was then picked off on to agar plates. Contamination from bacteria has been the most difficult to avoid, the use of latic acid in the medium being unsatisfactory owing to the inhibition of the fungus. Repeated sub-culturing has often been necessary. Isolation from fruits in an advanced stage and obviously much contaminated with secondary organisms has been obtained by transplanting portions of the least infected tissues into sound fruit, and then making cultures from the latter as soon as infection became evident. In general, however, it has been considered sufficient to recognise the fungus in such cases and not to attempt isolation in pure culture. It has been found possible to readily recognise the mycelial growth as it differs considerably from that of Pythiacystis or Phytophthora terrestris (Plate II).

For comparison purposes these latter fungi (cultures obtained from California) were inoculated in oranges, and re-isolated from the affected fruits. These organisms have been kept going in check series of cultures with the Australian pathogen for two seasons.

In making isolations from leaves it was found that tissue taken from the bases of leaves showing lesions only on their apical portions readily produced the organism. This undoubtedly has a bearing on the falling of the leaves while only visibly affected at their tips.

CULTURAL NOTES.

P. hibernalis grows well on potato dextrose agar, oat extract agar, prune juice agar, French bean agar, dextrose peptone agar, prune juice and wheat meal.

These media were prepared as under:—

Potato-Dextrose Agar. Potato, not peeled, washed and cut into ½ inch cubes, 200 grams. Boiled gently in 1 litre of tap water in steamer for 1 hour, strained through muslin, made up to 1 litre with water, 20 grams dextrose and 25 grams agar added, and then autoclaved.

Oat-Extract Agar. 50 grams crushed oats boiled gently in steamer for 1 hour in 300 c.c. tap water, strained through wire gauze, 10 grams agar added and water to make 500 c.c., then autoclaved.

Prune-Juice Agar. 12.5 grams of dried prunes, without stones, boiled in 100 c.c. tap water for 5 minutes, filtered, 7.5 grams agar and water to make up 500 c.c. added, then autoclaved.

French-Bean Agar. 50 grams dried beans pounded in mortar, boiled 30 minutes in 300 c.c. water, then strained through wire gauze, 10 grams agar and water to make up 500 c.c. added, then autoclaved.

Dextrose-Peptone Agar. Dextrose 10 grams, meat extract 2 grams, peptone 5 grams, sodium chloride 2.5 grams, agar 7.5 grams, autoclaved in 500 c.c. water.

Wheat Meal. Wheat meal moistened with distilled water and autoclaved.

Potato dextrose agar has been the most satisfactory medium tried and has been generally used. Both conidia and oospores are formed fairly freely in cultures after 10 days at temperatures of 10-15° C. On prune juice agar and French bean agar conidia are formed scantily though oospores are more plentiful. On oat extract agar and dextrose peptone agar and wheat meal only oospores are formed. In prune juice decoction no spores are formed. Conidia formed on agar media are remarkably constant in shape and similar to those occurring in nature though varying considerably in size.

To obtain conidia and oospores the best method adopted was to plate on potato dextrose agar fairly large pieces of affected leaf tissues. Pieces about 1 cm. square have been used. Fruit tissues are less effective. From the edges of the plated pieces there is a strong growth of mycelium, while on the upper surface conidia are developed in great numbers. Within the tissues oospores are developed in large numbers shortly after the conidia appear. With sufficient care the growth is practically pure.

Conidia may also be obtained by half submerging affected leaf, twig or fruit fragments in water. Those developed on the free surfaces are normal in shape. An aquatic mycelium is developed in the water. This bears conidia which are rather more liable to vary in shape, though not markedly so.

Owing to lack of equipment it has not been possible to ascertain the limits and optima of temperature and humidity for growth. Both field and laboratory evidence indicate a low temperature optimum and maximum. The optimum is probably below 15° C. and the maximum below 25° C. Fresh occurrences in the field have not been noted later than October, or before May, even when October has been exceptionally wet as in 1925, or under irrigation conditions. It should be noted that the mean maximum and minimum temperatures for Perth for the months in which the disease is evident are:—

	June	July	Aug.	Sept.	
Max.	17.8°	17.0°	17.8°	18.9°	Cent.
Min.	9.7°	8.7°	8.9°	10.2°	Cent.

(Figures supplied by Commonwealth Meteorological Bureau, Perth).

As the mean for the affected areas during these months is certainly lower than for Perth, though in several cases within 20 miles of that point, the evidence points to an optimum for *P. hibernalis* lower than those for *P. citrophthora* and *P. terrestris* which are given by Fawcett (14) as 26.5° and 31.5° respectively. Moniz da Maia has also noted (20) the relation of the disease in Portugal to low temperatures.

As pointed out already cultures have failed to survive at room temperature in Perth during the summer necessitating their storage in a cool place. Sub-culturing during the summer has been possible only by keeping the cultures at reduced temperatures. Two attempts to forward cultures to Dr. E. J. Butler, at Kew, failed. A similar failure resulted when Dr. Butler forwarded a culture isolated by him in 1924 from orange shipments in London from Western Australia. A culture forwarded to Mr. W. Waterhouse, at Sydney, died during the summer, and I have since heard from Dr. Butler that his isolation had come to the same end. Cultures of *P. citro-*

phthora (No. 846) and *P. terrestris* (No. 760) April, 1924, received from Professor Fawcett, of the Citrus Experiment Station, Riverside, California, have not only survived room temperatures at Perth, but also carried well to London, being forwarded at the same time as *P. hibernalis.*

While tissues placed on agar fruit freely, this does not apply to affected fruits, leaves and twigs placed in the moist atmosphere in a stoppered jar, or under a bell-jar. Under such conditions a strong short crisp growth of sterile mycelium develops on the surfaces. With less humid conditions better results are sometimes obtained. By loosely closing a jar with cotton wool, or by exposing to continued rainy conditions in the open spores may sometimes be obtained. A fruit forwarded by Mr. Samuel from South Australia packed with paper in a cardboard box had developed spores on the surface when received five days later. When spores are developed there is no surface growth of mycelium.

MORPHOLOGY AND DEVELOPMENT.

The mycelium is at first continuous, much branched, very irregular in width, and with swellings and knots and short haustoria-like branches at irregular intervals. In older cultures septa are developed scantily (Plate IV). In tissues the mycelium appears to be both inter and intra-cellular, well distributed in leaves, but in fruit confined for some time mainly to the skin and rag. On agar the aerial hyphae are twisted and somewhat irregular, but much less so than the submerged mycelium. The average width of the hyphae on potato dextrose agar is about 5mmm. but varies from 3 to 12mmm., with considerable variation along the same hyphae. Septa occur mainly in the older cultures, especially on subsurface growth. They may be straight, but are frequently bent to form a curve or angle or have a central thickening. They commence as ingrowths from the opposite sides of a hypha. The hyphae are filled with granular protoplasm, but in older cultures frequently become empty in part being cut off by the septa from the still active portions. When damaged on handling the broken ends of hyphae readily discharge their protoplasmic contents. On fruit, and to a lesser extent, leaves and twigs kept in a moist jar, and on agar media, the aerial mycelium develops as a dense short white mat of branched hyphae. In nature during continued wet weather conidia develop on fruits, leaves and twigs. They also develop on aerial and aquatic mycelia from leaves and twigs, rarely on fruits half submerged in water, and on the aerial mycelium of potato dextrose, prune juice agar, and French bean agar. On tissues the sporophores develop singly or in clusters from any portion of the surfaces though principally from the upper sides of leaves. They are usually clustered developing from a stromatic mass beneath the epidermis. On culture media conidia are borne terminally on sporophores which branch from the aerial hyphae. There are usually enlargements at the junction of the sporophores and hyphae. The sporophores are narrower than the hyphae proper having a width of 1-2mmm. The conidia are hyaline, elliptical or lemon shaped, the larger almost flattened on the sides. Undersized conidia are more rounded. Pear shaped forms occasionally occur. The papilla is broad and flattened and up to 5mmm. long. The most characteristic feature is a constant pedicel or tail consisting of portion of the sporophore. This pedicel is rarely less than one half the length of the conidium and frequently exceeds it in length. The persistent pedicel is so constant that the occasional spore found without one has been regarded as having lost it as a result of accident in handling. Such spores have not constituted 1% of the many thousand seen. The conidia are very deciduous. The surface of a fruiting culture usually has many spores lying on it which have fallen away from their attachments. When mycelium is mounted in water for microscopic examination it is difficult to find spores still attached.

Measurements of 100 conidia developed on lemon leaves on potato dextrose agar gave an average of 34.6 x 16.1mmm., with a range of 17-56 x 10-21. These measurements agree so closely with the comparative few found in nature on leaves and fruit that the writer considers that conidia developed in this manner may be regarded as typical of the species. The bulk of these fall within 26-45 x 14-19mmm. as shown in Table 1.

No.	Length mmm.		Width mmm.	No.
3	Over 50	—	Over 20	3
8	46—50	—	20	7
18	41—45	—	19	8
23	36—40	—	17 — 18	36
18	31—35	—	15 — 16	24
19	26—30	—	14	9
7	21—25	—	13	5
4	Under 21	—	Under 13	8

Table I. Measurements of 100 conidia grown on lemon leaf fragments on potato dextrose agar.

41 conidia developed on leaf and fruit tissues in water gave a mean of 34.6 x 16.4 with a range of 20—46 x 12—28mmm. Conidia grown on fragments of *Colocasia sp.* on potato dextrose agar gave a mean of 34.9 x 15.5. 52 conidia from a potato dextrose agar culture gave amean of 30.3 x 14.3 (range 18.3—41.8 x 9.6—19.2mmm.). It is evident from the figures given that the variation

of the mean size of conidia grown on tissue under different conditions is small. The average ratio of length to breadth is 2.3 as shown in Table 2 hereunder:—

No.		Ratio.
1	—	3.4
1	—	2.8
3	—	2.7
2	—	2.6
10	—	2.5
6	—	2.4
15	—	2.3
12	—	2.2
14	—	2.1
11	—	2.0
10	—	1.9
5	—	1.8
7	—	1.7
3	—	1.6
100	Mean	2.3

Table 2. Ratio of length to breadth of 100 conidia grown on lemon leaf fragments on potato dextrose agar.

The majority range from 1.9 to 2.5. The extreme ratios of 3.4 and 1.6 to 1.8 are confined to exceptionally large and small conidia. The average length of the persistent pedicels of the same 100 conidia was 23.5mmm. (range 2—56mmm.). On the Colocasia leaf culture the pedicels averaged 39mmm. (range 10—63). The average length of the pedicels of 43 conidia developed in water from potato dextrose agar and wheat meal cultures was 39mmm., with a maximum length of 54mmm. There is no cellulose plug at the point of insertion of the sporophore which averages 4mmm. in width at that point.

The conidia germinate with germ tubes or as zoosporangia. In the former case the germ tube usually emerges from one side of the papilla, which is finally absorbed. A growth of 120mmm. in 2½ hours has been noted after placing the spores in water at a temperature of approximately 12° C. Occasionally a short hypha is produced by a conidium which becomes terminated by another but smaller conidium. This may be repeated until a chain of three or four is formed. At other times the tip of hypha appears to have started to form a conidium and then reverted to vegetative growth thus producing swellings in its length. The formation of zoospores occurs readily when the spores are placed in water at a room temperature of 11—15°C, though a percentage always germinate as conidia. At higher temperatures germination as conidia is the normal method. Discharge of zoospores commences an hour and a half to two hours after placing the spores in water and continues for about one hour. The first indication of zoospore formation noted is a movement of the protoplasm of the spores causing it to round into a central mass. This mass then breaks up into zoospores which rapidly move towards the apical end of the spore where the papilla is apparently distended into a vesicle. This vesicle has not been seen, but the papilla disappears, and the subsequent movement of the zoospores certainly suggests the presence of a vesicle. The zoospores are at first attached by their flagella and in some cases two have been noticed to remain attached for some minutes after emergence. Each spore is compressed as it squeezes through the aperture. Sometimes two jam in the opening and either finally escape or remain blocking the exit, preventing the emergence of the remainder of the zoospores. Immediately on leaving the sporangium the zoospores collect in a mass suggesting the presence of a vesicle, and then dart in all directions, the whole process from the first signs of movement within the sporangium taking only two or three seconds. When killed with iodine solution the zoospores average 9.9 x 8.3mmm. (range 8.7—11.3 x 7.8—9.5). When in movement they appear to be about 11 x 9mmm. They are more or less kidney-shaped with two flagella attached to the concave side, one longer than the other. The average length of the longer is 14.6mmm., and of the shorter 6.1mmm. The number of zoospores formed in a sporangium varies from 5 to 20. Occasionally the whole protoplasmic contents are discharged in an undifferentiated mass. After swimming for about 30 minutes the zoospores round off. Germination commences within 12 to 24 hours, one or more germ-tubes emerging. Not infrequently some zoospores round off within the sporangium.

In citrus leaf and fruit tissues and on *Colocasia sp.* leaf tissue particularly the leaves both of citrus and *Colocasia*, and to a lesser extent in potato dextrose agar, oat juice agar, French bean agar, prune juice agar, and wheatmeal, oogonia with amphigynous antheridia are formed. In leaf tissues in water or on potato dextrose agar the number of oogonia formed is very large, the tissue being filled with them. Very occasionally the antheridia are paragynous (Plate IV). Antheridia and oogonia as far as could be observed appear to come from either the same or different hyphae. On affected tissues oogonia are developed in about a week at 10-15° C, in culture in from 10 to 14 days. The oogonia, which are round to ovoid average 40.8mmm. in greatest length with a range of 22.4—56mmm. (100 measurements from orange leaf tissue on potato dextrose agar). Oospores are spherical and average 35mmm. in diameter with a range of 22 to 45.6mmm. The antherida are hyaline and very persistent. The oospores range from yellow to tawny

(24). The oogonial wall takes on the same colour and persists as a rather irregular rough coating to the oospores.

The *Phytophthora* causing rotting of citrus fruits in Portugal described by Moniz da Maia (20) agrees so closely with *P. hibernalis* that there is no doubt that they are identical. The former has been isolated from the orange, mandarin and lemon fruits. The conidia are formed in similar manner to *P. hibernalis*, and are similarly characterised by their elongate form and the presence of persistent pedicels. Moniz da Maia, however, recognises macro-conidia on fruit measuring 17.5—58mmm. x 7.5—15mmm., and micro conidia on cultures measuring 30—37.5mmm. x 16—18.5mmm. In the work done on *P. hibernalis* the author has found no definite distinction between the larger and smaller conidia, and regards them as simply indicating the range of variation, and perhaps in the case of the smaller as evidence of immaturity. As already shown conidia comparable with Moniz da Maia's largest and smallest have been obtained from cultures of *P. hibernalis*.

Only 6-10 zoospores have been noted in Moniz da Maia's cultures but he has admittedly observed only a very few cases of zoospore formation. He gives 22 to 42.5mmm. as the measurement of the oospores, which compares favourably with 22 to 45.6mmm. in *P. hibernalis*. "This disease appears in mid-winter (January), and causes damage in the early spring, covering a period of markedly low temperature, and generally associated with rain, snow and frost." This agrees absolutely in seasonal occurrence with *P. hibernalis*. The microphotographs published of mycelium, conidia, and oogonia also agree very closely with *P. hibernalis*.

INFECTION EXPERIMENTS.

In 1923 infection was secured of two oranges with spores produced in water cultures from brown-rotted oranges. The suspension of the spores in water was placed in glass rings fastened to the fruits with plasticine, and covered with glass slips sealed with vaseline. The positive results were obtained with scratched fruit only.

	Culture A.		*Culture B.*	
9/10/23—	Unscratched	Scratched	Unscratched	Scratched
16/10/23—	—	+	—	+
24/10/23	—	+	—	+

Control.

9/10/23—	Unscratched	Scratched
16/10/23	—	—
24/10/23	—	—

In 1924 many attempts were made to infect fruits by placing them in contact with affected fruits, or in water containing affected fruits, or in which the same had been placed for several days. In all cases the results were negative. The fruit in water regularly became attacked by various organisms. It is possible that these were secondary to and masked the infection by the brown rot organism.

In August, 1924, an experiment was made to infect the leaves of orange trees in pots with a suspension of spores from a water culture from orange leaves.

19/8/24.—A branch of tree A sprayed with spore suspension and placed in open. Tree B. treated as in A. but placed in cold frame. C. small branch in lamp glass sprayed with suspension and closed with moist cotton wool. Placed in cold frame. D. as in C., but with spore bearing leaf fragments placed on leaf.

19/8/24	A.	B.	C.	D.
14/9/24	+	—	—	—

Infection followed a very wet week. It is difficult to account for the lengthy period preceding infection. The disease is not known in the nursery in which the work was done and several citrus trees growing there were not affected. About 10% of the sprayed leaves were affected and none on the unsprayed branches.

As it was found readily possible to infect leaves in a water suspension of spores the failure to secure infection on trees B., C., D. was probably due to the difficulty of keeping a film of moisture on the leaves except when exposed to continuous wet weather.

During 1925 numerous attempts were made to secure infection The following gave positive results:—

(1). *On 29th May*, 2 oranges and 2 lemons were placed in contact with naturally affected oranges in a jar. No lesions having appeared the affected oranges were removed and replaced with more affected oranges on 12th June. These were removed on 29th June, the original fruit remaining sound. On 1st July one orange developed Brown Rot, the other fruit remaining sound. This result would appear to indicate infection from spores formed on the affected fruit rather than mycelial infection. Controls remained sound.

(2). *On 29th May* 2 oranges and 2 lemons were infected with diseased tissue from an affected orange. On 9th both oranges developed Brown Rot. Lemons developed secondary rots.

(3). *On 16th June* 1 orange and 1 lemon infected with mycelium of *P. hibernalis* on potato dextrose agar isolated from orange fruit in 1924. On 25th orange developed Brown Rot. Lemon developed Penicillium, etc.

(4). *On 16th June* 2 oranges and 1 lemon infected with mycelium of *P. hibernalis* on potato dextrose agar from orange. 24th one orange developed Brown Rot. The second orange was re-infected on 1st July. On 9th July lemon developed Brown Rot, and the second orange on 16th.

(5). *On 27th June* 2 oranges and 2 lemons infected with mycelium of *P. hibernalis* on potato dextrose agar isolated from lemon leaves the same month. On 7th July one orange and one lemon developed Brown Rot, the others moulds.

(6). *On 29th June* 2 lemons infected with *P. hibernalis* culture on potato dextrose agar from lemon fruits. 9th July both developed Brown Rot.

(7). *On 1st July* 1 orange infected with culture on potato dextrose agar from orange. Developed Brown Rot on 15th.

(8). *On 2nd July* 2 sound lemons were placed in contact with an affected lemon. On 13th one lemon developed Brown Rot. The other remained sound.

(9). *On 2nd July* Brown-rotted orange placed in water with 2 oranges and 1 lemon, but not allowed to come in contact. Water removed on 7th. By 8th all appeared to develop Brown Rot, but this was not confirmed owing to contamination.

(10). *On 2nd July* Brown-rotted oranges placed in water in contact with two oranges and two lemons. Water removed on 7th. 8th apparent Brown Rot in all but not confirmed.

(11). *On 2nd July* Brown-rotted orange placed in contact in jar with one orange and two lemons. 13th Brown Rot on all but confirmed by isolation only from orange as the lemon cultures became overgrown with contaminations.

(12). *On 16th July.* Conidia from lemon leaf tissue on potato dextrose agar placed in water in glass cells attached to two oranges and two lemons with plasticene. 3rd August one lemon developed Brown Rot. Others remained sound.

(13). *On 17th July.* Orange and lemon leaf fragments placed in water with conidia from a culture of lemon tissue on potato dextrose agar. 22nd Brown Rot lesions on all.

(14). *On 24th July.* One lemon infected with tissue from lemon with Brown Rot. 31st Developed Brown Rot.

In all cases except where stated *Phytophthora hibernalis* was **identified** by culture on potato dextrose agar.

In infecting fruit with mycelium on agar media or with tissues from affected fruits the following method was used. The fruits were first washed in water and then with alcohol. A small cylinder penetrating into the rag was then removed with a small cork borer with the rod allowed to remain loose in the tube. With mycelium infection, a fragment of agar with mycelium from a culture was then placed in the hole and the outer portion of the cylinder of tissue replaced by means of the rod in the tube. When infecting from another fruit, a cylinder of tissue from the affected fruit made with a cork borer slightly larger than that used on the fruit to be affected was then forced into the opening. In this way a tight fit was secured to compensate for shrinkage. In cutting into lemons the rag should not be penetrated so as to cause juice to flow, as this appeared to effectually stop infection. With oranges less trouble was experienced from this cause.

The fungus was found to grow readily on leaf fragments of *Colocasis sp.* infection being obtained by placing them after sterilising in corrosive sublimate and washing well, in a decoction of conidia in sterile water. Attempts to inoculate the Colocasia leaves by placing conidia in a drop on the leaf within a large jar failed. Attempts to inflect leaves of *Richardia africana* Kunth. also failed.

It is evident from the foregoing that while oranges may be infected from conidia developed on orange leaves or fruit, and lemons from lemon leaves and fruit, it has not been demonstrated definitely that oranges may be infected by conidia from lemons or vice versa. As no distinction has been noted between the growth of cultures obtained from either lemons or oranges, the possibility of biological strains is suggested.

Germination of oospores has not been observed. No Chlamydospores have been recognised.

SYSTEMATIC POSITION.

Phytophthora hibernalis belongs to the *Phaseoli* group of Rosenbaum (25), which is identical with the *Phytophthora infestans* group of Pethyridge (21). This group is based upon the presence of amphigynous antheridia.

Owing to the past confusion with *Pythiacystis citrophthora* it is desirable to point out some of the differences between the two species. It may be stated here that it has been pointed out by several writers (3 & 16) that *Pythiacystis* is closely allied to and should probably be merged with *Phytophthora*. Smith & Smith, the authors of *Pythiacystis* have agreed (31) on the close affinity, but consider that the merging of *Pythiacystis* with *Phytophthora* is at present inadvisable owing to the doubtful delimitation of these genera and of *Pythium*.

P. citrophthora (29) is defined as having ovate or lemon-shaped sporangia 20 x 30 to 60 x 90mmm. averaging 35 x 50mmm. and producing 5—40 zoospores. The zoospores are 10—16mmm. in diameter with lateral cilia 30 to 40mmm. in length. No sexual bodies have ever been developed in cultures of typical *P. citrophthora* according to Smith & Smith (31). They also state that the mycelium on affected fruit is always sterile (29 & 30).

Cultures of *P. citrophthora*, Sm. & Sm. and *Pythophthora terrestris*, Sherb, were obtained from California in 1914 through the courtesy of Professor Fawcett. The latter fungus is the cause of mal-di-gomma or foot rot of citrus in California, Florida, etc., (13 & 15). Oranges were infected with these cultures and with *P. hibernalis*, and the resultant Brown Rots were identical in appearance. Both organisms were grown in parallel series of culture media with *P. hibernalis*. In no case were oospores produced on *P. citrophthora* though conidia were produced in fair numbers on potato dextrose agar, oat extract agar and glucose peptone agar, especially on cultures over four weeks old. They were produced more readily by placing portions of agar cultures in water. Measurements of 100 conidia produced in water from a culture on potato dextrose agar averaged 30 x 38.5mmm. with a range of 19—37 x 19—60mmm. In shape they varied from globose to flask-shaped or ovoid. The attachment of the sporophore was very frequently, even normally, eccentric and at times quite lateral (Plate V.). This character is illustrated by both Smith (30) and Doidge (12). There was also not infrequently a cellulose projection into the conidium at the point of attachment of the sporophore. This also is shown by Smith (30). Neither of these two features are found in *P. hibernalis*.

P. terrestris, Sherb., is readily distinguished from *P. hibernalis* by its more globose spores, and smaller oospores and the presence of chlamydospores. As already stated this species is considered to be synonymous with *P. parasitica*, Dast. The culture used agreed very closely with Sherbakoff's description.

It is interesting to note that the three cultures were found to be readily distinguishable macroscopically on potato dextrose agar so that determination could be made long before the conidia were developed (Plate II.).

The following notes were prepared from six series of plate cultures, and three on slopes made at different times.

GROWTH ON MEDIA AT TEMPERATURES 10—15°C.

Medium.	*P. citrophthora.*	*P. terrestris.*	*P. hibernalis.*
Potato dextrose agar.	Very strong. Loose woolly aerial growth. 1.5cm. long. On plates the growth in medium develops in super-imposed radiating fans.	Weak, irregular and tufted. Aerial growth as long as *P. citrophthora*, but scanty.	Strong, aerial growth a dense short felted mat, somewhat granular in appearance. Aerial growth 0.7 cm. long.
Oat extract agar.	do.	do.	do.
French bean agar.	Weak. Aerial growth scanty 0.75 c.m. long.	Medium. Aerial growth scanty 1.5 cm.	Very weak. Aerial growth scanty. 0.7 cm.
Prune juice agar.	Strong, in radiating fans. Aerial growth up to 2.1 cm. More abundant on slopes than plates.	Similar to potato dextrose agar, but aerial growth more scanty and only 0.5 cm. long.	Very strong. Aerial growth up to 2.2 cm. but matted.
Glucose peptone.	Strong piled cheesy growth, much wrinkled with superimposed radiating fans. Aerial growth scanty 1.5 cm. long.	Very similar to *P. citrophthora*, but weak. Aerial growth 1.0 cm.	Strong. Aerial growth loose woolly 1.2 cm. long.

All three species develop conidia on potato dextrose agar. *P. citrophthora* has given the strongest vegetative growth on all the above media. *P. hibernalis* comes next except on French bean agar on which it makes poorer growth than *P. terrestris.*

As already stated *P. hibernalis* belongs to the *Phaseoli* group of *Phytophthora* as defined by Rosenbaum. He also points out (25) that one of the most important and constant factors available for the distinction of species is the ratio between the mean length and the mean breadth of the conidia. Extending Rosenbaum's table to include all the species noted in the literature available to the writer which would appear to belong to the *Phaseoli* group, the following table is proposed as a skeleton key to the species:—

PHYTOPHTHORA—PHASEOLI GROUP.

Majority of antheridia amphigynous.

1. Mean ratio of length of conidia to breadth 1.75 or less:—

P. melogena, Sawada	1.2	(17)
P. parasitica. var. rhei, Godfrey	1.32	(17)
P. allii, Sawada.	1.35	(17)
P. terrestris, Sherb.	1.39	(28)
P. phaseoli, Thax.	1.40	(25)
P. infestans (Mont.) de Bary	1.45	(25)
P. cryptogaea, Peth. & Laff.	1.48	(22)
P. faberi, Maubl.	1.53	(25 & 23)
P. erythroseptica, Peth.	1.57	(25)
P. arecae, Colim.	1.59	(25)

2. Mean ratio greater than 1.75 and less than 2:—

P. parasitica, Dast.	1.82	(25 & 11)

3. Mean ratio—2 or greater:—

Conidia without persistent pedicels:—

P. mexicana Hot. & Hartge.	up to 2	(18)
P. Meadii, McRae	2	(19)

Conidia with persistent pedicels:—

P. colocasiae, Rac.	2.2	(5)
P. hibernalis, Carne	2.3	

In *P. colocasiae* the persistent pedicel is only occasional, and when present is less than half the length of the conidium. The conidia are larger and oospores smaller than in *P. hibernalis. P. colocasiae* is further distinguished by the presence of a cellulose plug at the point of insertion of the conidiophore into the conidium, and by the presence of chlamydospores.

In some cases the ratios given in the Key may be subject to slight variation where the writer has not been able to obtain the mean dimensions of the conidia, but only the range within which the majority occur. The ratios when not given by Rosenbaum were calculated from figures in the references indicated. *P. faberi* is included on the authority of Ashby (2).

PHYTOPHTHORA HIBERNALIS n.sp.

Mycelium irregularly branched, hyaline; hyphae at first continuous, somewhat septate and often empty when old, 3—12mmm. in width usually 5mmm., inter or intracellular; conidiophores simple bearing a single terminal conidium; conidia elliptical papillate 17—56 x 10—28mmm., deciduous with very persistent pedicels 2—56mmm. long, often germinating as zoosporangia; zoospores reniform, biciliate 11 x 9mmm. germinating by germ tubes; oogonia hyaline, subglobose 22—56mmm. in length, at first smooth, but later forming a rough covering on the oospore; antheridia persistent, hyaline, ovoid, smooth, amphigynous, rarely paragynous; oospores spherical, 22—45.6mmm. yellow to tawny when mature.

Hab. On fruit, leaves and smaller branches of citrus spp. Western Australia, South Australia, and probably Victoria, Queensland and the Mediterranean Region.

Mycelio ramoso irregulariter, hyalino, ex hyphis primo continuis tandem septatis, 3—12mmm. plerumque 5mmm. crassis, inter et intra-cellularibus; conidiophoris unicis et sustinentibus conidium unum in apice; conidiis ellipsoidalis, papillatis, 17—56 x 10—28mmm. deciduis, cum pedicellis persistentibus, saepe formatibus zoosporangia; zoosporis reniformis biciliatis 11 x 9mmm.; oogonis subglobosis, hyalinis, 22—56mmm., longis, levibus sed vestutioribus rugosis; antheridiis persistentibus, hyalinis, ovoideis, levibus, amphigynis raro paragynis; oosporis sphaericis hyalinis vestutioribus luteis, 22—45.6mmm.

Hab. in fructibus, foliis, ramis Citri spp.

In Western Australia, South Australia et probabiliter Victoria, Queensland et Regionis Mediterranae.

PROBABLE LIFE HISTORY IN WESTERN AUSTRALIA.

From field and laboratory evidence the following life history appears probable. The fungus lives over the summer in the oospore stage. With the next winter rains (May or June) the oospores germinate, the fungus grows to the ground surface and forms conidia. These are blown or splashed on to the lower parts of citrus trees by the driving winds, which so frequently accompany rain in this State, or they may come in contact with leaves or fruits touch-ing the ground. Spores are formed and infection takes place only during or immediately following wet weather. Infection is greatest on the sides of the trees most sheltered as it is there that the leaves or fruits most frequently remain wet long enough to allow the conidia to germinate and bring about infection. The incubation period is about 10 days. During or following wet weather the affected parts of trees produce conidia which infect other parts of the same plants or are carried by wind to other trees. Infected leaves and fruits fall to the ground, and there produce oospores. Infection ceases about October with the rise in temperatures.

This suggested history already given elsewhere (6) lacks confirmation on one point namely the germination of the oospores which has not yet been observed.

The disease does not spread in store or case fast enough to be a serious consideration in the local trade. This spreading may be more important in exported fruit. No evidence has been obtained of mycelial infection between fruits. The indications point to infection taking place from conidia borne on the fruits, which is, of course, possible only when they are damp. There is also no evidence of the disease carrying over in the twigs. Many cases have been noted of defoliated branches producing clean shoots

CONTROL.

Excellent control has been obtained by spraying citrus trees with Bordeaux Mixture (4—4—50), or Burgundy Mixture (4—6—50) in April or early in May before the winter rains. This subject has been dealt with in more detail elsewhere (6 & 8).

It is recommended that the ground under the trees be sprayed and that the spray be applied to the trees only to a height of four feet. This has been found to give excellent results, and at the same time reduces the danger of the rapid increase of scale insects and aphides which unfortunately frequently follows the use of fungicides on citrus trees.

The writer desires to express his appreciation of the assistance received from many sources. Especially is he indebted to Dr. E. J. Butler, Imperial Bureau of Mycology, for references to literature, a translation of Moniz da Maia's paper, and a very helpful interest. to Mr. W. L. Waterhouse, B.Sc., Agr., Sydney University, for helpful criticism; to Mr. G. Wickens, Officer in Charge of Fruit Industries, Department of Agriculture, and his Inspectors, for assistance in the field; to Mr. J. G. C. Campbell, B.Sc., his assistant in 1923, who first isolated the organism in pure culture; to Mr. C. A. Gardner, for redrawing camera lucida drawings; to Mr. J. Clark, for assistance in making microphotographs; and to Mr. A. C. R. Loaring of Bickley on whose orchard most of the field work was done.

SUMMARY.

A serious fruit rot, leaf blight and twig dieback of citrus trees in Australia caused by *Phytophthora hibernalis* sp. nov. is here described.

This pathogen is identical with an undescribed species of *Phytophthora* recently found by Moniz da Maia to be responsible for a citrus fruit rot in Portugal and probably in other Mediterranean countries.

Phytophthora hibernalis occurs in the States of Victoria, South Australia, Western Australia and Queensland. It is active only in the cooler months (May to October) under conditions of high atmospheric and soil humidity.

It is characterised by the presence of persistent pedicels on the conidia. The conidia measure 17—56 x 10—28mmm., with an average ratio of length to breadth of 2.3. The oospores measure 22—45.6mmm. The optimum growth temperature is about 12° C.

It has been confused in the past with *Pythiacystis citrophthora* Sm. & Sm., from which it is separable on morphological and cultural characters.

Phytophthora hibernalis is effectively controlled by spraying with Bordeaux or Burgundy Mixtures before the advent of the cool wet season.

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EXPLANATION OF PLATES.

I.

Upper. Orange tree partially defoliated.

Lower. Lemon tree completely defoliated. Fruit not affected.

Effects of *Phytophthora hibernalis*. Maddington, July, 1924.

II.

Cultures on potato dextrose agar. Growth in 15 days at 12—15° C. Upper—*Phytophthora hibernalis*. Left lower—*Pythiacystis citrophthora*. Right lower—*Phytophthora terrestris*.

III.

Phytophthora hibernalis—Microphotographs showing oogonia and antheridia from potato dextrose agar culture. Inset—Germinating conidium showing germ tube and persistent pedicel.

IV.

Phytophthora hibernalis—

A1. Conidia showing shape and vacuoles.

A2. Conidia discharging zoospores.

A3. Discharged conidia.

A4. Zoospores.

A5. Zoospores rounded off and germinating.

A6. Conidia germinating.

A7. Conidium producing secondary conidia.

B. Oogonia, oospores and antheridia.

B1 & 2. Paragynous antheridia.

B3. Antheridium.

C. Mycelium showing septa.

V.

A. *Phytophthora hibernalis.* Oogonia, oospores and antheridia.

A1 & 2. Showing oil globules in oogonia.

A3. Antheridium.

B. *Phytophthora hibernalis.* Sporophores on potato dextrose agar.

C. *Pythiacystis citrophthora.* Conidia produced on potato dextrose agar.

PLATES IV. & V. redrawn from camera lucida drawings.

IV. A. & B. x 500.

IV. C x 400.

V. A x 700.

V. B x 175.

V. C x 500.

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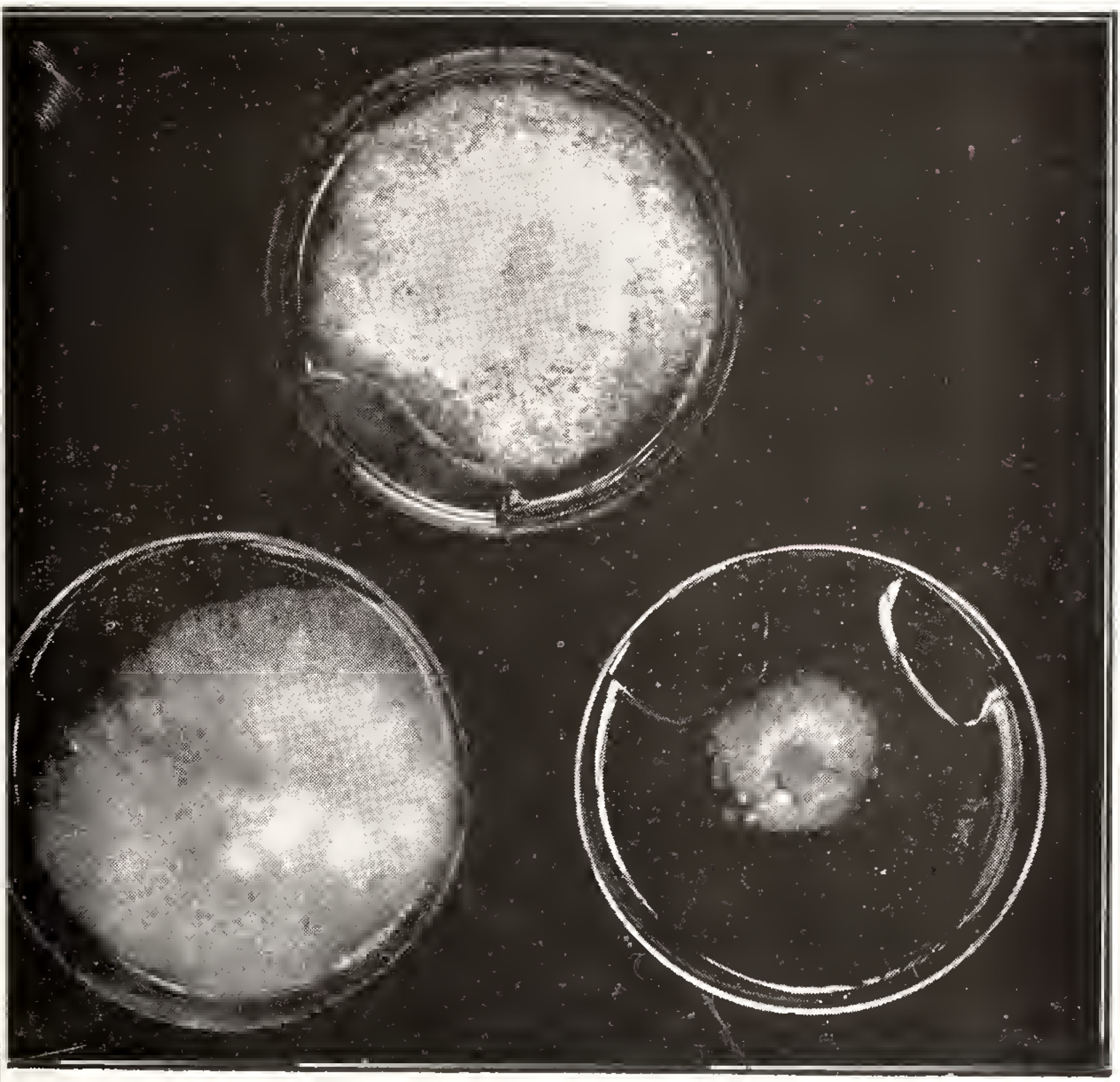

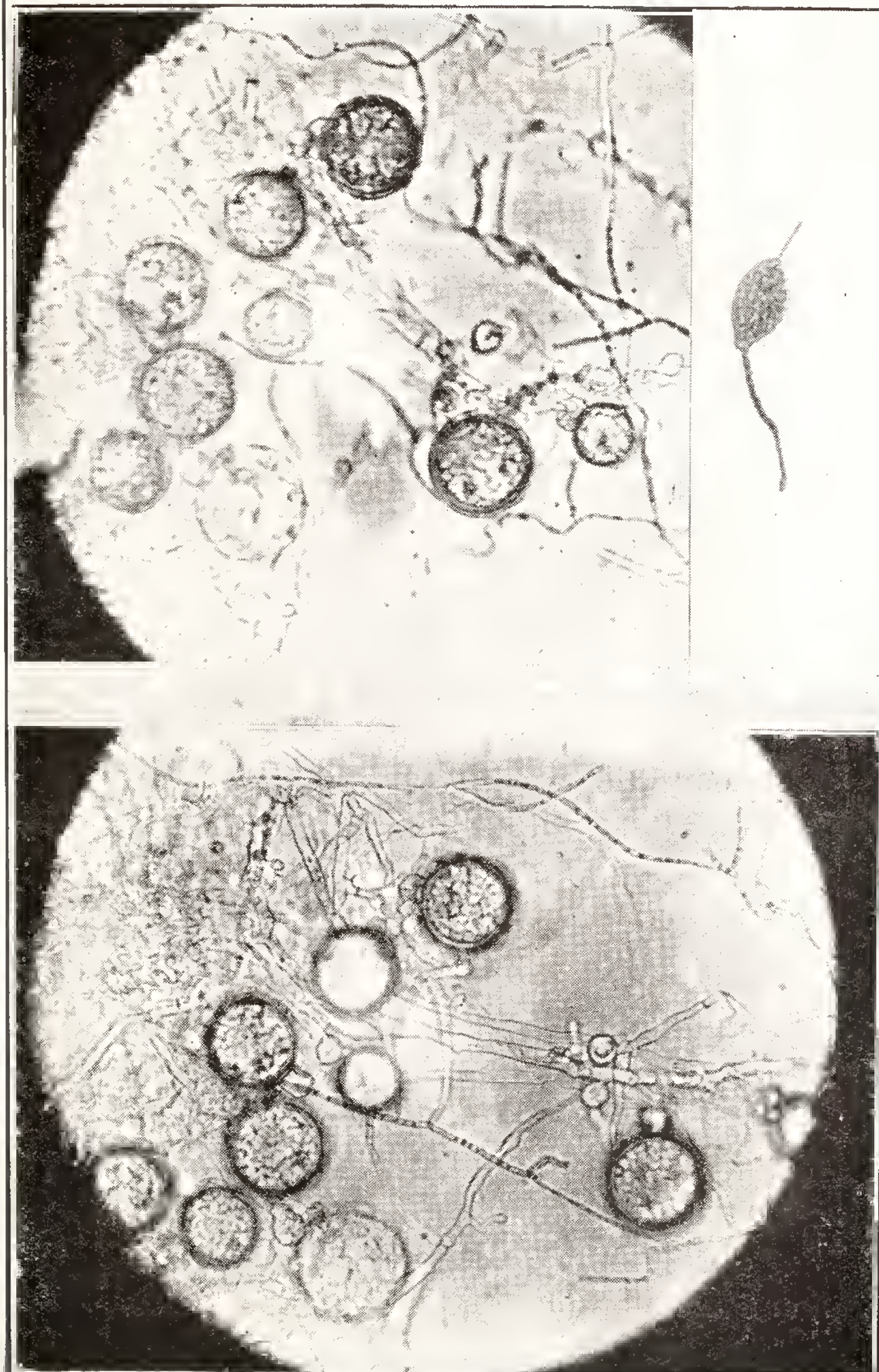

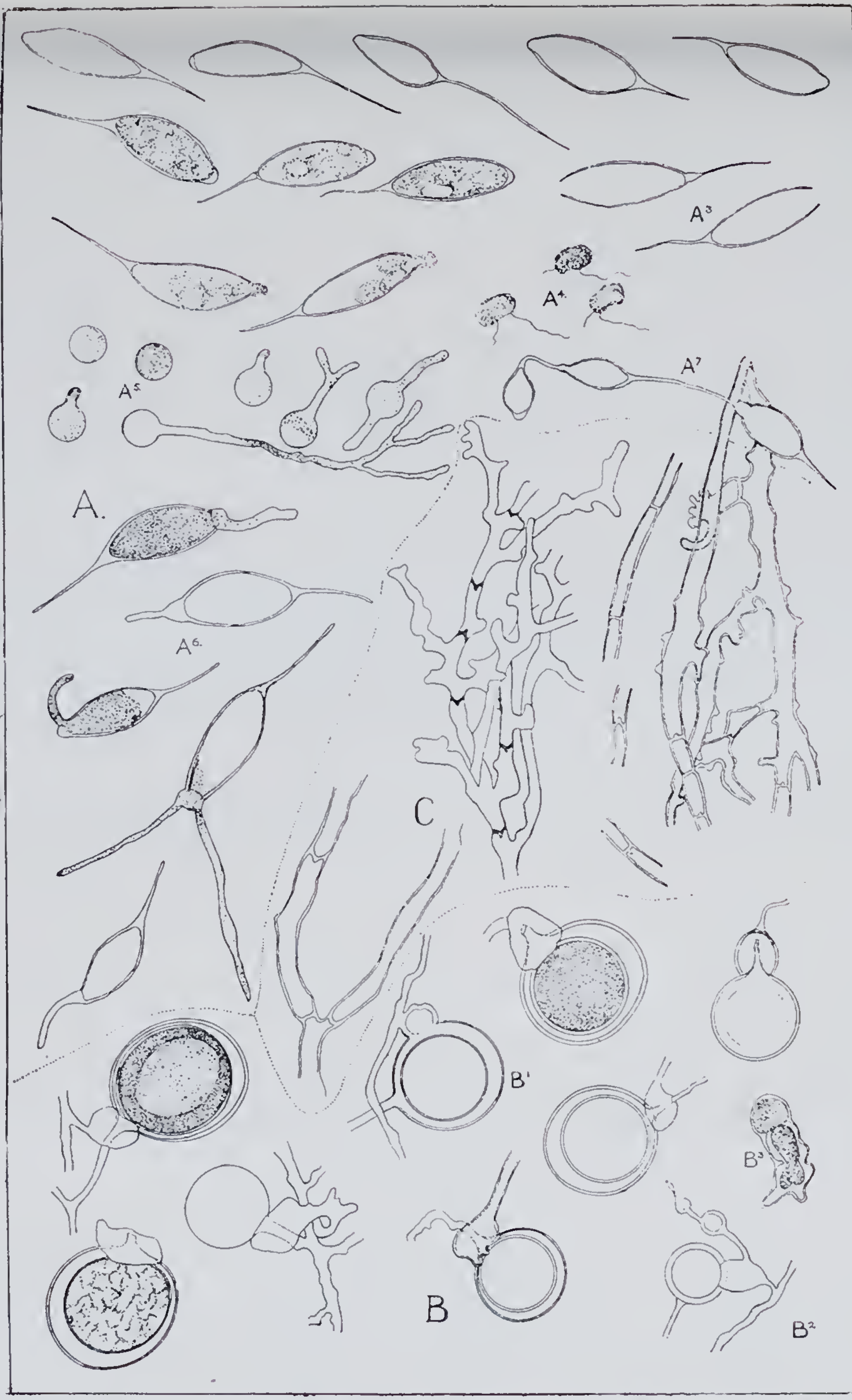
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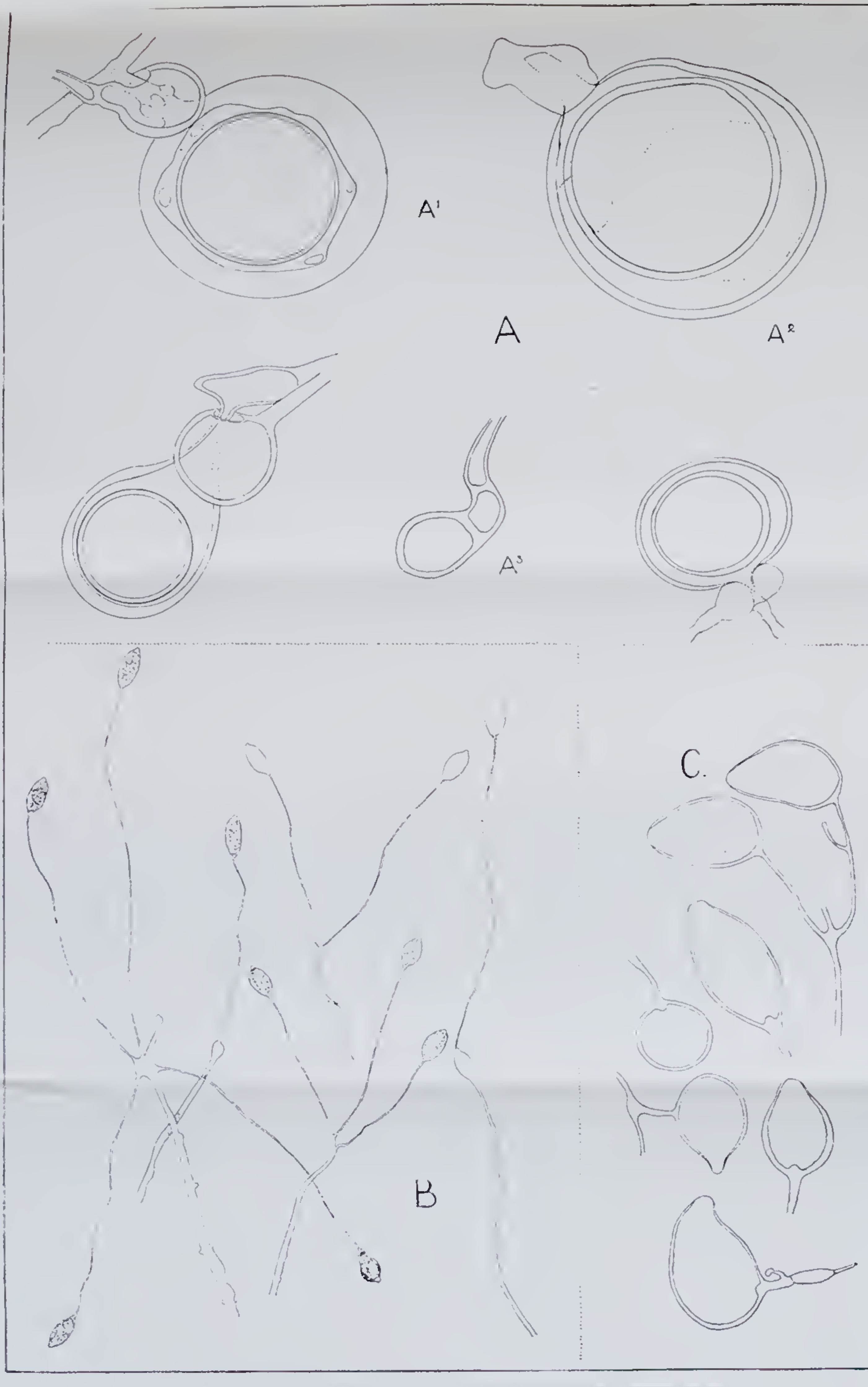
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Australian Formicidae by John Clark, F.L.S.

(*Read* December 8, 1925. *Published* January 25, 1926).

The individuality of the Ant Fauna of South West Australia is pronounced, as previously noted by Prof. A. Forel. * Most of the species known at that time had been described by him, from material collected by visiting naturalists.

Until recent years little collecting had been done by local naturalists, but the collections so made tend to show that we have representatives of various groups which exhibit a rather interesting distribution.

In the following pages three new species, and the female of a recently described species, are recorded from South West Australia, and one new species from New South Wales.

The most important of these is a species of *Discothyrea*, a genus not previously found in Australia. This genus has a wide distribution, members of it are found in Africa, America, New Zealand, New Guinea and Java. The occurrence of this species in South West Australia is of particular interest.

The genus *Acanthoponera* is at present represented in Australia by one species and one variety; these have been recorded from Queensland and South Australia. I have now to record a new species from the South West of this State. This genus was originally described from South America, but has also been found in New Zealand.

The genus *Pseudopodomyrma* was recently described by Crawley. He noted the general resemblance of the workers to those of the genus *Podomyrma*. While the workers are similar in general appearance the females are very different, as will be seen from the following description and figures.

The remaining species belong to genera which have already been dealt with by me in the Journal of this Society.

The types of the new species are at present in the author's collection.

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* Die Fauna Suedwest Australiens, Band 1, Lieferung 7, 1907.

Sub-family: CERAPACHYINAE.

Eusphinctus (Nothosphinctus) nigricans n.sp. (Pl. VI, 1.)

Worker: Length 5—5 3mm.

Black; antennae and legs brownish. Hairs yellowish, long, sub-erect, longer and more numerous on the gaster than elsewhere, short and adpressed on the antennae and legs. Pubescence yellowish, sparse throughout except on the antennae and legs, and more abundant on the head than on the gaster.

Shining. Head finely and densely punctate, mandibles coarsely punctate and feebly striate. Pronotum and mesonotum coarsely and sparsely punctate; epinotum more densely and finely punctate. Petiole and anterior half of the postpetiole coarsely and sparsely punctate; anterior half of the abdominal segments finely and sparsely punctate.

Head longer than broad, as broad in front as behind, widely concave on the occipital border, the angles sharp, sides nearly straight. Frontal carinae short, erect, truncate and confluent behind, extending back to the top of the antennal depression. Carinae of the cheeks short, prominent. Clypeus very short and broadly rounded. Eyes and ocelli absent. Mandibles abruptly bent at their base, indistinctly dentate. Antennae robust, scapes extending back beyond the middle of the head; first joint of the funiculus as long as broad, second to ninth broader than long, tenth longer than broad, the apical joint as long as the three preceding joints together. Thorax one and three-quarters times longer than broad, slightly broader through the pronotum than through the epinotum, slightly constricted in the mesonotal region; mesonotal sutures feebly indicated; pronotum rounded in front and on the sides, the anterior angles bluntly pointed; epinotal declivity abrupt, concave, marginate on the top, submarginate on the sides. Node of the petiole fully one and one-quarter times broader than long, broader behind than in front, the anterior border nearly straight, the sides feebly convex, the posterior border widely, but not deeply, concave; in profile slightly higher than long, the anterior face vertical, the dorsum is strongly rounded and convex above; the ventral surface in front with a long broad, blunt, tooth-like projection directed slightly backward; there is also a small sharp tooth at the posterior end of the ventral surface. Postpetiole one and one-quarter times broader than long, broader behind than in front, all four borders feebly convex; the ventral surface in front feebly produced and with a short blunt tooth-like projection. All the segments of the abdomen separated by wide, deep constrictions; the first segment is twice as broad as long.

Pygidium truncate, submarginate, minutely spinulose on the sides and tip. Legs moderately long and stout.

Hab.: New South Wales, Lismore (C. F. Deuquet).

Described from two specimens collected by my friend Mr. Deuquet in the scrub near Lismore. This species is apparently near *E. N. Froggatti* Forel, which I have not seen, but from the description of the latter it is very distinct. The colour distinguishes it from all the other Australian species.

Phyracaces reticulatus n.sp. (Pl. VI, 2).

Worker: Length 3.5—4mm.

Red; antennae and tarsi testaceous. Hairs yellowish, short, erect, moderately abundant. A thin grayish pubescence on the antennae and legs.

Shining. Head, thorax and petiole densely and finely reticulate, the postpetiole and abdomen more coarsely reticulate-punctate.

Head as long as broad, much broader behind than in front, the occipital border straight, the angles rounded. Frontal carinae erect, short, truncate behind. Carinae of the cheeks forming a blunt angle in front, and extending back to the middle of the eyes. Clypeus short, broadly rounded, with a long tooth-like projection in the middle in front. Eyes large, moderately convex, placed slightly in front of the middle of the sides. No traces of ocelli. Mandibles large, strongly bent at their base, the external border convex, the terminal border strongly dentate: they are coarsely punctate-striate. Antennae robust, scapes extending to the posterior margin of the eyes, gradually thickened to the apex; first joint of the funiculus as long as broad, the second to ninth broader than long, the tenth longer than broad, the apical joint pointed, as long as the four preceding joints together. Thorax barely one and one-half times longer than broad, as broad in front as behind, mesonotal sutures not indicated; anterior border of the pronotum convex, the angles rounded, posterior border of the epinotum nearly straight, with a slight indention in the middle; in profile strongly rounded and convex above, the epinotal declivity sloping at a slight angle; all four sides of the dorsum and sides of the declivity strongly marginate. Node of the petiole twice as broad as long, as broad as the thorax, concave in front, the angles sharp, the sides and posterior border convex, the posterior angles produced as long sharp spines, directed inward and slightly upward, the anterior and lateral borders strongly marginate; in profile feebly rounded and convex above, the anterior face vertical; the ventral surface with a short blunt tooth in front.

Postpetiole one and one-half times broader than long, as broad as the thorax, the anterior border concave, the angles sharp, the sides convex; the anterior and lateral borders strongly marginate the lateral margins ending abruptly just in front of the posterior border. A strong constriction between the postpetiole and the first segment of the gaster; this latter is much broader than long and broader behind than in front, it is broader than the thorax. Pygidium truncate, minutely spinulose on the sides and tip. Legs short and stout.

Hab.: Western Australia, National Park (J. Clark).

This species is not near any other known to me. The peculiar tooth-like projection on the clypeus will readily distinguish it from all the described forms. The whole insect has a heavy thick-set appearance, and looks shorter than it really is.

Sub-family PONERINAE.

Discothyrea crassicornis n.sp. (Pl. VI, 4 and 4a.)

Worker: Length I.8mm.

Rufo-testaceous; mandibles, apical joints of the antennae and legs yellow. Hairs whitish, short and sparse on the whole body. Pubescence whitish, short, very fine and abundant everywhere, longest on the gaster.

Opaque. Densely and finely punctate-reticulate on the head, more coarsely so on the thorax and abdomen, node coarsely punctate above.

Head longer than broad, broader behind than in front, the occipital border and sides convex, the posterior angles rounded. Frontal carinae short and erect, dilated behind, truncate behind the dilation and confluent to the middle of the head. Clypeus produced, widely convex in front, feebly but distinctly crenulate. Mandibles moderately long, subtriangular, the terminal border with a sharp cutting edge which shows no traces of teeth, ending in a somewhat long sharp point. Eyes small, flattened, placed slightly in front of the middle of the sides. No traces of ocelli. Antennae 9-jointed, short and very thick; scapes short, extending to about the occipital third of the head, club-shaped, fully three times thicker at the apex than at the base; first joint of the funiculus as broad as long, cylindrical, five times longer than the second, the second to seventh much broader than long, subequal, the seventh fully three times broader than the second, the apical joint very large, about two and one half times longer than broad, and much longer than the remainder of the funiculus. Thorax fully twice as long as broad at the pronotum; one and one half times broader through the pronotum than through the epinotum; pronotum convex in front and on the sides, feebly concave in the mesonotal region; there are no traces of mesonotal sutures; the posterior margin of the epinotum slightly concave and marginate, the angles bluntly produced; in profile rounded and convex above, the epinotal declivity abrupt, almost at a right angle with the dorsum, the sides marginate. Node, from above, two and one half times broader than long, all four sides of the dorsum convex; in profile it is twice as high as long, rounded above, the anterior face almost straight, the ventral surface in front with a short blunt tooth-like projection, to the front edge of which is attached a keel-like, translucent lamella. Postpetiole slightly broader than long, much broader behind than in front, the anterior border and sides rounded; in profile it is convex and rounded above, the ventral surface with a transverse, tooth-like process in front. A strong constriction between the two segments of the gaster. The second segment is one fourth broader than long, broader in front than behind, strongly rounded and convex, narrowing rapidly to the small apical segments which are placed below. Legs short and stout.

Hab.: Western Australia, Manjimup (J. Clark).

Two examples under a rotten log.

The occurrence if this insect in South West Australia is of great interest, as it shows the wide distribution of this ancient genus. This species appears to be intermediate between *D. clavicornis*. Emery, from New Guinea, and *D. antarctica*. Emery, from New Zealand.

Acanthoponera occidentalis n.sp. (Pl. VI. 3).

Worker: Length 3.5—4mm.

Head, thorax and node castaneous, abdomen with a yellow tinge; mandibles, antennae and legs testaceous. Hairs yellow, long, slender and erect, abundant on the apical segments of the gaster, longer and more bristle-like on the clypeus. Pubescence yellow, long and adpressed on the gaster, shorter and more abundant on the antennae and legs.

Head and thorax opaque, gaster shining. Head finely and longitudinally rugose on the middle, finer and more punctate on the frontal areas and on the sides. Mandibles shining, with large, scattered, piligerous punctures. Thorax densely and coarsely punctate, becoming almost rugose on the epinotum. Node coarsely punctate. Gaster densely covered with wide, shallow punctures.

Head longer than broad, as broad in front as behind, the occipital border concave, the angles rounded sides feebly convex. frontal carinae rather flat, overhanging the antennal insertions in front, extending back to the eyes, and continued further as feeble carinae; there is a faint carinae in the middle, between the frontal carinae, extending from the front edge of the clypeus to the occipital border; in some examples the carinae is scarcely to be distinguished from the rugae of the head. Clypeus broadly rounded in front, convex above. Eyes small, flattened, placed behind the middle of the sides. No traces of ocelli. Mandibles triangular, the external border convex, the terminal border armed with five long sharp teeth. Antennae short and robust, the scapes extending back slightly beyond the posterior margin of the eyes, they are gradually thickened to the apex; first joint of the funiculus about twice as long as broad, the second a little longer than the third, but broader than long, third to tenth broader than long, the apical joint about twice as long as broad, and as long as the four preceding joints together. Thorax fully one and one half times as long as broad, broadest through the pronotum, which is almost twice as broad as the epinotum at the top of the declivity; pro-mesonotal suture sharply impressed; the suture between the mesonotum and the epinotum feebly indicated. The anterior and lateral borders of the pronotum convex, the anterior angles sharp, the posterior border of the epinotum concave, the angles produced as tooth-like projections; in profile the thorax is rounded and convex above, the epinotal declivity abrupt, feebly margined above and on the sides. Node twice as broad as long, broadest just behind the middle, almost oval, but the posterior border not so strongly convex as the anterior; in profile it is more than twice as high as long, the anterior face sloping at a slight angle, the top edge rounded, the posterior face straight, the ventral surface with a moderately long sharp tooth-like projection almost directly under the anterior face; this tooth has a broad translucent lamella attached to its anterior edge, the lamella is as long as it is broad. First segment of the gaster broader than long, broader behind than in front, the anterior border straight, the angles rounded, the sides convex; in profile it is bluntly produced in front below. A slight constriction between the first and second segment. The second segment is as long as the first, it is broader in front than behind. The apical segments short, hidden by the second. Sting long and stout. Legs short and stout.

Hab.: Western Australia, National Park (J. Clark).

Described from a small colony found under a stone.

This ant feigns death on being disturbed, or when the stone is removed from above the nest. This is the first example of the genus to be found in Western Australia. The other Australian species, *A. imbellis.* Forel, was described from Queensland, but also occurs in South Australia. I have lately received examples which were collected at Ferntree Gully, Victoria. The variety *hilaris.* Forel, was described also from Queensland.

Sub-family MYRMICINAE.

Pseudopodomyrma clarki Crawley. (Pl. VI, 5, 5a).

Ent. Record, vol. XXXVII, No. 3, p. 40-41, 1925 *Worker.*

Female: Length 5mm. (Ergatoid). (Not previously described).

Dark reddish brown; mandibles, clypeus, scapes, terminal joints of the antennae and legs testaceous. Hairs yellowish, confined to the head and apical segments of the gaster, particularly below, where they are longer and more erect. Pubescence very fine and sparse.

Head and thorax shining, petiole and abdomen opaque. Mandibles striate and with scattered punctures. Clypeus smooth and shining in the middle, finely and densely reticulate-punctate at the sides. Head densely covered with large, deep punctures, a faint longitudinal striation between the frontal carinae. Pronotum with larger and coarser punctures, more scattered. Scutellum with large shallow punctures, more numerous on the sides than on the middle. Mesonotum with a few small punctures. Punctures on the epinotum similar to those on the scutellum. First node densely and more closely punctured than the rest of the body; the postpetiole not quite so densely covered and the punctures more shallow. Abdomen smooth, but with a microscopical reticulation.

Head as long as broad, broader behind than in front, the occipital border straight, the sides convex, the occipital angles broadly rounded. Frontal carinae short, extending back about level with the anterior margin of the eyes, wide apart, separated by fully their length behind; a moderately deep median impression between them extending to the occipital border. Clypeus produced, bilobed in the middle. Mandibles triangular, with moderately large teeth on the terminal border, apical point long and sharp. Eyes small, flattened, placed behind the middle of the sides. No traces of ocelli. Antennae short, scapes extending only to the occipital third of the head, curved, and gradually thickened to the apex; first joint of the funiculus broader than long, second and third as broad as long, fourth to ninth broader than long, tenth as broad as long, rounded at the apex. Thorax one and three-quarters times longer than broad, much broader through the pronotum than through the epinotum. Pronotum twice as broad as long, convex in front and on the sides, the anterior angles sharp, but not produced as teeth, the posterior angles feebly projecting at the scutellum. Scutellum large, slightly broader than long, broader behind than in front. There are no traces of wing pads. Mesonotum small and transverse. Epinotum broader than long, the dorsum and declivity united in one curve; near the bottom of the declivity, on each side, is a flange-like projection. Node broader than long, somewhat cone-shaped, bluntly rounded on the dorsum, which is small, the anterior border below slightly concave, the angles produced outward and forward as broad, blunt, tooth-like projections; in profile it is as high as long, highest in the middle, the anterior face sloping at an angle of forty-five degrees, the posterior face sloping at a more obtuse angle, slightly convex, the posterior being much shorter than the anterior face. Post-petiole fully twice as broad as long, convex in front and on the sides; in profile it is twice as high as long. Abdomen one and one-third times longer than broad. First segment broader than long, much broader behind than in front. Legs short and stout, all the femora greatly incrassated in the middle; the anterior tibia very massive.

Hab.: Western Australia, Claremont (J. Clark).

This female is from the same colony from which the worker was described by Crawley. It is very much like the worker in general appearance, and was only noticed when some examples were being carded. The head is much smaller than in the worker, and the scapes much shorter. The nodes of the pedicle are very dissimilar, and the gaster considerably larger. The colour is lighter, more reddish, with the clypeus, antennae and legs testaceous; they are dark castaneous in the worker. The pilosity and pubescence are similar, even to the two stout hairs on the base of the postpetiole above.

Although its general facies are extremely like the genus *Podomyrma*, the habits are quite different. All the species of *Podomyrma* are arboreal, living in the branches and trunks of trees. The present species lives underground, in the roots of a small shrub (Leptospermum), growing on the coastal sandhills. It appears to utilise the burrows of wood-boring insects for its nest. I have not seen this ant outside of the nest during the day, but specimens have been found late in the evening, just before dark. The nest generally contains a large amount of insect remains.

Explanation of Plate VI.

1. Eusphinctus (Nothosphinctus) nigricans n.sp., dorsal view of worker.

2. Phyracaces reticulatus n.sp., dorsal view of worker.

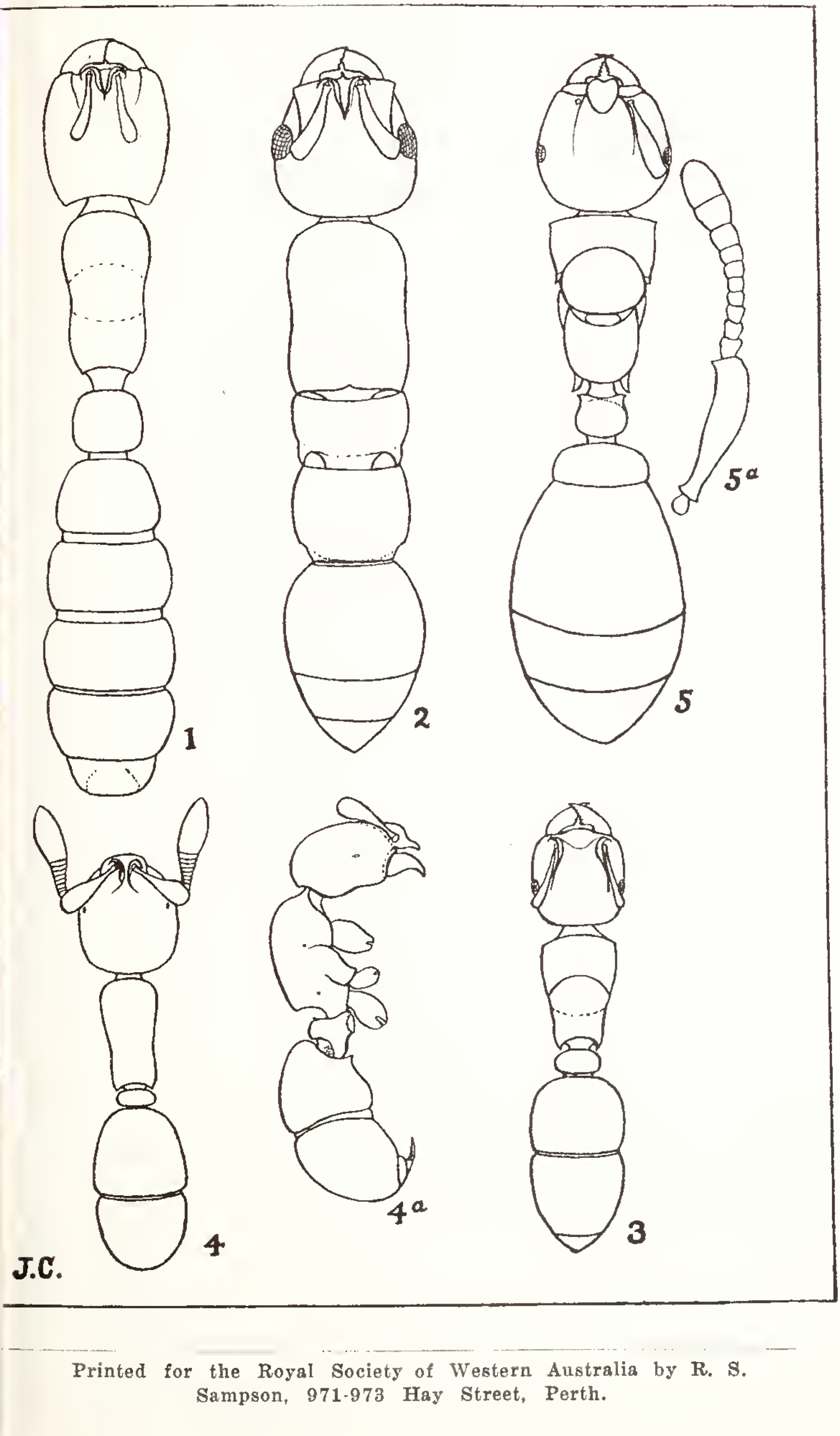
3. Acanthoponera occidentalis n.sp., dorsal view of worker.

4. Discothyrea crassicornis n.sp., dorsal view of worker.

4a. Discothyrea crassicornis n.sp., lateral view of worker.

5. Pseudopodomyrma clarki Crawley. Dorsal view of female.

5a. Pseudopodomyrma clarki Crawley. Antenna of female.



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Note on two ammonites from the Gin Gin Chalk

by **L. F. Spath,** D.Sc., F.G.S. *Communicated by L. Glauert.*

(*Read* March 9, 1926. *Published* April 7, 1926.)

Mr. L. Glauert, F.G.S. of the Western Australian Museum, through the kind intervention of Mr. Thomas H. Withers, F.G.S., has sent to me for examination two Gingin Chalk ammonites, which it is proposed to discuss briefly in the following lines. The specimens are labelled No. 3979 (One Tree Hill) and No. 10101 (three fragments).

Ammonites are not common in the Gingin Chalk and appear to be always in the condition of crushed or otherwise badly preserved casts. The seven examples recorded by R. Etheridge junr. in his paper on the "Cretaceous Fossils of the Gingin Chalk"* had long puzzled observer until Mr. Withers† announced the occurrence of the crinoid *Uintacrinus* in the Gingin Chalk and established the Senonian age of this deposit. In so recent a work as Dr. F. R. C. Reed's "Geology of the British Empire"‡ the Gingin Chalk was stated to comprise beds ranging from the Albian to the Cenomanian, its fauna showing a remarkable resemblance to that of corresponding English beds. Some of Etheridge's examples were compared to "*Haploceras*" *daintreei* Etheridge§ and to "*Haploceras*" *flindersi* M'Coy sp.||, of which latter "*Ammonites beudanti* Brongniart, var. *mitchelli*" Etheridge¶ referred to by the writer on a recent occasion** is said to be a

* Part IX. of Palaeontological Contributions to the Geology of W. Australia, (IV.) Geol. Surv. W. Austral. Bull. No. 55, 1913.

† Journ. Roy. Soc. W.A., vol. XI., No. 2, 1924, pp. 15-8.

‡ London (Edw. Arnold), 1921, p. 376.

§ "Description of the Palaeozoic and Mesozoic Fossils of Queensland" in Daintree, "Geology of Queensland." Quart. Journ. Geol. Soc. vol. XXVIII. (1872), pl. XXIV., figs. 1-2.

|| Trans. Roy. Soc. Victoria, vol. VII. (1866), p. 49 (not figured).

¶ Loc. cit. (1872), p. 345, pl. XXIII., figs. 1-2. Haploceras. is a strictly Jurassic genus, see L. F. Spath "Ammonites and Aptychi" (VII.), Collection of Fossils and Rocks from Somaliland, Monogr. Hunterian Mus. Glasgow, I. 1925, p. 113.

** Spath, Monograph of the Ammonoidea of the Gault. (Pal. Soc.) part I. (1921), 1923, p. 52.

synonym. Mr. F. W. Whitehouse, M.Sc., is now revising the ammonite-fauna of the Rolling Downs Beds of Queensland, and, as the writer* mentioned in a recent paper, the occurrence of Aptian fossils together with Upper Albian forms, has hitherto prevented a correct identification of the Australian species. The true affinities of the Desmoceratids, described by Etheridge will thus, no doubt, soon be established, and it is clear that their resemblance to some of the Gingin Chalk forms is only superficial.

Another of Etheridge's examples was compared to *Amm. peramplus* Sharpe, non Mantell†; and a fourth, globose, species was considered to be entirely distinct, but from the description may also be a Pachydiscid.

The two examples under examination are also poorly preserved and, although recognisable at first sight as Pachydiscids and superficially resembling *Pachydiscus peramplus*, they cannot easily referred to any one of the numerous genera of this family. *Eupachydiscus*, with similar periodic strengthened ribs, on the whole, seems the most likely group, i.e., the lineage including *E. isculensis* (Redtenbacher) and *E. jeani* (Grossouvre)‡ which, probably, also includes *Pachydiscus haradai* Jimbo, for which Yabe, in 1924§ used the name "*Mesopachydiscus.*"

Until the Japanese forms are described and their horizons are known, definite identification and correlation are impossible. As it is we can only state that the two examples appear to belong to two separate species, and that the ammonite evidence supports Mr. Wither's view of the Santonian age of the Gingin Chalk. In a recent paper on "New Ammonites from the English Chalk"* the writer correlated the lower part of the zone of *Marsupites testudinarius* (or *Uintacrinus* bed) with the Upper Mortoniceratan age, characterised in England by the (rare) occurrence of *Parapuzosia* (*lepptophylla* group). The presence of comparable forms in the Gingin Chalk probably explains the identification, by Etheridge, of some of his examples with earlier species of "Puzosids."

From the zone of *Micraster cor-anguinum*, below the *Uintacrinus*

* Geological Magazine, February, 1926.

† "Description of the Fossil Remains of Mollusca in the Chalk of England." Cephalopoda, I., 1853, p. 26, pl. X. fig. 2. *Pachydiscus sharpei* Spath.

‡ See Spath. "Senonian Ammonite Fauna of Pondoland." Trans. Roy. Soc. S. Afr. Vol. X., part III, 1925, p. 124.

§ "Stratigraphical Sequence of the Lower Tertiary and Upper Cretaceous Deposits of Russian Saghalin." Japan. Journ. of Geol. and Geogr., vol. III., No. 1, 1924, p. 12.

* "Upper Albian Ammonoidea from Portuguese East Africa, etc. Annals Transv. Mus., vol. XI., pt. III., 1925, pp. 191 and ff.

bed, with *Mortoniceras texanum*, now also known from England, no Pachydiscids have been recorded by Grossouvre† but Yabe‡ mentioned what may be a *Eupachydiscus* even from the supposed Lower Senonian Himenoura Group, where perhaps *Nowakites* (*vaju* group) are likely to occur.

The genus *Pachydiscus*, it should be added, is here used (as in previous publications, and as listed in Diener's [3a] Catalogue) to cover only the group of *P. peramplus* Mantell sp. Since Grossouvre, however, in 1893§ restricted *Pachydiscus* to the group of *P. neubergicus* Hauer sp. (now *Parapachydiscus* Hyatt) our use of the term¶ is not in conformity with the law of priority in palaeontological nomenclature and can be justified only on grounds of universal sanction.

† "Les Ammonites de la Craie Superieure." Recherches sur la Craie Sup. II., Mem. Carte Geol. Det. France, 1893, p. 237.

‡ Fossilium Catalogus. I., pt. 29 Ammon. Neocretac, 1925, p. 104.

§ Loc. cit. p. 177, also "Sur L'Ammonites peramplus et quelques autres fossiles Turoniens." Bul. Soc. Geol. France (3), vol XXVII., 1899, p. 328.

¶ Spath: "Senonian Ammonoidea from Jamaica." Geol. Mag., Jan., 1925, pp. 29-30; also Geol. Mag., Feb., 1926.

Contributions to the Mineralogy of Western Australia

by **Edward S. Simpson,** D.Sc., B.E., A.A.C.I.

Series 1.

(*Read* April 13, 1926. *Published* May 6, 1926.)

Contents:

(1). *Lithiophilite, Wodgina, N.W. Div.*

This very rare phosphate of lithium and manganese has previously been recorded from only three districts in the world, all in the United States, viz., in Maine, North Carolina and California.

A single detrital boulder of this mineral, over a kilogram in weight, has been received in Perth from a locality said to be about 20 miles south west of Wodgina (Lat. 21-22° S., Long. 118-119° E.). On the surface of the specimen there is a thick (1 to 2 cm.) crust of mixed limonite and psilomelane evidently pseudomorphous after the lithiophilite. Beneath is the unweathered mineral composed of two crystal individuals traceable by the well defined, but far from perfect, basal cleavage. Indications of the prismatic cleavages b (010) and m (110) are also to be seen. The mineral is translucent in slices 1 mm. thick, possesses a resinous lustre, and a color in mass which is slightly variable, ranging from almost colorless to about Ridgways 19'k (buffy citrine) and 21'i (olive lake). The powder is nearly pure white, and under the microscope is transparent and colorless, with the lowest refractive index slightly above 1.660, and with moderate birefringence. Its density is 3.39 and hardness 5.

In a closed tube the mineral decrepitates slightly, gives off water and darkens in color. Before the blowpipe it fuses rather readily to a black slag.

The powder moistened with strong sulphuric acid does not etch glass, but gives a strong lithium flame. Ground fine the mineral dissolves rather slowly in cold dilute (5E) HNO_3, HCl or H_2SO_4, but rapidly in all three when warmed. An analysis of carefully selected material showed the presence of 0.06 per cent. moisture and 0.72 insoluble matter of which 0.58 was silica. Deducting these impurities the results obtained were:

P_2O_5.	MnO.	FeO.	CaO.	MgO.	Li_2O.	Na_2O.	K_2O.	H_2O+	Total.
45.99	30.80	10.44	2.78	0.94	7.87	0.34	nil	1.11	100.27

A duplicate determination of the Li_2O by another analyst gave 7.88 per cent. The corrected density of the analysed material was 3.39. The analytical figures yield ratios: P_2O_5:(Mn,Fe)O:$(Li,H)_2O$ of 0.990:1.995:1.012, theory requiring 1:2:1.

Other than the products of its own decomposition the only foreign mineral visible in the specimen was quartz in small amount. It would appear as if the boulder were shed from a pegmatite vein.

The only other phosphate known in the district is apatite, which occurs in large masses up to several kilos in weight.

(2). *Leucite, Fitzroy Valley, Kim. Div.*

A number of small plugs of a volcanic agglomerate rich in leucite have been discovered by Messrs. T. Blatchford and H. W. B. Talbot in the middle Fitzroy valley where they rise through upper Carboniferous sandstones and shale in the form of small hills along a line running north 65° west. The easternmost dome is at Survey station C.48 on Christmas Crk. (Lat. 18°41′ S., Long. 125°37′ E.), the westernmost at "B.E." Hill (Lat. 17°57′ S., Long. 124°19′ E.), 13 miles N.W. of Mt. Wynne, the distance between the two being 100 miles. Mr. J. E. Wells has also discovered an isolated neck of the same rock at Mt. North (Lat. 17°29′ S., Long. 124°49′ E.), 45 miles N.E. of B.E. hill. The rocks have been very briefly referred to by R. A. Farquharson in the Annual Reports of the Geological Survey for 1919* and 1921†, but no published description is available.

The rocks are dark green to pale grey in color, and characteristically dotted with small flakes of red brown biotite. An agglomeratic structure is often distinctly visible.

An analysis was made of a specimen from Barjar Hill near Noonkanbah homestead with the following results:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
52.45	8.64	5.48	.94	.13	6.42	2.01	.38	10.42

H_2O-	H_2O+	TiO_2	CO_2	P_2O_5	FeS_2	SO_3	BaO	Total	D
1.99	2.89	5.85	nil	1.58	nil	nil	1.19	100.37	2.60

Analyst, D. G. Murray.

The high percentages of titanium and barium are remarkable. Washington, however, records a leucitite from Bearpaw Peak, Montana, with 0.50 per cent of BaO. A thin section of this rock reveals the fact that idiomorphic leucite is the most abundant constituent. The rounded or octagonal crystals vary from 0.03 to 0.50 mm. in diameter, and the larger ones show numerous dusty inclusions arranged either concentrically or radially. Between crossed nicols the larger crystals are flecked with small areas which are faintly birefringent.

The associated minerals are finely divided chlorite, innumerable small needles of rutile, small prisms of apatite and irregularly scattered flakes of biotite larger than the largest leucite.

In the rock from "B.E." Hill, the leucite is not so plentiful, and is in larger grains up to 1mm. in diameter, and the inclusions are not so regularly arranged. There is more biotite present, and a considerable proportion of a titaniferous augite, with yellow to violet pleochroism. In this rock, too, the larger augite and biotite individuals usually enclose several crystals of leucite.

This is the only district in West Australia from which leucite has been recorded.

(3). *Ferrimolybdite, Mulgine, S.W. Div.*

Ferrimolybdite is preferable to molybdite as a name for the natural hydrated molybdate of iron, as most text-books give entirely misleading descriptions of "molybdite" based not on the

* A.R.G.S.W.A., 1919, p. 42. According to J. E. Wells the locality given as Mt. Eliza should be Mt. North. This rock contains K_2O, 7.50 per cent.; Na_2O, 0.68 per cent.
† A.R.G.S.W.A., 1921, p. 56.

natural mineral, but upon artificial molybdic oxide, with which it was for long quite erroneously assumed to be identical.

As first noted by A. Gibb Maitland and the author in 1917*, excellent specimens of this mineral in a great state of purity have been found from time to time in the upper workings on the molybdenite deposits of Mt. Mulgine (Lat 29°S., Long. 117°E.). The mineral occurs in joints or small cavities in granite greisen or pegmatite, in some cases being plainly pseudomorphous after molybdenite. The masses are all distinctly fibrous, even when still preserving the broad foliation of the original molybdenite. They are very friable, and therefore difficult to collect and handle, passing soon into a michoscopically fibrous powder, the individual fibres having a diameter of 2 to 8 microns with lengths up to 1 mm.

As some doubt has existed regarding the composition of the mineral, more particularly in regard to its water content, an analysis was made of carefully selected material taken from the largest single mass obtained, which weighed nearly 2 grammes. A very small quantity of associated quartz was removed with methylene iodide, and after thorough washing in the cold with xylol, alcohol and ether in succession, it was kept under loose cover sufficiently long to be sure of its having reached equilibrium under prevailing cool dry atmospheric conditions. Analyses were made of two separate lots at intervals of some days, the results being as follow:—

Ferrimolybdite, Mulgine.

Lot	A		B		Theory
	per cent.	mols.	per cent.	mols.	(Simpson) per cent.
Ferric oxide, Fe_2O_3	17.87	112	18.29	115	17.44
Molybdic oxide, MoO_3	62.90	437	(62.46)	434	62.90
Water over $CaCl_2$	10.20	566	19.25 (water over $CaCl_2$ and at 250°, combined)	1069	9.83
Water at 250° ..	9.95	552			9.83
	100.92		100.00		100.00

The appreciable difference in water percentage between the two analyses of the one well-mixed mass of material, as well as the variable and often quite low proportions of water noted by Schaller and others† were explained by experiments made to determine the temperature and rate at which the mineral loses

* A.R.G.S.W.A., 1916, p. 10, 25. †U.S.G.S. Bull. 490, pp. 84-92.

its water. This constituent was found to be very readily lost as the following figures show:—

Dehydration of Mulgine Ferrimolybdite.

	Total time. hours.	Water loss per cent. Individual	Total	Colours.
Stage I.				
In balance	2	1.87	1.87	Picric yellow
case with	3	.50	2.37	
$CaCl_2$	6	1.33	3.70	
	12	2.12	5.82	
	100	2.93	8.75	
	365	1.37	10.12	
	440	.08	10.20	Deeper yellow
Stage II.				
Steam oven	2	.52	10.72	
at 100°	8	.38	11.10	
	11	nil	11.10	Dark yellow
Stage III.				
Air oven	1	1.50	12.60	
at 125°	2	.65	13.25	
	4	.72	13.97	
	12	3.48	16.45	
	14	.05	16.50	Yellowish green
Stage IV.				
Air oven	1	3.15	19.65	
at 200°	3½	.22	19.87	
	5	.05	19.92	Olive green
Stage V.				
Air oven	1	.23	20.15	
at 250°	3	nil	20.15	Olive green

Very many intermediate weighings were made which are not shown in the table. Almost identical figures to those shown under Stage I. were obtained when the mineral was desiccated over sulphuric acid.

It is evident that ferrimolybdite is very susceptible to desiccation, a fact which explains the lower water percentage in B, after keeping a few days in the warmer atmosphere of the laboratory. It also explains the lower and variable ratios for H_2O to MoO_3 given for the artificial compounds and for the minerals from American localities given by Schaller. The colour changes during drying were most marked, and have previously been noted by Schaller in the mineral from American localities.

The ratio of Fe_2O_3 to MoO_3 for the unusually clean Mulgine mineral is (A) 1:3.90. This is close to the ratio 1:4 given for the artificial compound. Schaller's ratios are nearer 1:3, but his material may have contained limonite, which is a frequent associate.

The formula for ferrimolybdite drawn from these figures is $Fe_2O_3.4MoO_3.5H_2O+5H_2O$. This differs somewhat from previous suggestions ($Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$, Schaller).

The Mulgine mineral is insoluble in water, but is readily dissolved by warm hydrochloric acid, and slowly decomposed by warm ammonia water, MoO_3 going into solution and the iron being converted into ferric hydroxide. Remembering that ferrimolybdite is an acid salt, these facts point to the genesis of the mineral in weakly acid ferruginous waters resulting from the simultaneous weathering of pyrite and molybdenite. Secondary powellite on the other hand results from the weathering of molybdenite in the presence of alkaline calcareous waters.

The physical properties of the Mulgine mineral are as follow:—Density, 2.99. This agrees with Schaller's figure for the mineral from Hortense, Colorado. Hardness, small but indeterminable owing to the extreme fineness of the fibres and their almost complete lack of cohesion. The colour in mass is identical with Ridgways 23 d, picric yellow. Under the microscope the fibres are perfectly transparent and of a pale yellow colour at right angles to the elongation. Parallel to it the absorption is very marked, the thicker fibres being dark yellowish green and almost opaque, the thinner ones a lighter green.

After partial dehydration to a light green colour caused inadvertently by mounting in hot balsam, the absorption parallel to the fibres is complete in thicker fibres, which appear quite black, changing to yellowish green across the fibres. The marked pleochroism is referred to by Lacroix in describing the mineral from Corsica, and by Schaller in describing the United States specimens. The extinction is in all cases parallel, and the birefringence high, with Z parallel to the elongation.

(4) *Kyanite, Chittering Valley, S.W. Div.*

Kyanite has been found in several places in the gneissic granite ranges north of the junction of the Chittering Brook and the Swan River. The three occurrences here described all lie between Lat. 31° and 32° S, and a little east of Long. 116° E.

Lower Chittering.—The first known occurrence is on the south side of a small valley tributary to the Chittering Valley east of

Loc. 818. Close to the main valley the rock is massive granite, which becomes more gneissic as one goes east until at the kyanite locality (about 1¼ miles east of Loc. 818) the rock is highly foliated and micaceous. Occasional dykes of epidiorite and veins of quartz are seen running north, parallel to the foliation of the rock. Where the kyanite is found the outcrops are considerably obscured by soil, but the observations made show that all the mineral occurs in a large quartz vein probably forming a contact between gneiss and somewhat platy epidiorite. It is apparently confined to quite a small section of the vein, as specimens could only be found over an area of a few square yards. Within this area, however, magnificent specimens can be obtained of white quartz thickly studded with large tabular crystals of kyanite. At the surface this is grey blue in colour and often rather heavily iron-stained. Where protected, however, it is translucent with a colour ranging from orient blue through Alice blue to sky grey (Ridgway, 45″ to 45″ f), rarely sky blue (47′d) or Yale blue (47′b). The tint quite frequently varies in different parts of the one crystal. The crystals vary in size from 5 x 2 x 1 mm. to 70 x 20 x 5 mm., the larger sizes being more plentiful. A single crystal collected in the vicinity by A. King (a local resident) reaches 80 x 30 x 15 mm. Often the crystals are curved or bent. They occur singly in the quartz or in large confused groups of many individuals. Fine scaly muscovite or biotite in very small amount is the only mineral associated with them in the quartz. The forms commonly seen are (100), (010) and (001); (011) appears in traces on one or two crystals. The typical cleavages and basal parting are everywhere conspicuous. No twinning can be recognised in hand specimens.

South Bindoon.—E. de C. Clarke was the first to find kyanite in 1925 on a northerly spur of Red Hill, about ¾ mile east of the school reserve and near the south-east corner of Loc. 1363. The mineral is abundant over several acres of outcrop of what appears to be a granite gneiss. The main rock is traversed by an epidiorite dyke and by many thin lenticular quartz veins which are parallel to the foliation. That severe metamorphism has gone on in the locality is indicated not only by the development of secondary kyanite, muscovite and biotite, but by intense local folding over small areas. Two detrital boulders of vein quartz were picked up showing embedded kyanite in white and iron-stained crystals up to 45 x 20 x 5 mm., the specimens being reminiscent of the Lower Chittering occurrence. None was found, however, in situ in any of the many small quartz veins, but in many places smaller kyanite crystals are plentiful in this biotitie layers of the rock in contact with the veins. The typical occurrence, however, is in long narrow lenses of the gneiss parallel to the foliation. These frequently occurring lenses are often many metres in length, but seldom exceed 30 cm. in thickness. They are usually characterised by abundant dark mica and numberless long-bladed crystals of kyanite lying at various angles closely parallel to the foliation, and showing out prominently on weathered surfaces. The proportion of kyanite in a specimen from a typical lens was found by crushing and floating in methylene iodide to be 15 per cent. In colour the mineral is white, pale grey or somewhat iron-stained. The smallest visible crystals measure about 5 x 1 x ½ mm., the largest 70 x 5 x 3 mm., a very common size is 20 x 2 x 1 mm. Under the microscope in fine grains they are seen to be colourless, with the typical cleavages, extinction angle, and refractive indices.

Wattle Flat (Cullalla).—Eight miles north of the South Bindoon occurrence, and almost on the same line of strike, the writer recently found a kyanite-bearing schist in a hill on the west side of Wattle Flat, almost at the extreme head of the Chittering Brook, here called the Brockman River. This place is near the N.W. corner of Loc. 805, three miles N.E. of Cullalla railway station.

The rock is a coarse-grained biotite schist interbedded with other more or less highly altered rocks of a gneissic character, and striking approximately north. The kyanite was found in two forms. First as distinct white or pale grey crystals, varying in size from 10 x 4 x 3 mm. to 60 x 15 x 10 mm., and having surfaces indented by crystals of biotite. Some of these crystals are solid kyanite and have the full density of 3.60, others have a lower density down to 3.35, apparently due to inclusion of quartz and mica. Some crystals show evidence of repeated twinning on (001). Quartz veins are small and rare, and in only one case was kyanite found associated with one. In this case large dense crystals were attached to the outside of the vein and included in a biotite parting in the vein.

The second mode of occurrence is really a modification of the first. A number of granular white lenticular "eyes," which were conspicuous in the schist, were found on examination to consist of a mixture of quartz and kyanite, the former preponderating. A typical one weighing five grammes was crushed and separated with methylene iodide. The returns were 60 per cent of quartz with typical optical properties and a density under 2.67*, and 38 per cent of kyanite with density over 3.32 and of characteristic appearance under the microscope. The small remainder was biotite. A close examination of these "eyes" usually discloses a Fontainebleau structure, the predominant granular quartz being

* The whole fraction under 2.67 contained over 96 per cent. of silica. The fraction over 3.32 contained 43 per cent. of silica and 56 per cent. of alumina, indicating the presence of 89 per cent. of kyanite, with 10 per cent. of included quartz.

enveloped by a single crystal individual of kyanite, whose continuity over the whole "eye" can be traced by reflection from a cleavage face.

(5) *Staurolite, Cullalla.*

In 1920, in describing staurolite from Mogumber, the writer referred to specimens of the mineral having reached Perth from an indefinite locality about 13 miles N.E. of Gingin.* Wattle Flat, referred to above is 12 miles N.E. of Gingin, and at this point Mr. de Courcy Clarke and the writer discovered a loose boulder of staurolite schist early in 1926. A further search by Mr. Bowley and myself resulted in the discovery of the outcrop of this rock within a few yards of the kyanite schist described above.

The staurolite schist occurs on the crest of a ridge on the west side of Wattle Flat close to the north end of Loc, 805. It forms an approximately vertical band several feet wide in a series of gneisses and schists, including gneissic microcline-hornblende granite, quartz-kyanite-biotite schist, quartz-garnet-biotite gneiss and gneissic epidiorite. The staurolite rock appears at first sight to be a highly ferromagnesian rock, the comparatively large flakes of black biotite enveloping and concealing all the other constituents except the large "eyes" of staurolite. A section of the rock, however, reveals its constituents in approximate order of abundance to be (1) quartz, (2) staurolite, (3) biotite, (4) hornblende, (5) muscovite, (6) chlorite, (7) felspar, (8) iron ore, (9) zircon. There is no indication of the quartz ever having been water worn.

A partial analysis shows that the fresh rock as a whole carries 73 per cent. of silica, and 13 per cent. of alumina. These are the proportions present in typical Darling Range granite, e.g., at Mahogany Creek (SiO_2, 73; Al_2O_3, 14), and Bannister (SiO_2, 72; Al_2O_3, 12.5). The iron in the staurolite schist appears, however, to be higher and the lime lower than in these granites. The only other staurolite schists whose analyses are on record differ greatly from this in their low silica percentages, 40.8 in one from Mogumber analysed by the author, and 41.5 in one from Switzerland quoted by Grubenmann.†

The staurolite occurs as abundant "eyes" in the schist, which are very prominent on exposed surfaces, and round which the scales of biotite and muscovite sweep in graceful curves. Each "eye," measuring from 5 to 30 mm., is usually composed of a single crystal individual which, however, is very rarely solid

*Jour. Roy. Soc. W.A., Vol. VII., p. 71.
†Since this paper was read Prof. E. W. Skeats has drawn my attention to the analysis of a staurolite schist from Kanton Tessin, Switzerland, showing SiO_2, 66.97; Al_2O_3, 14.22.

staurolite. Commonly it is an intergrowth in almost any proportions of staurolite and granular quartz, the former mineral impressing a Fontainebleau structure on the eye. As much as 70 or 80 per cent. of quartz may be thus enveloped, though usually not more than 30 or 40. The colour of the eye varies with the proportion of quartz, usually it ranges from chesnut brown to tawny (Ridgway 11′m to 13′i). A typical light brown "eye" which was sectioned was found to consist of about 46 or 47 per cent. staurolite, and the same of quartz, whilst the balance was made up of granular iron ore, muscovite, biotite, and chlorite, with pleochroic haloes in the last, surrounding some small and some relatively large zircon crystals. In only one instance were crystal faces indistinctly seen, though the strong cleavage parallel to (010) is readily observed in most cases.

Genesis of the Chittering Kyanite and Staurolite.

Too little is known of the petrology and structural geology of the Chittering Valley to be sure of the origin of the staurolite and kyanite observed there. It is to be noted in this connection that the staurolite rock at Wattle Flat occurs in at least one, possibly three, narrow bands, interbedded with garnetiferous gneiss and more normal gneiss, as well as with a siliceous kyanite schist. A microline granite only slightly gneissic is found within at most a few miles on two sides of the Wattle Flat occurrence, and within at most a mile of the South Bindoon and Lower Chittering kyanite localities. Innumerable other rock outcrops are to be seen in every direction in this hilly country, but as yet have not been examined.

It would appear as if the whole of this area were occupied by a fluxion gneiss traversed by occasional epidiorite dykes, and that either certain portions were originally more highly foliated and showed greater differentiation on a small scale, due to a local relative poverty in alkalis and lime, or that shearing stresses have spent themselves on certain zones, without affecting the whole mass, and along these zones there has been a circulation of heated waters charged with active chemical agents. The latter theory would explain the presence of numerous lenticular quartz veins at all three localities, as well as the development of kyanite crystals in the heart of a quartz vein at Lower Chittering. The production of secondary mica from felspar involves the solution and removal of two-thirds of the potash and silica in the original mineral. Were this common process intensified and part of the remaining alkali removed, kyanite or one of its congeners would be likely to result, and might be crystallised in part in situ, in part in cavities with the dissolved silica, resulting in a kyanite-bearing quartz vein.

Contributions to the Flora of Western Australia—No. 5, by C. A. Gardner.

(*Read* March 9, 1926. *Published* May 29, 1926.)

Eucalyptus Dielsii Gardner sp. nov.

Arbor pusilla, sive "Mallee," quindecim vel octodecim peduum altitudinus, e cortice plano-tenui, viridi-fusco et trunco quinque vel septem unciarum diametri. Ligno tenaci, recte granulato, duro, pallide, fusco, denso.

Juvenibus foliis potius pallido-viridibus, parce petiolatis, tenuiter inaequalibus, pellucidis ex punctis oleosis, inconspicuis lateralibus venis angulum facientibus circiter 75 graduum cum costa centrali.

Maturiis foliis denso-rigidis, anguste lanceolatis, tenuiter falcatis, vel fere rectis, petiolatis, idem color utrinque habentibus costa centrali prominenti venis lateralibus circiter parallelis angulum efformantibus circiter 40 graduum cum costa media, vena intramarginali remota a margine.

Pedunculis generaliter axillaribus, modice planis et curvatis, sub umbella expansis, quae consistit ex tribus vel quinque floribus. Pedicellis tenuibus, sursum incrassatis. Operculo conico, dilatato super lineam commissuralem: tubo calyceo modice campanulato, disco efformante calycis prolongationem atque in gemmatione constituenti annulo staminali. Antheris oblongis longitudinaliter aperientibus, albicantibus, filamentis in gemma inflectis. Stylo crasso breviori staminibus, cum capitato stigmate.

Fructo urceolato-globulari, abrupte imminuenti versus pedicellam; margine distincte definita, protrusa et reflexa ita ut suspendentum limbum formet, summitate formam cupulae habente, valvulis deltoidis magis minusve planis cum capsula.

Foliis 7-12 cm. longitudinis, 10-17 mm. amplitudinis. Pedunculis circ. 2.5 cm. long: pedicellis modice supra 1 cm. long. Operculo 1 cm. long, 8 mm. amplitudinis supra basim. Calyci 6 mm. long. Fructo 1.3 cm. long, idemque in diametro.

Habitat prope SALMON GUMS, versus meridiem DUNDAS in argillosis constituentibus parvis silvis gignentibus *E. diptera*. Floresrit mense Januario-Aprile.

Typus est No. 1051a, *C. A. Gardner*, et collectus fuit per W. T. Brown, die 13a Januarii, 1925.

Nuncupatus in honorem L. Diels, illustris moderator Hortus Botanici apud Berlin, qui extense peragravit Australiam occidentalem in principio hujus saeculi, quique tantum contulit historiae botanicae hujus regionis.

Haec species affinis est cum *E. erythronema*, a qua discrepat in speciali sculptura fructus, et breviori operculo.

Range.—The species appears to be confined to the forest flats between Salmon Gums and Dundas, occurring with *E. diptera* and *E. Flocktoniae*, forming low forests in the red clay soil.

Affinities:—

1. With *E. erythronema*.

This species is close to *E. erythronema*, but differs in being red-green barked, and is a tree. The fruit is urceolate not turbinate, and the summit is conspicuously domed. It is even closer to the var. *marginata*—a Wongan Hills plant. The staminal ring of both species lines the operculum, and can be distinguished externally as a ring like swelling, also has the appearance of overlapping the calyx. This is more conspicuous in *E. Dielsii* than in *E. erythronema*.

2. With *E. urnigera*.

There is a certain similarity in the fruits, but the Tasmanian plant has not the conical operculum or domed fruit of the new species.

3. With *E. eremophila*.

On account of its inflected stamens *E. Dielsii* cannot be placed within the *Cornutae*, but there are, however, several points of similarity between the two species. Maiden (crit. Rev. Gen. Euc.) has already pointed out a possible connection between *E. erythronema* and the *Cornutae*.

I am indebted to Mr. W. T. Brown, of Salmon Gums, for his untiring efforts to secure adequate material of this plant, which he first brought under my notice in 1924, and for his assistance in helping to elucidate several interesting points connected with the Eucalypts of this interesting district.

Gastrolobium densifolium Gardner sp. nov.

Frutex dense foliatus, parvus, diffusus, e trunco lignoso ostendente ex antiquis foliis, bases persistentes. Foliis oppositis, plus minusve congestis, diffusis, lineari-lanceolatis, basi angustis, acute pungentibus, punctis leniter recurvis, rigidis, crasso-marginatis, media costa deorsum prominenti. Petiolis pallidis, brevibus, planis. Stipulis lanceolatis, setaceis.

Racemis terminalibus, brevioribus, densis, rachi pubescentibus. Bracteis ovatis, concavis, fuscis, rigidis, punctis erectis breviter terminalibus praemature cadentibus, basi pubescentibus, marginibus ciliatis. Calycis segmentis aequalibus, duo superiorbus ad medium junctis. Petalis circiter aequali longitudinis, vexillo eis modice longiori. Ovario e brevi stipite, sericeo-villoso. Stylo incurvato, glabro dimidia superiori parte tantum. Fructo non viso.

Affinis cum **G. floribundo**, **G. microcarpo**, et **G. oxylobiocide**, ab eis discrepans in habito, brevioribus, rigidis, diffusis, acutis pungentibus foliis, aequalibus calycis segmentis, comparative longioribus stipulis, stylo et bracteis duobus ultimis speciebus similibus.

A bushy shrub of about 12 inches in height, with erect or spreading leafy branchlets, the older parts of the branches marked by the persistent petioles. Leaves opposite, somewhat crowded and imbricate, spreading, linear-lanceolate, narrowed towards the base, acute with a slightly recurved pungent point, thickly coriaceous and rigid, not at all glaucous and quite glabrous, the margins somewhat thickened, the midrib very prominent underneath, the veins reticulate. Petiole short and somewhat flattened. Stipules lanceolate, with thin setaceous points, gradually narrowed upwards.

Racemes all terminal, short and dense, the rhachis pubescent. Bracts deciduous, ovate, brown, rigid and concave, the points breaking away before the bracts fall, the lower parts pubescent, the margins ciliate. Calyx shortly pedicellate, campanulate, white silky-villous, the lobes about as long as the tube, ovate-lanceolate, acute, all equal, but the two uppermost connate to about the middle. Standard nearly twice as long as the calyx, orbicular, yellow with purple striations; the wings and keel about as long, the latter purple. Ovary shortly stipitate, silky-villous; style incurved or hooked, glabrous in the upper half only. Fruit not seen.

Shrub 30 cm. high, spreading to at least the same in diameter. Leaves 1-1.5 cm. long, 3 mm. wide, the petiole about 1 mm. Stipules about 6mm. long. Racemes 2 cm. long and almost as wide. Calyx about 5 mm. long, the lobes 2.5 mm. long and 1.5 mm. wide. Standard about 9 mm. diameter, on a long claw; keel 7.5 mm. long.

In the DUDININ district, flowering in October, 1925 (Gottsch Bros.) Gravelly rises in the KUKERIN district, in thickets of *Eucalyptus redunca* var. *elata*, fl.m. Sept.-October (W. E. Blackall and C. A. Gardner, No. 1910). The Type.

The new species belongs to the section *Racemosae* of Bentham, with affinity to *G. floribundum*, *G. microcarpum* and *G. oxylobioides*. It is closest to *G. floribundum*, from which it differs in the much smaller acute thick leaves, much shorter petioles, somewhat longer (comparatively much longer) stipules, which are perhaps also broader, and equal and larger calyx-lobes, and in the racemes. The style is also hairy in the lower half. From *G. microcarpum* and *G. oxylobioides* it differs in habit, much thicker, smaller and more crowded leaves, which are also not glaucous, denser and shorter racemes, and other particulars.

The delineation of the species of *Gastrolobium* is so artificial, being based in some species on measurements and indumentum, that it becomes a difficult matter to define exactly the limits of these species. Such differences, for example, between *G. microcarpum* and *G. oxylobioides*, are very much less than those which separate the varieties of *G. spinosum*. The proposed new species is very different in habit from any of the Gastrolobiums known to me, and the rigid crowded leaves are suggestive more of a *Pultenaea* than a *Gastrolobium*.

Gastrolobium densifolium is a poison plant. An investigation into its toxicity was undertaken by H. W. Bennetts, Veterinary Pathologist of the Department of Agriculture, Perth. The material used was in a dried condition, and was fed to guinea-pigs. The experiment on the first animal was discontinued on the fourth day. The second guinea-pig, which ate 7 grams of leaves in three days, was dead on the fourth day. The symptoms shown by the first animal were, rough coat, inappetence, shivering and erratic movements. The animal completely recovered on the sixth day. On post mortem examination the second animal showed congestion of the organs, notably liver, kidneys and lungs.

EXPLANATION OF PLATE VII.

Eucalyptus Dielsii Gardner—The type.

A.—½ natural size.

B, C, D, and E.—1½ times natural size.

F.—Front and back view of anther (enlarged).

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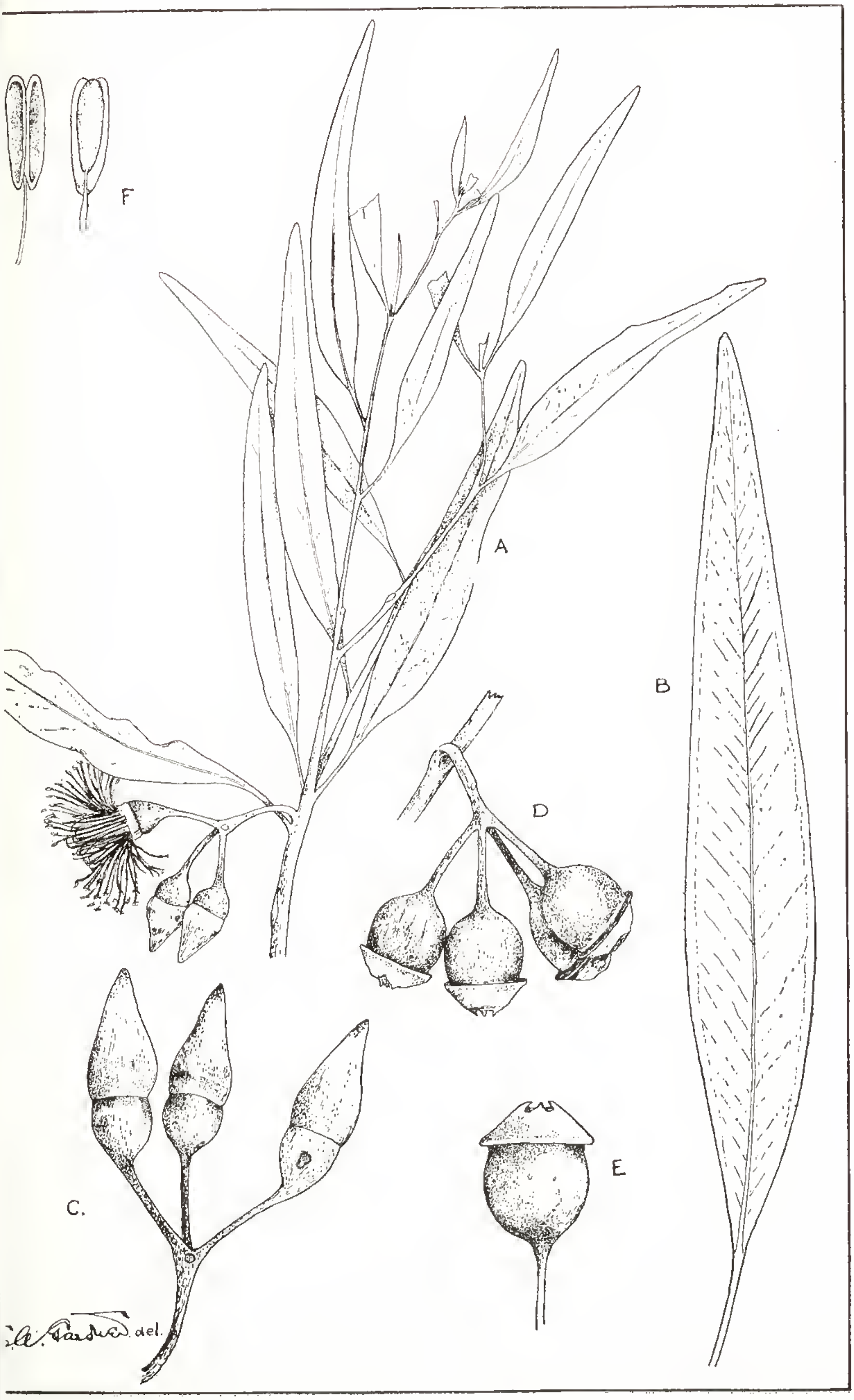
F
A
B
D
C.
E
C.A. Gardner del.

Contributions from the Department of Biology, University of Western Australia—No. 1.

Protocrangonyx fontinalis, a new blind freshwater Amphipod from Western Australia,

by George E. Nicholls, D.Sc., F.L.S., Professor of Biology, University of Western Australia.

(*Read* June 8, 1926. *Published* June 29, 1926.)

In December, 1923, with Miss Milner, I described a new Phreatoicid, *Hyperoedesipus plumosus,* taken by myself during the previous winter, in a spring near Lesmurdie Falls. With this were collected a few small, blind and transparent Amphipods, which form the subject of the present communication. The general appearance of both of these Crustaceans was highly suggestive of a subterranean habitat. Associated with them were a number of translucent white planarians. The spring flows only for a brief period after heavy rainfall, and it is practically certain that these forms are swept to the surface only when the water gushes up strongly from below and are then to be looked for, hiding from the light, beneath decaying vegetable matter accumulated in the little hollow immediately below the inch-wide orifice of the spring. A somewhat similar condition, apparently, was found by Sayce (1902) in the association of *Phreatoicoides gracilis, Janirella pusilla* and *Niphargus pulchellus,* all blind forms occurring in surface waters in Victoria. Sayce supposed, however, that this was an attempt on the part of blind subterranean forms to re-occupy surface waters permanently. It would appear much more probable that, like the association I have described, it is merely an accidental and involuntary temporary reversion to life at the surface. Undoubtedly these surface-living individuals and their offspring must either perish at the onset of the dry weather, or, creeping after the retreating moisture, return to their subterranean haunts. That they do so retreat, or more probably that some escape being swept to the surface, and continue to lead a subterranean life, is evident, for during the next two winters (1924 and 1925) the spring was not found running, and no specimens were to be discovered, although the spot was frequently visited and carefully searched, but in the present winter, the first visit of the season, made on May 26th, after several days of heavy rainfall, yielded more than a hundred specimens of both Amphipod and Isopod, the planarian being less abundant. An extended search, lasting the whole day, revealed the Amphipod, occurring not very abundantly, in another similar spring some hundreds of yards lower down the valley, but *Hyperocdesipus* was not found there.

The Amphipod proved not only to be new, but to exhibit a combination of characters which made it difficult to assign it to any described genus; coming nearest, perhaps, to *Eucrangonyx* (known only from Central Europe and North America), from which it differs principally in the shape of the telson and certain of the mouth parts. From the New Zealand genus *Paracrangonyx* it was excluded by its retention of both the rami of the pleopods. It is clearly marked off from *Crangonyx*, to which it has obvious affinities, by its possession of an inner ramus to the third uropod, which has been lost in *Crangonyx;* some species of this genus, however, have preserved the entire condition of the telson, as have the single species of both *Paracrangonyx* and *Apocrangonyx*. The latter, however, has lost both rami from the third uropod. In its mouth parts, the Lesmurdie specimen approaches more closely to *Paracrangonyx* and to *Neoniphargus* (an Australian genus), from which latter it is readily distinguished by the cleft telson and elongate third uropod of that genus. It has been found necessary, therefore, to constitute a new genus for the reception of this Western Australian form, for which I propose the name *Protocrangonyx*.

PROTOCRANGONYX gen. nov

Body compressed, not carinate. Side-plates shallow, 1—4 scarcely deeper than the following. Eyes absent. Antenna 1 the longer, accessory flagellum small, 2-jointed. Upper lip rounded, lower lip with indistinct inner lobe, mandibular palp with 2nd joint longer than 3rd, maxilla 1 inner plate with a single seta, palp differs on the two sides, maxilla 2 inner plate partly fringed on both inner and outer margins, maxilliped with outer plate reaching to middle of 2nd lobe of palp, and set mesially with stout spines and setae. Gnathopods 1 and 2 equal, subchelate, 6th joint not markedly wider than 5th. Peraeopods 3—5, 2nd joint slightly expanded, accessory branchiae on 3 and 4. Uropods 1—3 projecting backwardly to the same level, rami unequal, uropod 3 small, with short 1-jointed outer ramus, inner ramus reduced to a scale. Telson small, entire.

Protocrangonyx fontinalis sp nov.

Body slender. Side plates shallow, side-plate 4 the deepest. Pleon segments 1—3 broader than the preceding, a couple of setules on each dorsally, usually two or three setae upon ventral margin of each plate; postero-lateral corners quadrate or obtusely quadrate. Eyes wanting. Antenna 1 almost half the length of the animal, flagellum with 12—13 joints, twice as long as peduncle; accessory flagellum 2-jointed, usually as long as first two articuli of flagellum. Antenna 2 two-thirds length of antenna 1, 4th joint of peduncle considerably longer than 5th, flagellum of 7 joints equal to combined length of peduncle joints 3—5. Upper lip rounded, lower lip with inner lobe not distinct. Mandible with cutting edge and accessory plate dentate, 4 or 5 spines in spine row, palp 1st joint longer than broad, 2nd joint longer than 3rd; accessory plate slighter on right mandible. Maxilla 1 inner plate small, rounded apically with a single feebly plumose seta, outer plate with 8 (9) pectinate strongly chitinised setae, 2nd joint of palp with 6 (occasionally 5) stout tooth-like spines on apex. On the opposite side these spines are replaced by a like number of stiff setae, feebly plumose. Maxilla 2 both plates with 12-14 curved setae apically, outer plate fringed with fine setae, externally, inner plate with similar fringe on both inner and outer margins and at summit of inner margin a couple of stiff plumose setae. Maxilliped outer plate broader than inner, armed mesially with several stout spines (? spine teeth) and three longer setae, apically set with a number (6-7) of curved spine teeth extending to middle of 2nd joint of palp, palp moderate, 4th joint with nail.

Gnathopods 1 and 2 similar, 5th joint triangular, cup-shaped, 6th much longer, broad at base, widest at middle; palm oblique, guarded by a few setae and stout spines with notch and cilium near tip; finger strong, curved. Peraeopods 1—3 subequal, shorter and more slender than peraeopods 4 and 5; 2nd joints peraeopods 3—5 oblong oval; accessory branchiae, long oval in shape, on peraeopods 3 and 4.

Uropods 1 and 2 projecting as far backwards as uropod 3; uropod 1 peduncle considerably longer than the rami, of which outer is shorter than inner; uropod 2 peduncle as long as the longer (inner) ramus; uropod 3 short stout peduncle slightly longer than the outer 1-jointed ramus, inner ramus a minute scale without setae or spines.

Telson rounded, entire, shorter than ramus of uropod 3, twice as broad as long, armed posteriorly with one pair of large and one of smaller spines.

Spines on rami of uropods and telson are notched and bear each a curved cilium near the apex.

Length of largest specimen barely exceeding 5 mm.

Colour.—In life, creamy white and semi-transparent.

Habitat.—Taken beneath mud and decayed vegetable matter, around the orifices of small springs in the valley of the Yule Brook, below the Lesmurdie Falls, in the Darling Range. Evidently normally subterranean, but brought to the surface when the water wells up unusually strongly after exceptionally heavy rainfall.

The smooth *body*, Pl. VIII. Fig 1, almost wholly free from conspicuous setae is somewhat narrowly compressed, the impression of slenderness being enhanced by the shallowness of the side plates, and the slightness of the expansion of the second joints of the hinder peraeopods. Thus in females, only partly grown, the developing marsupial plates hang down well below side-plates 2—4, while the oval branchiae, both primary and accessory, are clearly visible pendant between the 2nd joints of the peraeopods.* On each of peraeon segments 5 and 6 two pairs of these gills occur, the more anteriorly placed apparently being the supplementary structure.

The *head* is relatively short, without rostrum and exhibiting no trace of eyes.

In the *peraeon*, the segments are sub-equal, the third, fourth and fifth being very slightly narrower. The dorsal margin of the side-plates is very slightly indicated and difficult to determine. The fourth side-plate shows very little posterior emargination, and the lobing of side-plates 5—7 is little developed. This slight development of the side plates, giving a sub-cylindrical shape to the slender body is doubtless an adaptation to the subterranean life, permitting more ready passage through the narrow crevices in the granitic rock.

In the *pleon*, the first three segments are wider than the preceding and as deep as the combined depth of segment and side-plate. In the mid-dorsal line these three segments each bear on the posterior margin a couple of a small simple setae, the peraeon segments and those of the urus being devoid of such setae.

Appendages.—In the *upper antennae*, the three joints of the peduncle diminish progressively in length and stoutness. The flagellum has twelve or thirteen articuli (sometimes differing on opposite sides). The 2-jointed accessory flagellum usually has a length almost equalling the first two articuli of the main flagellum, but is occasionally found much shorter, the second (terminal) joint in these cases being very small. In one specimen, on one side, there were present three, almost equal, joints.

Of the *lower antenna*, the two proximally situated joints of the peduncle are fused with the head, the sutures remaining quite distinct; the three succeeding joints (3—5) are stout, the third much the shortest, the fourth slightly longer than the fifth. The flagellum, also, is relatively stouter than that of the upper antenna, consists of seven joints which together are very slightly longer than the three free joints of the peduncle.

The mouth parts have already been described in some detail in the specific diagnosis. A few further notes may be added here.

The *upper lip* (Pl. VIII. Fig. 2) is rounded, as in *Neoniphargus spenceri*, but much more setose. The *lower lip* (Pl. VIII. Fig. 3)

*Cf. *Niphargus pulchellus* Sayce (1900, Vol. 12, Pl. 15, Fig. 1).

has the median lobe less well defined and the setae of the ventral border are not very numerous. The outer limit of the setae on the left side is defined by a short stout spine which is, perhaps, present also in *Neoniphargus spenceri* and *Niphargus pulchellus* [Cf. Sayce's figures (1900, Pl. 16, Fig 5, and 1900a, Pl. 40, Fig. 2)], though Sayce makes no mention of it. I find a somewhat similar structure in *N. branchialis.* (1924, Pl. 10, Fig. L.2). Mandibular processes are well developed.

The *left mandible* (Pl. VIII. Fig. 4) is much as in *Niphargus pulchellus* (1900, Pl. 16, Fig 4), but the accessory dentate edge is more widely separated from the principal cutting edge. The *right mandible* (Pl. VIII. Fig. 4a) approximates much more nearly to the condition figured by Sayce for *Neoniphargus spenceri* (1900a, Pl. 40, Fig Mr.).

The *first maxilla* (Pl. VIII. Fig. 5) somewhat resembles that of *Neoniphargus branchialis* (1924, Pl. 10, Fig. M1) and *N. thomsoni* (1893, Pl. 6, Fig. 5). The small rounded inner lobe is crowned by a single slight, scarcely plumose seta set in a general fringe of delicate setae. The outer plates are relatively larger and are armed apically with 8 (or 9) strongly chitinised pectinate setae with an innermost simple seta. The palp, which differs on opposite sides, is broader relatively (as compared with *N. branchialis.*) On the one side it bears terminally 6 short conical spines, while on the other (Pl. VIII. Fig. 5a) these are replaced by five stiff setae sparsely plumose.

FIG. 1.—*Protocrangonyx fontinalis* sp. nov. Second Maxilla.

The *second maxilla* (Fig. 1) has the outer plate the broader; it is fringed externally with delicate setae and crowned with a dozen stiffly curved setae. The inner plate has the fringe of setae on both inner and outer margins and an apical set of fourteen curved setae and two inner plumose setae, an arrangement closely paralleled in *Neoniphargus spenceri* (1900a, Pl. 40, Fig. M2).

The maxilliped (Pl. VIII. Fig. 6) has somewhat narrow inner plate with 3 apical spine-teeth; the broader outer plate has six apical curved setae (spine-teeth), somewhat more slender setae forming a fringe along the inner margin of this plate; proximally there are three long straight setae.

The two *gnathopods* (Pl. VIII. Fig. 7) are alike, not very strong and apparently similar in both sexes. In these (and in the *peraeopods* 1 and 2) the second joint is of narrow oblong shape, its posterior margin bearing a number of elongate flexible setae. The palm is quite oblique, has a sharp dentate edge and is guarded by spines and setae (Pl. VIII. Fig. 7a). The legs generally are slender* a slight widening of the second joint of *peraeopods* 3—5 producing a narrowly oval structure. The shallowness of the side plates 5—7 exposes a narrow distal portion of the first joint.

The *pleopods* are biramous, of moderate length, with unequal rami, the third pair distinctly shorter than the preceding.

The *uropods* (Pl. VIII. Fig. 1) consists of a stout peduncle with a pair of slender and unequal rami, armed with spines. In the first and second uropods it is the inner ramus which is the longer. In uropod 1 the peduncle is half as long again as the longer ramus and twice as long as the outer ramus. The second and third uropods have the peduncle subequal in length to the longer rami. The third uropod (Pl. VIII. Fig. 9) has the inner ramus represented by a small scale which bears neither spine nor setae and reaches a length barely a third of the peduncle. The *spines* on telson (Pl. VIII. Fig. 10) and uropod, as already noted, are peculiar, being stout, notched near the apex to receive a slender curved cilium. This form of spine is (fide Stebbing, 1906, pp. 372-373) apparently of constant occurrence in species of the genus *Crangonyx*. Of the setae found, in *Protocrangonyx fontinalis*, upon the peraeopods some are of this character as are the few setae occurring upon the basal joints of the pleopods (the long setae upon the rami of the pleopods are plumose), but most of the setae upon the legs as well as those near the ventral margins of the side-plates and pleon segments appear to be simple setae.

Remarks.—As noted above, the affinities of this species seem to be in nearly equal degree with the forms grouped under

*As an abnormal development, one specimen showed the 1st peraeopods as stout and as long as the 4th or 5th.

Crangonyx, *Paracrangonyx*, *Eucrangonyx*, and *Neoniphargus*.* In the genus *Crangonyx* are placed a number of species (mostly from wells and springs in North America), in which the telson may be either entire or cleft in varying degree. In all of these, however, the inner ramus of the third uropod has disappeared. In *Eucrangonyx* (habitat and distribution agreeing with that of *Crangonyx*) with one of the species of which (*E. vejdovskyi*) the Western Australian form shows many points of agreement, the genus is defined as possessed of an emarginate telson. Had the telson in this genus been variable, as it is in *Crangonyx*, I should have been inclined to refer the new species to it. To the New Zealand form, *Paracrangonyx compactus* (Chilton), also, *P. fontinalis*, comes very near inasmuch as although both rami of the pleopods are retained in the latter, there is a marked difference in the degree of development of the two rami, one apparently undergoing retrogression. In both the telson is entire. The mouth parts, too, are more nearly alike, the inner plate of maxilla 1 being small and with but few setae (2 and 1 respectively), whereas in *Crangonyx* and *Eucrangonyx* the inner plate has numerous (4—6) setae. In the condition of the mouth parts, *P. fontinalis* approaches, also, to *Neoniphargus*, but in this genus the telson is cleft and the third uropod elongated.

In the character of the setae it is interesting to note that the notched seta with the cilium is found not only in *Crangonyx* and *Protocrangonyx*, but also in *Neoniphargus*. In this genus I find it in a blind Victorian species (*N. obrieni*, 1926), and also in another blind form, *N. westralis* Chilton (1925). What may readily be a transitional condition in the evolution of this type of seta is figured by Sayce in his account of *Niphargus pulchellus* (1900, Pl. 16, Fig. 12), where a stout plumose seta, occurring near the base of a pleopod ramus, is shown with one branch closely comparable in position and size to the *Crangonyx* cilium. Upon the dactyl of the peraeopods (Pl. VIII. Fig. 8) there is in *P. fontinalis* a single stiff seta in the position occupied in *Neoniphargus* by the characteristic, well-developed plumose seta.

*All of these genera are, however, represented almost entirely by forms which have taken to a subterranean mode of life, and while the resemblances may well be explained by a common ancestry, it is possible that many of their common features may be due to convergence resulting from adaptation to a similar manner of life.

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EXPLANATION OF PLATE VIII.

Protocrangonyx fontinalis mihi.

1. Entire animal.
2. Upper lip.
3. Lower lip.
4. Left mandible; in the spine row the spines are seen bent back.

4a. Right mandible, cutting edges.

5. First maxilla, with enlarged setas.

5a. Palp of first maxilla, of opposite side.

6. Maxilliped.

7. Gnathopod.

7a. Palm of gnathopod, still further enlarged.

8. Dactyl of Peracopod 1.

9. Third uropod, seen from above, with enlarged spine (sp).

10. Telson.

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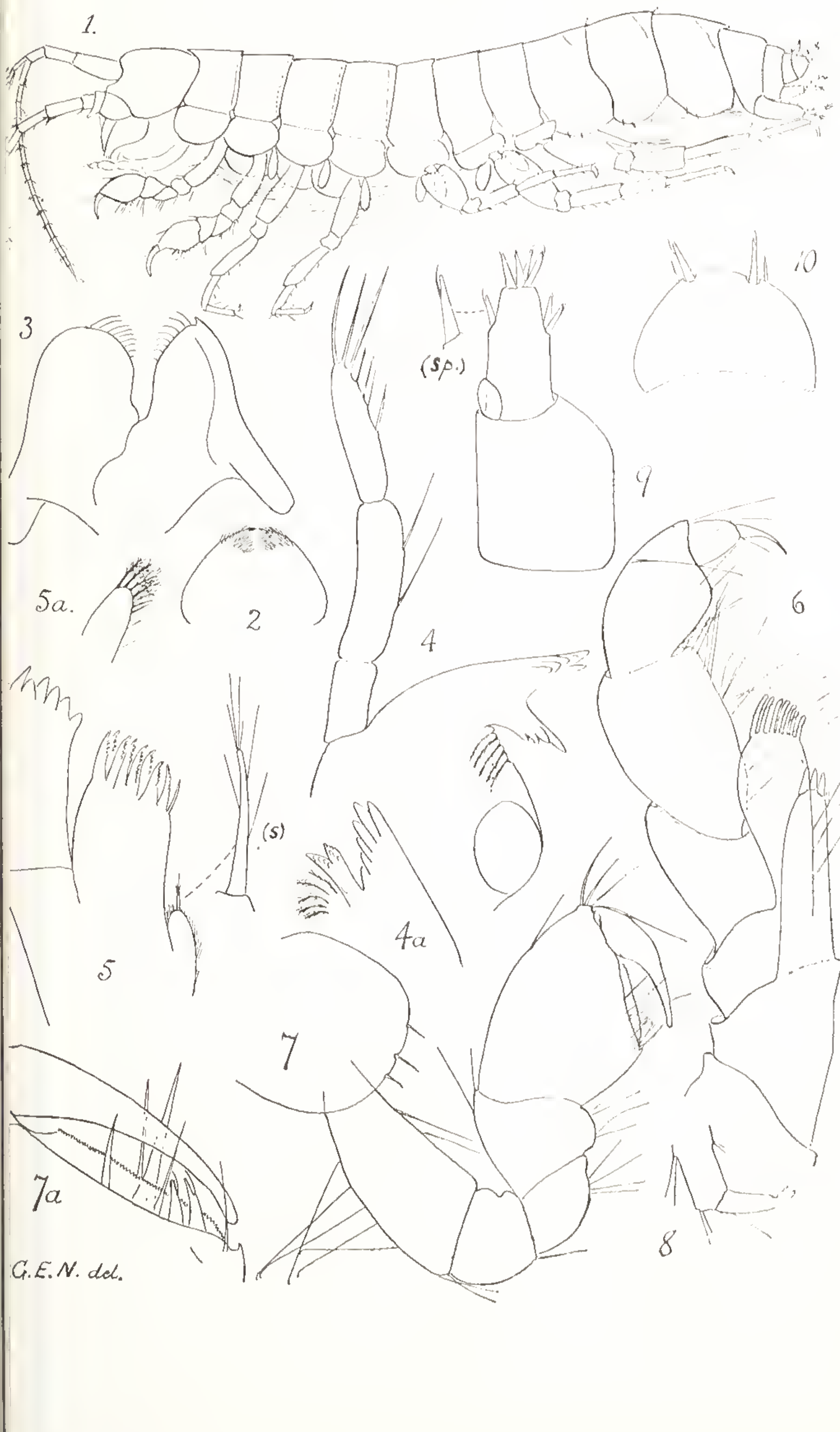
1.
3
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10
9
5a.
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(s)
4a
5
7
7a
8
G.E.N. del.

Contributions from the Department of Biology, University of Western Australia. No. 2.

Neoniphargus obrieni, a New Species of Blind Amphipod from Victoria, by **George E. Nicholls,** D.Sc., F.L.S., Professor of Biology, University of Western Australia.

(*Read* June 8, 1926. *Published* July 6, 1926.)

During a short visit to Melbourne, in February of this year, I was able to spend a week-end at Mt. Buffalo. Collecting trips were made to all parts of the plateau, and in practically every place, where water stood in shallow pools or flowed in reedy runnels, specimens of *Phreatoicus* were found abundantly. As, so far as I can discover, *Phreatoicus* has not been recorded from this locality and as the specimens seemed to differ in some particulars from *P. australis*, I collected a large number from different parts of the plateau for more careful examination.

From my experience in collecting *Phreatoicus* in Western Australia, as well as from Geoffrey Smith's account of collecting in Tasmania, I looked to find some specimens of *Neoniphargus* associated with the isopod and was surprised at its apparent absence. Finally, on the last day of my stay, tracing *Phreatoicus* up a creek, I came upon a small spring discharging into a sphagnum bog, at an altitude of about 4,800 feet; here, by removing a quantity of the bog-moss, I cleared a small space, to the depth of a couple of feet or so, and from the exposed water and the decaying moss at the bottom of the cavity secured more than two dozen small pink Amphipods. Several were evidently mature females with obvious brood-pouch. With but a pocket lens, it was not possible to identify these positively as *Neoniphargus*, but their practically eyeless condition (a tiny spot of white pigment alone remaining of these organs) marked them as almost certainly new, the only other blind Amphipods, known to me from Eastern Australia, being *Gammarus haasei*, which is a much larger form, and *Niphargus pulchellus*, readily to be recognised by its long third uropod.

The taking of a Gammarid at this height seems to constitute a record for this group in Australia, *Gammarus barringtonensis* being taken in N.S.W. at an altitude a few hundred feet less. That, also, was accompanied by a species of *Phreatoicus* (*P.*

shephardi) and, alongside, were found two terrestrial forms, *Talitrus sylvaticus* and *Cubaris helmsianus.* On the Mt. Buffalo Plateau, under logs and leaves, I took a few *Talitrus* (probably *T. sylvaticus*) and an Oniscid, not yet identified. Both species of *Phreatoicus* described from Eastern Australia have been taken at comparable and even greater heights.

The Victorian specimens of *Neoniphargus spenceri*, first received by Sayce, seem to have been taken from a precisely similar situation, though at a much lower altitude, yet these retained well-developed eyes. From Tasmania a number of species of *Neoniphargus* have been recorded by Thomson and Geoffrey Smith, but apparently all of these occur in open water and none are blind.

It is probable, therefore, that *N. spenceri* normally lives for a considerable part of the year in open water, while the Mt. Buffalo form has become permanently adapted to a life in darkness. It seems not to occur in Lake Catani (into which the bog drains), nor in the New Reservoir, both of which have been made practically permanent and comparatively deep in recent years by the construction of a dam near the original outlet. Apart from these two small lakes, there seems to be on the Plateau no standing water. The lesser creeks and runnels would be likely to freeze solidly during the quite severe and prolonged winter season, while the many shallow swamps would also be liable to become completely dry.* Only in the sheltered waters beneath the surface of the bog would these Amphipods be likely to survive upon the Plateau in a retreat secure from both freezing and dessication. Except for these two Crustaceans and a few insect larvae, the waters of this area seemed devoid of life at the time of my visit.

In size, *Neoniphargus obrieni* is smaller than any species of its genus described hitherto, my largest specimen barely exceeding 5 mm. As a further adaptation, probably, to life in these sunless peaty waters, there are a number of accessory branchiae. It is highly probable that the water beneath a foot or so of moss (much of it dead), would be but comparatively poorly oxygenated. It is

* The *Phreatoicus sp.* which occurs abundantly and widespread over the Plateau, seems much more able to survive a considerable degree of dessication. A large number of specimens were taken on one occasion (Feb. 14th) curled up on the surface of some rapidly drying mud, beneath a piece of bark. Some of these were taken, with the underlying mud, and kept without water, in a small wooden box, till my return to Perth on March 4th. Placed in water, they promptly unrolled and continued to lead an active existence in the laboratory for several weeks, when they all died during the prevalence of a short spell of hot weather. I have similarly taken *P. lintoni* and *P. palustris* curled up in practically dry mud.

interesting to note that somewhat similar structures occur in the Western Australian form, *Neoniphargus branchialis*, which is frequently taken in the waters of peaty swamps and in shallow lakes, the muddy floors of which are heavily loaded with decomposing organic matter.

The species is named in compliment to Mr. F. G. O'Brien, who was my companion in the long tramps over the Plateau.

Neoniphargus obrieni sp nov.

In general appearance somewhat closely resembling *N. fultoni* Sayce, it has a rather more slender build, particularly in the pleon, where the segments are unusually shallow.

Cephalon equals in length the first two peraeon segments. The side-plates are rounded, the first narrow and not so deep as its segment; side-plates 2 and 3 equal in width and deeper than their respective segments; side-plate 4 emarginate, distinctly deeper than its related segment, but scarcely as wide as side-plates 1 and 2 combined. Upon the ventral border of side-plates 1—4 there is a single seta anteriorly and a group of three or four setae posteriorly.

Pleon segments 1—3 with inferior margin rounded, postero-lateral corners angular, the second being prolonged into an acute projection; posterior margin of the second, sinuous, of the third, notched. A pair of somewhat widely separated setae dorsally on the posterior margin of the second pleon segment; near the anterior corner of the inferior margin of the pleon segments are a couple of stout setae, notched sub-apically and set with a cilium. (In a male specimen examined, there were three of the setae on the second pleon segment.) Last segment with stout spinule on either side of the base of the telson, but none on penultimate segment.

Telson, slightly longer than broad, cleft for two-thirds of its length.

Eyes vestigial, not to be distinguished in spirit specimens. Antenna 1 about two-fifths of the length of the body; peduncle with first joint once and a half the length of the second, which is once and a half the length of the terminal joint; flagellum 14-jointed, more than once and a half the length of the peduncle, with olfactory cylinders upon all the articuli from the sixth onwards; accessory flagellum 2-jointed, barely as long as the two proximal joints of the primary flagellum. Antenna 2 barely two-thirds the length of Antenna 1, with prominent antennulary cone, terminal joint of peduncle little shorter than preceding joint; flagellum 7-jointed, scarcely equalling the combined length of the two distal joints of peduncle. Olfactory cylinders on joints 3, 4, 5, and 6 in the male, absent in the female.

Mandibles closely resembling those of *N. spenceri*, but with fewer spines in spine-row; mandibular palp with second joint once and a half the length of the third. First maxillae with palp differing on the two sides (with six spines and a simple seta apically on the left and with six or seven simple setae on the apex of opposite palp); the inner plate with the usual two plumose setae and fringed along both inner and outer margins with very numerous fine setae. Second maxilla much as in *N. spenceri*, but with the short external spinule on the apex of outer plate, represented by a long plumose seta; mesial margin of inner plate set with a series of eight small tufts of setae.

Gnathopods 1 and 2 nearly similar and of equal size, the fifth joint produced into an obtuse lobe and widened distally to form the typical sub-triangular (cup-shaped) joint to support the almost quadrate propod; palm convex and slightly oblique in gnathopod 1, straight in gnathopod 2.

Gnathopod 2 bears a small accessory branchia; on peraeopods 1 and 4 the accessory branchia appears as a large branched structure.

Uropods 1 and 2 extending backwardly to the level of the end of the telson; uropod 3 elongated, inner ramus small with single apical seta, outer ramus with minute second joint, surrounded by a crown of setae. These setae, as, also, those arming the apex of the telson, are notched sub-apically and bear a slender cilium.

Length.—5 mm.

Colour.—In life, a delicate pink, translucent; in spirit, a pale yellowish-brown, with, in some, a streak of darker brown along dorsal line.

Habitat.—Taken in February of this year, associated with *Phreatoicus* sp., beneath the surface of a bogmoss, at the head of a creek draining into Lake Catani, Mt. Buffalo. Altitude about 4,800 ft. Twenty-eight specimens, several of which were adult females.

Remarks.—While possessing certain distinctive characters, *N. obrieni* seems, in respect to very many of its features, to occupy a position intermediate between *N. spenceri* and *N. fultoni*, the only representatives of the genus described, hitherto, as occurring in the eastern part of the Australian mainland.

It is smaller and more slender even than the tiny *N. fultoni* and is peculiar in its eyeless condition and in the shortness of its first antennae. In the occurrence of olfactory cylinders (Pl. IX., Fig. 1) on both antennae in the male, it resembles *N. fultoni*, although these organs are apparently much more numerous in the blind form. The existence of these structures in *N. spenceri* is not recorded nor does Sayce state whether they are to be found in the female of *N. fultoni.* The second antennae (Pl. IX., Fig. 2) are much as in *N. fultoni.*

In the condition of the mouth parts, *N. obrieni* agree quite closely with *N. spenceri;* no account of these structures is included in Sayce's description of *N. fultoni* (1902, p. 57).

The upper lip (Text, fig. 1) is rather more rounded, practically semi-circular in shape, with a dense ventral tuft of setae. The description of the mandibles in *N. spenceri* (Sayce, 1900, p. 240) would serve, with but little modification, for this species (Text, figs. 2, 2a), the spines in the spine-row being fewer (four on the left side, two on the right) and the terminal joint of the palp better armed with setae, but not broadened.

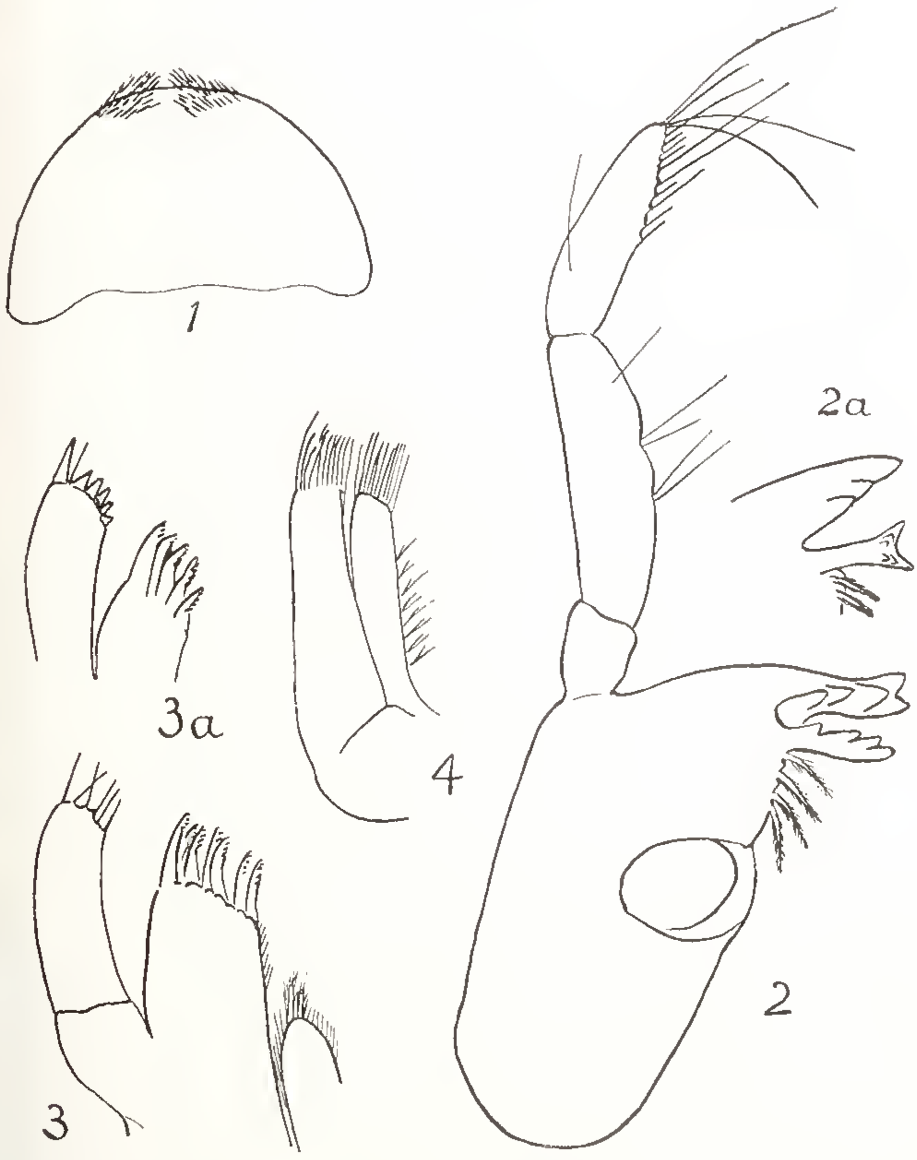

FIG. 1.—*Neoniphargus obrieni.*—1, upper lip; 2, left mandible; 2a, cutting edges of right mandible; 3, first maxilla; 3a, part of first maxilla of opposite side; 4, second maxilla.

In the first maxillae (Text, fig. 3, 3a), too, there is a marked agreement between the two species, the inner lobe in *N. obrieni* being, however, slightly more rounded with the setose fringe extending along both inner and outer margins and the apical plumose setae shorter. A similar difference between the palp of opposite sides occurs in both species. In the second maxillae (Text, fig. 4) the only points of difference observed are that the external spinule on the outer plate of this appendage in *N. spenceri* is replaced in *N. obrieni* by a long plumose seta and that the fringe of setae along the mesial margin of the inner plate in the former is broken up in the latter into a series of small tufts.

The maxillipedes (Pl. IX., Fig. 3 and Text, fig. 2) show the inner and outer plates as a little longer, relatively to the palp, than appears, from Sayce's figure, to be the case in *N. spenceri*. Upon the inner plate, plumose setae are fewer and the apex is more

FIG. 2.—*Neoniphargus obrieni.*—Distal portion of inner and outer plates of maxillipedes.

rounded; the outer plate has the series of spine-teeth extended proximally by long stout spines; the fringing setae on the inner margin of the second joint of the palp appear distinctly longer, the third joint of the palp relatively shorter and stouter than in *N. spenceri*. Each of the tufts of setae, springing from the outer distal end of the joints of the palp, is represented in *N. obrieni* by but a single seta.

The side plates of the gnathopoda are well rounded, the anterior considerably the smaller; the gnathopoda (Pl. IX., Figs. 4, 5) are much alike excepting for a slight difference in the shape of the 6th joint and a consequent alteration in the slope of the palm. The basos, too, of the second gnathopod is rather longer than the corresponding joint in the preceding limb.

The peraeopods (Pl. IX., Fig. 6) do not differ noticeably from those of *N. fultoni* excepting, perhaps, that they are a trifle shorter relatively. The grouping of the setae on the inferior margin of the side-plates 1—4 is closely paralleled in the side-plates 1 and 2 of *N. fultoni* (fide Sayce's figures, 1902, Pl. VII., Gn.[1] and Gn.[2]), but these setae are not shown in the figure of the fourth side-plate (op. cit., Pl. VIII., pr. 2). In *N. spenceri*, these setae are shown as much more numerous, but still separable into two groups (1900, Pl. XL., Fig. Gn.[2]). In *N. thomsoni* they appear to form a continuous fringe (Thomson, 1893, Pl. VI., Fig. 8). while in the Western Australian form, *N. branchialis* (1924, Pl. XI., p. 1), these setae have undergone a decrease in number, the two groups of setae being represented by but one and two setae respectively.

The occurrence, on the dactyl of the peraeopoda, of a single plumose seta may be a character of generic value. It certainly occurs in all of the undoubted species of *Neoniphargus* which I have been able to examine and is figured by Sayce, for *N. fultoni*, but without mention in the text. It does not appear, however, in that author's figures of *N. spenceri*.

Accessory branchiae (Pl. IX., Figs. 6, 7) related to certain of the peraeopods, seem to be peculiar to *N. obrieni*, among Eastern Australian forms, nor does Geoffrey Smith refer to such structures as present in Tasmanian species. Their branched condition on two, at least, of the peraeopods is paralleled in *N. branchialis* (1924, Pl. X., Fig. Gn.2 and Pl. XI., Figs. P.1 and P.3).

The pleon is much less deep, than in either of the species described by Sayce; the ventral margin of each of the three segments is armed with two setules each with a sub-apical notch bearing a cilium;† in *N. fultoni* there is but one well developed spinelet in this position and in *N. spenceri* this is absent, apparently. The urosome is, however, less spinulose than in *N. fultoni*.

The third uropod (Pl. IX., Figs. 8, 9, and 9a) has the outer ramus unusually short and less spinulose than in *N. spenceri*, and

† This type of seta is said to characterise members of the genus *Crangonyx*. It is also present, as I have pointed out (1926), in a blind Western Australian form, *Protocrangonyx*, intermediate in character between *Crangonyx* and *Neoniphargus*.

lacks, also, the plumose setae of *N. fultoni*. The terminal joint is extremely minute. The inner ramus, however, is relatively larger and with but a single apical spine, in place of three in *N. spenceri* or the two plumose setae of *N. fultoni*. On the whole, in the condition of this uropod, this species agrees rather more closely with *N. thomsoni* than with either of the two eastern mainland forms.

The telson resembles, in shape, that of *N. fultoni*, being distinctly longer than broad. In *N. spenceri* the breadth equals the length, while in *N. thomsoni* the breadth is considerably greater than the length. In the two latter, the cleft is roughly half the length; in *N. fultoni* and *N. obrieni* the cleft is deeper and the two portions narrower, but the apical cluster of three spines in *N. spenceri*, *N. thomsoni* and *N. obrieni* is reduced to two in *N. fultoni*.

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Explanation of Plate IX.

All figures are of *Neoniphargus obrieni* (female).

Fig. 1. First Antenna.
2. Second Antenna.
3. Maxilliped.
4. Side-plate 1 and first Gnathopod.
5. Side-plate 2 and second Gnathopod, with marsupial plate and primary branchia.
6. Side-plate 3, first peraeopod, marsupial plate, primary and branched accessory branchia.
7. Side-plate 6, base of fourth peraeopod, simple primary and branched accessory chanchia.
8. Urns, uropods 1—3 and telson, in lateral view.
9. Third uropod, inner view.
9a. Apex of third uropod, more highly magnified.
10. Telson, in dorsal view.

br, branchia; br^1, accessory branchia; c, olfactory cylinders; m, marsupial plate.

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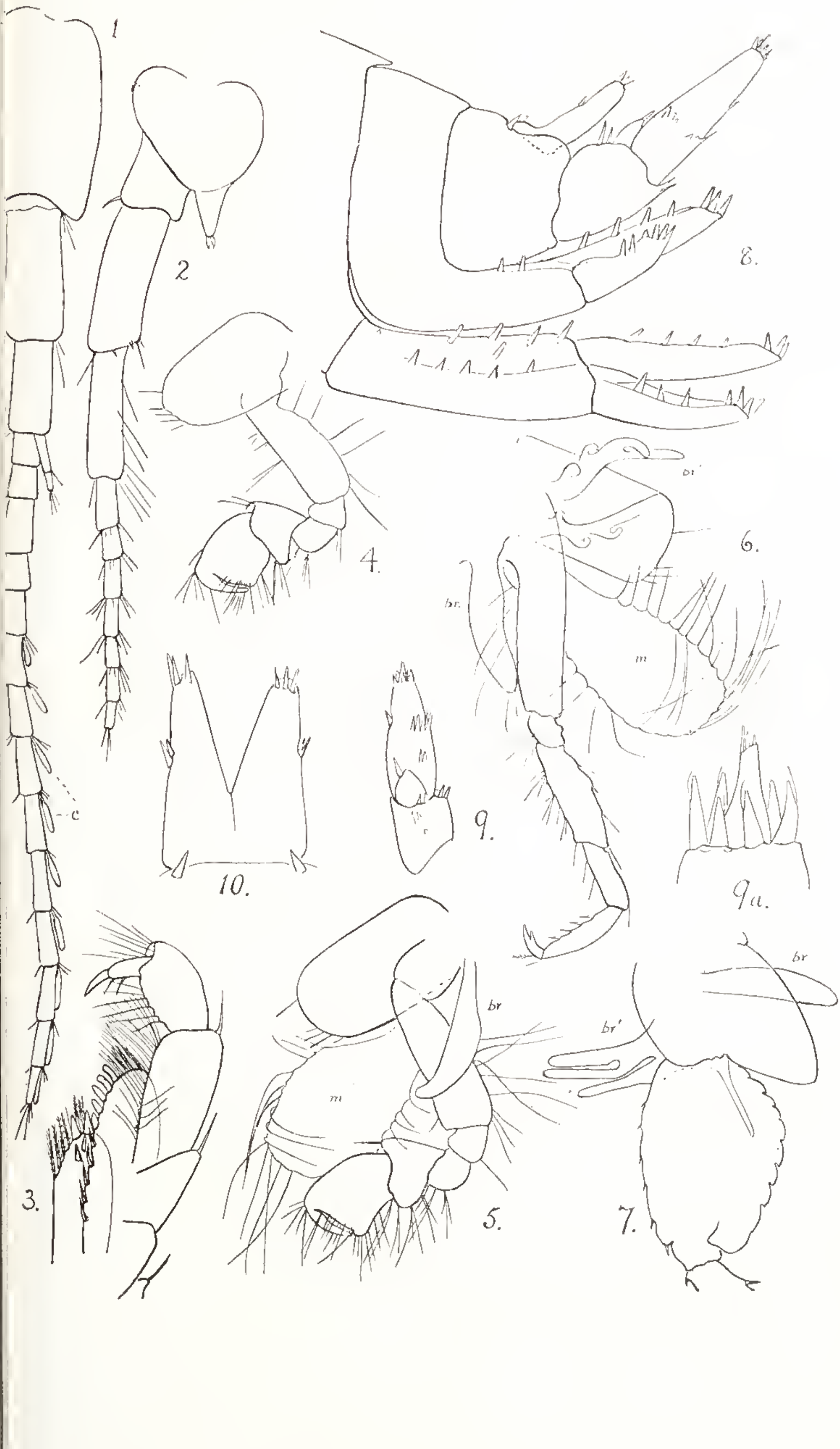
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Contributions from the Department of Biology, University of Western Australia. No. 4.

Description of a New Species of Terrestrial Isopod, Haloniscus stepheni, from Western Australia, by **Geo. E. Nicholls,** D.Sc., F.L.S., Professor of Biology, and **Helena M. Barnes,** B.Sc.

(*Read* July 13, 1926. *Published* July 20, 1926.)

The specimens which form the subject of the present communication were collected by one of us (G.E.N.) when on a trip through the northern part of the Wheat Belt in January of this year.

The find was a purely accidental one, a trivial motor defect having caused us to pull up by the bank of the Kokatea Creek; at the particular spot the Creek at this time was dry, but the surface crust, thickly spread with salt crystals, covered a viscid mud beneath.

The weather was intensely hot (115° F., shade temperature), but a slight fall of rain a couple of days earlier had served to effect a temporary moistening of the surface, which persisted in shaded spots. When flowing, the Creek (which had been strongly salt for several years, as was learned from enquiries made locally) discharged into the Greenough River. A few stones resting upon the muddy crust were turned and yielded nothing of interest, but a couple of small logs, in a very decayed state, just upon the upper limit of the Creek bank, concealed each a dozen or so of the Oniscid. They were comparatively small, but their unusual colour (whitish, with dark intestine indicated through translucent body wall) and their exceptionally compressed and elongate shape, marked them as new, and, consequently, as many as possible were collected. They were quite active and a number succeeded in making good their escape down tiny burrows into the softer mud beneath. Undoubtedly they are capable of leading life under terrestrial conditions, but their occurrence upon the banks of a creek which is brackish at the best and predominantly salt, suggested a relationship with forms inhabiting salt waters or the shores of salt lakes. A comparison of our specimens with the description furnished by Chilton of *Haloniscus searlei*, left us in no doubt of its close relationship with that form. Advantage was taken of the opportunity afforded by a recent visit to Adelaide to examine specimens in the collection of the S.A. Museum, and it then became apparent that our Western Australian form also showed marked affinities with *Philoscia salina* Baker, known only from salt water pools near the South Australian Coast. Chilton states (1920, p. 725) that he had experienced considerable difficulty in assigning the new species to its proper place in the Oniscoidea, and he finally decided to constitute for it a new genus. He pointed out that its nearest affinities with existing genera were with *Philoscia,* from which, however, it differs in a number of characters. Baker, in referring the South Australian species to *Philoscia*, appears to have been unaware of Chilton's paper.

It has seemed best to us to accept Chilton's view of the generic distinctness of this species, and since all three forms are much alike in mode of life (in or upon the shores of salt water), and agree closely in their structural peculiarities, we suggest that Baker's species should be transferred to Haloniscus.

For the West Australian form the name *Haloniscus stepheni* is proposed, the specific designation being in compliment to Mr. Wm. Stephens, of Perth, through whose kindness this collecting trip was rendered possible.

Gen. HALONISCUS. Chilton.

1920, *Haloniscus* (Sp. typ. *H. searlei*). Chas Chilton, Proc. Linn. Soc. N.S.W., Vol. 44, Part 4, p. 723.

Body elongated narrow oval, convex; dorsal surface smooth, covered with fine hairs. Cephalon rounded in front, without lateral lobes. Mesosome with the side plates not greatly expanded. Metasome very slightly narrowed; third, fourth and fifth segments with distinct epimera; last segment large and with well-developed lateral portions; extremity sub-triangular. Eyes present, lateral in position. First antenna minute three-jointed. Second antenna comparatively short, flagellum three-jointed. Legs well developed and increasing in length posteriorly, the anterior four pairs prehensile, more or less sub-chelate; the fifth, sixth and seventh, simple; dactyls bi-unguiculate, without special dactylar seta. Pleopoda conspicuous with well developed opercular plates lacking air cavities. Uropoda exposed, moderately developed, with peduncles reaching beyond the end of metasome; inner ramus attached only slightly in front of the outer.

Remarks:—Closely related to *Philoscia,* but differing from that genus in the scarcely narrowed metasome, the possession of a large terminal segment, with well-developed lateral expansions. Of perhaps lesser importance as distinctive features are the comparatively short antennae, and the occurrence of definite epimera on third, fourth and fifth segments of the metasome.

With three species:—

H. searlei Chilton, 1920, sp. typ., Proc. Linn. Soc. N.S.W., Vol. 44, p. 723.

H. salina (Baker), 1926, Philoscia s., Baker in Rec. Sth. Austr. Mus., Vol. 3, No. 2, p. 145.

H. stepheni, sp. nov.

Haloniscus stepheni sp. nov.

Specific diagnosis.

Body almost four times as long as broad, with dorsal surface covered with numerous short hairs. Eyes moderately developed. Legs gradually increasing in size posteriorly; the four anterior pairs approximately similar in shape, slightly prehensile, and with their joints more or less rectangular; the fifth intermediate in shape and size; the sixth and seventh similar in shape; pleopods with opercular plates well developed, gradually decreasing in size posteriorly, with the exception of the first pair, which are small and apparently lack setae; endopods of the first and second pairs modified in the male in the usual manner, those of the third, fourth and fifth branchial and comparatively well developed. Uropods moderately exposed with the basal joint reaching slightly beyond the end of the metasome; rami different in shape, the outer three-sided and pointed, the inner tapering to a point, slightly flattened on one side.

Colour: Creamy white, translucent, the food laden intestine visible through the body wall.

Length: Largest specimen about 7 mms.

Locality: Under damp logs by the bank of Kokatea Creek, near Tenindewa.

Detailed description (taken from male specimen):—

The convex *body* is of a long oval shape, the length being almost four times as great as the breadth, and thus notably narrow; the lateral portions are not greatly expanded, the dorsal surface is smooth and covered with numerous minute fine hairs. The *mesosomatic* segments are sub-equal in length; the epimera of the first four are rounded posteriorly, while those of the last three are acutely produced. The *cephalon* is rounded and without lateral lobes. The frontal marginal line of the head is evident throughout its entire length and is bent downward on either side surrounding the epistome, being continuous with the vertical marginal line at the back of the eyes. The *metasome* is without epimera on the first and second segments, these being covered laterally by the last mesosomatic segment, in the extended position; the epimera of segments three to five are well developed. The first five segments are sub-equal in length, the two anterior being very slightly shorter; the last segment is large, slightly narrower than those preceding, rounded posteriorly and with very evident lateral portions.

The *eyes* are moderately developed, compound, lateral in position.

The *first antenna* (Pl. X, Fig 3) has three joints, the first broader and longer than the second; the third longer and narrower than the second, and bearing at and near the apex a number of stout setae.

The *second antenna* (Pl. X, Fig. 4) has the first three joints of the peduncle more or less sub-equal, the fourth is longer than the third, the fifth as long as the third and fourth combined. The flagellum is approximately equal in length to the last segment of the peduncle, and consists of three joints, the second being the shortest; the third longer than the first and tapering to the apex, which bears a tuft of setae.

The *upper lip* is broader than long, and has the central portion covered and fringed with short setae.

The *right mandible* (Pl. X, Fig. 6) has the outer cutting edge strong and composed of three chitinous teeth; the inner cutting edge is less strongly developed and divided into two teeth; two penicils are present and the usual tuft of long plumose setae; the ciliated lappet is small.

The *left mandible* (Pl. X, Fig. 5) has the outer cutting edge represented by four strong chitinous teeth; the inner is distinctly defined and divided into a number of teeth; three penicils are present, two upper and one lower; ciliated lappet prominent; setae in lowest group long and plumose.

Both the mandibles have the upper distal edge fringed with setae.

The *lower lip* is small, narrow, and has the inner and outer (distal) margins fringed with setae, also the surface near the inner margin.

The *first maxilla* (Fig. 1, 1) has the external margin of the outer lobe slightly sinuous and fringed distally with a number of fine setae; the apex bears eight or nine setae, the four outer darker in colour and stronger than the inner. The inner lobe is more delicate and about half its width; the outer margin bears a number of fine setae distally; at the apex are the usual two plumose setae, which are short and stout.

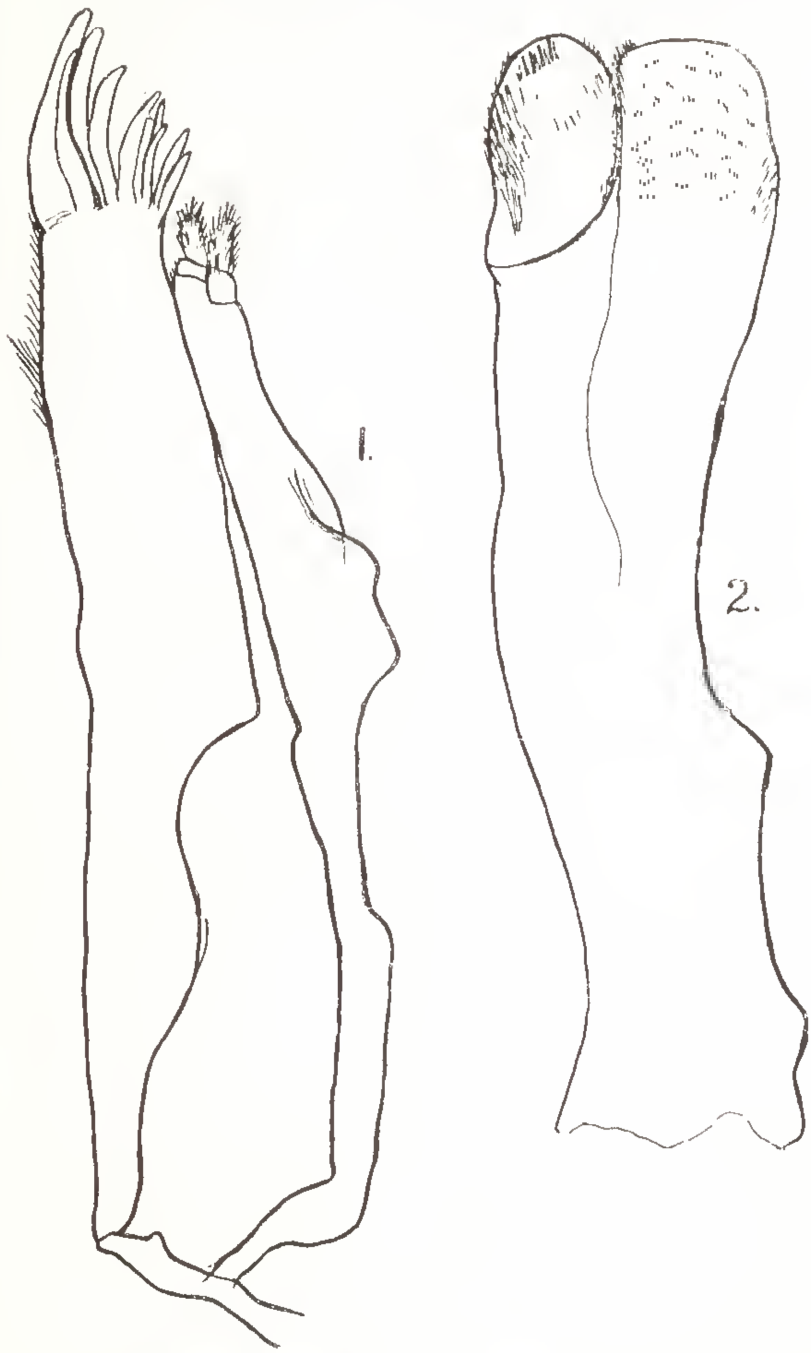

FIG. 1.—*Haloniscus stepheni.* 1, 1st Maxilla; 2, 2nd Maxilla.

The *second maxilla* (Fig. 1, 2) is delicate, the outer lobe broad and clothed apically with numerous fine setae. Its internal margin bears a number of longer and stronger setae. The inner lobe is narrower and more strongly chitinized, and bears numerous setae of different forms, a group of about nine or ten near the inner apex being thick and strong.

The *maxilliped* (Pl. X, Figs. 7, 8) has the basal joints broad and rectangular; in the palp the first joint only is well defined and bears a couple of spines. The three terminal joints are coalesced into a single piece, the extent of each joint being indicated only by the position of a group of setae. Slightly shorter than the palp, the truncate masticatory lobe bears sub-apically a penicillum, and apically is beset with short setae. The epipod is very considerably more than half the combined length of the basal joints.

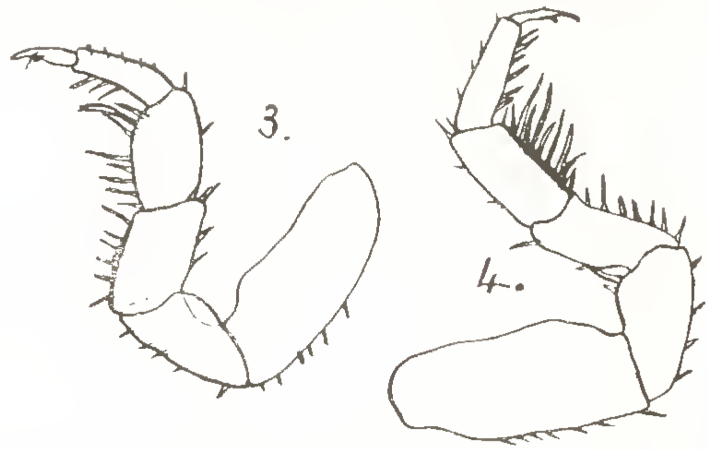

FIG. 2.—*Haloniscus stepheni*. 3, 1st pair of legs; 4, 2nd pair of legs.

The *first pair of legs* (Fig. 2, 3) is short, most of the joints being roughly rectangular in form, the ischium, however, being sub-triangular; the dactyl slender, bi-unguiculate and without a special dactylar seta. The propod is narrow, and has a number of stout setae on the inner side; with the dactyl it forms upon the carpus a prehensile structure. The inner sides of the carpus and merus bear a number of long stout setae similar to those on the propod.

The *second pair of legs* (Fig. 2, 4) is longer than the first, with the carpus and merus slightly narrower than those of the first pair. The propod and dactyl are similar, but longer. The spines on the carpus are much longer, those on the propod and merus more numerous.

The *third and fourth pairs of legs* are similar to the second

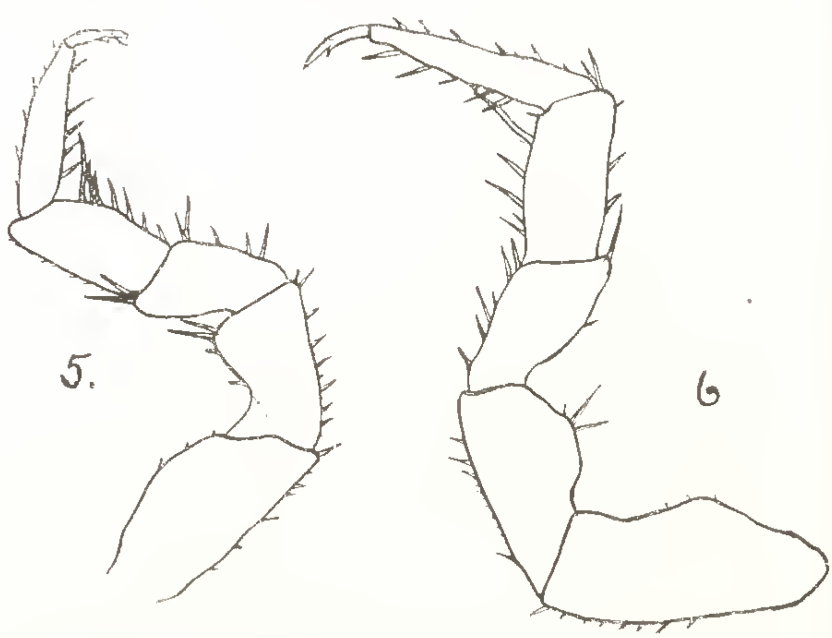

FIG. 3.—*Haloniscus stepheni*. 5, 5th pair of legs; 6, 7th pair of legs.

pair, but less sub-chelate, each slightly longer than the preceding. The spines on the propod, carpus and merus are more scattered.

The *fifth pair of legs* (Fig. 3, 5) is longer than the fourth, and intermediate in character between those of the anterior group and the following.

The *sixth and seventh pairs* (Fig. 3, 6) are similar in shape, the seventh longer than the sixth, both distinctly longer and stouter than the fifth pair. The spines are more sparse. The ischium bears a number of fine setae on its anterior border.

The *first pair of pleopods* in the male (Pl. X, Fig. 9) has the usual structure, the exopods delicate and slightly rounded, with no suggestion of setae. The endopod is modified, broad at the base and tapering to the apex, grooved on the inner margin. The endopods are approximately twice the length of the exopods. The male organ is single and tapering, reaching to the ends of the exopods.

In the *second pair of pleopods* (Pl. X, Fig. 10) the exopods differ from those of the first pair, being longer and broader, and pointed at their apices. The inner margin is fringed with fine setae, which increase in length posteriorly. The outer margin bears a few spinous setae together with numerous fine setae. The slender endopods extend beyond the exopods and taper to a fine point.

The *third, fourth, and fifth pairs of pleopods* (Pl. X, Fig. 11, 12, 13) are similar in shape, but become gradually smaller. The exopods are more or less pear-shaped with their inner margins fringed with fine setae, the outer bearing a number of long and stout spine-like setae interspersed with finer setae. The endopods are moderately developed, irregular in shape, and have the usual branchial function.

In all of the pleopods the peduncles are well developed.

In the *uropods* (Pl. X, Fig. 14) the basal joint is roughly quadrilateral in shape, almost as broad as long. The outer ramus is three sided and pointed, grooved externally. Apically it bears a number of long, fine setae. The inner ramus tapers to a point, is slightly flattened on one side and grooved as in the outer ramus. It is inserted only slightly anteriorly to the outer and is more than half the length of the latter.

The greater number of specimens collected are males, a fact which could readily be made out by an inspection of the endopods of the first two pairs of pleopods; of the remainder, none bear eggs and cannot be definitely recognised as females. In all, the body has the same general structure. The specimens were preserved in strong alcohol, and all had become dorsally flexed, some very strongly indeed.

H. stepheni may readily be recognised from its congeners by its extremely narrow body, four times as long as wide, the length in *H. salina* being less than three times the width, while in *H. searlei* the breadth is relatively greater still, being little less than half the length. The translucency of H. stepheni seems to be peculiar, also, and suggests that living as it does in an area of much lighter rainfall, and subjected to much greater risk of dessication, it has become habituated to lengthy periods of subterranean life, this burrowing habit doubtless being associated with the attenuated form of the body.

The eye of *H. stepheni* is intermediate in size between that of *H. searlei,* which is much larger, and that of *H. salina,* which is distinctly smaller.

In the general rectangular shape of the joints of the legs *H. stepheni* differs from both of the other species. In none of our specimens was the merus broadened as it is said to be in *H. searlei* and *H. salina.* The relatively considerable length of the endopodites of the pleopods 1 and 2 also appears to be peculiar to *H. stepheni.* In its telson it resembles *H. salina,* the lateral portions of this region being much more evident in *H. searlei.*

The discovery of a third species of this genus, which, unlike the other two forms, is capable of living out of water, is of considerable interest.

Chilton, in his discussion (1920, pp. 732-4) on the occurrence and origin of *H. searlei,* comes to the conclusion that that form is to be regarded as a terrestrial form which has become adapted to an aquatic existence, rather than a marine form cut off from its oceanic connections and surviving in salt lakes, his conclusion being strengthened by the evidence that Lake Corangamite is not of marine origin.

In *H. salina* we have equally an aquatic form living in the muddy border of a small coastal salt lake of a high degree of salinity, in a depth of six feet of water. All were taken well away from the shore and it is stated (1926, p. 145) that none were found under debris on the shore—though carefully sought for. This little crustacean is said also to occur in other salt lakes in the neighbourhood.

Our specimens found near Tenindewa were, as stated above, found on land, though evidently at the surface from burrows extending down into moist salt-impregnated mud. There is no means of knowing whether, in wetter conditions, the animals would have been found actually in the water.* There are, in the near vicinity, no salt lakes, although some exist at a distance of about 50 miles to the east. A few weeks earlier there had been unusual and heavy summer storms, and many creeks were flowing out of season, so that these small forms might easily have been carried for a considerable distance. The creek is, however, normally regarded as a salt creek, and was described as having been at this season rather less salt than usual. The visible salt at the surface suggested a considerable degree of salinity. It is possible, however, that the sea in Miocene times extended northwards from the Bight towards this southern fringe of the Murchison country, and we may perhaps regard these isolated forms as survivors of a definitely terrestrial, but coast-haunting form which once was distributed along the entire Southern Australian shore in Mid-tertiary times and which have remained as tolerant of salt as those recognised coastal forms, the Scyphacidae.

*It is my custom, when taking small crustaceans from the borders of streams or lakes, to ascertain by experiment, whether or no they will survive for any length of time in water. Unfortunately, on this occasion the experiment was not made, no water being available.—G.E.N.

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1926 Baker: Rec. S. Aust. Mus., Vol. III, No. 2, p. 145, Text Fig. 77.

Explanation of Plate X.

All figures refer to *H. stepheni*, and are drawn from a male specimen.

1.—Lateral view of entire animal. x14.

2.—Dorsal view of entire animal. x10.

3.—Antennule. x75.

4.—Right antenna. x32.

5.—Terminal portion of left mandible. x39.

6.—Terminal portion of right mandible. x39.

7.—Right maxilliped seen from ventral surface. x33.

8.—Terminal portion of left maxilliped in ventral view. x39.

9.—1st pleopod of male. x33.

10.—2nd pleopod of male. x33.

11.—3rd pleopod of male. x33.

12.—4th pleopod of male. x33.

13.—5th pleopod of male. x33.

14.—Terminal segment and uropods, dorsal view. x27.

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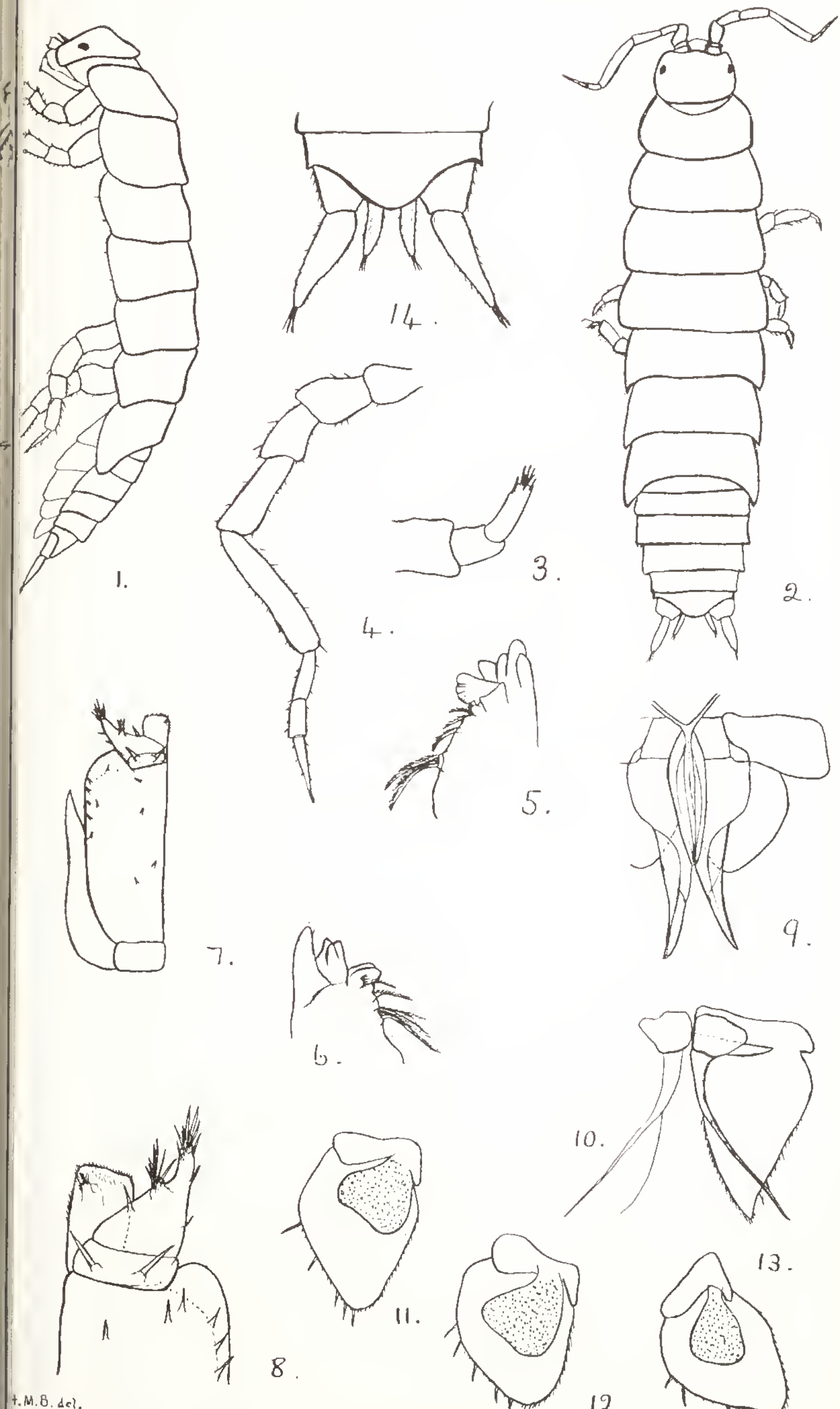
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The Crinoid Marsupites, and A New Cirripede from the Upper Cretaceous of Western Australia, by Thomas H. Withers, F.G.S.

(*Read* by L. Glauert, July 13, 1926. *Published* July 20, 1926.)

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The Crinoid Marsupites in the Upper Cretaceous of Western Australia.

Up till 1924 the exact age of the Cretaceous deposits occurring at Gingin, Western Australia, was in doubt, but the discovery in those beds of the crinoid *Uintacrinus*, enabled me to conclude (Withers, 1924, Jour. Roy. Soc. W. Australia, XI, No. 2, p. 18) that they were equivalent in age to the Santonian or Middle Senonian of the European Cretaceous. *Uintacrinus* has since been found by Mr. L. Glauert, F.G.S., at One Tree Hill, and Mole Cap Hill, at Gingin, and at Round Hill, Dandarragan, some fifty miles north of Gingin.

This discovery has stimulated further work on these deposits, and among the many interesting fossils that Mr. Glauert has since collected are a number of plates of the unstalked crinoid *Marsupites*. These were found in association with plates of *Uintacrinus* at the three above-mentioned localities and at "Compton's Chalk," Gingin. The association of these two crinoids seems to dispose of any possible doubt that the beds are equivalent in age to the *Marsupites*-zone of the European Cretaceous. It would seem also that they agree in age with some part of the Arrialoor Group of Southern India, in which *Marsupites* has been found.

First made known from the English chalk, *Marsupites* was later shown by Rowe and Sherborn (1900, "The Zones of the White Chalk of the English Coast," Pt. I, Kent and Sussex, Proc. Geol. Assoc., London, XVI, pt. 6, pp. 294, 347), to have a definite and restricted range in the Upper Chalk. It occurs commonly in a belt of chalk, bounded above by the zone of *Actinocamax quadratus*, and below by the *Uintacrinus* band. This distribution is apparently common to the whole of the European Cretaceous.

We know now that these two crinoids occur associated in Western Australia, and it is therefore curious that while *Uintacrinus* occurs so commonly over a wide area in the Upper Cretaceous beds of Kansas, U.S.A., no trace of *Marsupites* has yet been found. *Marsupites* does, however, occur in N. America, for two specimens, one a fairly complete calyx, have been described as *M. americanus* by Springer (1911, p. 160, pl. vi, figs. 4a, b, 5), and by Clark and Twitchell (1915, p. 39, pl. vii, figs. 2a, 2b, 3). This form was found in the Tombigbee Sandstone of the Eutaw Formation of Plymouth Bluff, Northern Mississippi.

Besides the present occurrence in Western Australia, and that just mentioned in North America, *Marsupites* has been recorded from England (Rowe and Sherborn, 1900, pp. 294, 347), France (Filliozat, 1906, p. 259, 1908, p. 255, 1910, p. 728; Janet, 1906, p. 244; and Leriche, 1905, p. 50), Germany (Roemer, 1840, p. 27, 1854, pp. 196, 232; Hosius, 1860, p. 74; and Strombeck, 1863, p. 132), Sweden (Schlueter, 1897, p. 46), Russian Poland (Pusch, 1837, pp. 9, 10, pl. ii, fig. 9), Algeria (Peron, 1899, pp. 510-11, fig.), and India (Stoliczka (1873, pp. 53, 54). Its occurrence in India seems to have been overlooked, notwithstanding that the specimens were described and figured by Stoliczka in 1873 (pl. vii, figs. 41, 42, 43); these came from the Arrialoor group of Arrialoor and Olapaudy, Southern India.

Marsupites testudinarius (v. Schlotheim).
(Plate XI, figs. 7-11.)

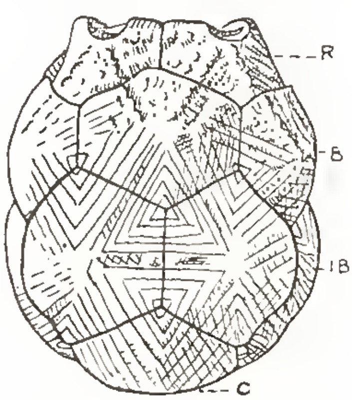

FIG. 1.—*Marsupites testudinarius* (v. Schlotheim). (After Bather.)
Middle Senonion (Santonian), Dorset, England.
Cup from the side, showing the character of the ornament.
Two-thirds natural size.
C, central plate; IB, infra-basals; B, basals; R. Radials.

The early synonomy of this form is given by Bather (1889), and there seems little doubt that the opinion expressed by him that the forms all belong to a single variable and widely-distributed species, is well founded. It is true that Springer (1911) later described the American form as a distinct species under the name *M. americanus.* He says, however, (p. 160), "The only real difference observable in the parts preserved is that in our species the brachials are shorter and wider than in *M. testudinarius,* and if we had enough specimens with brachials attached to get an average, this might disappear." Further, "As in *Uintacrinus,* the resemblance between the American and European forms is very great, and they may even be of identical species."

The material from Western Australia consists only of detached and slightly worn cup-plates. One (Pl. XI, fig. 10) is apparently a radial, and two others (Pl. XI, figs. 9, 11) probably represent basals. The weathered plate (Pl. XI, figs. 7-8) shows well the structure of the stereom, the inner layer (fig. 8) having been partly removed.

All the plates so far found are of the smooth type, but it is quite possible that further collecting will bring to light strongly ribbed plates, such as are found associated with the smooth type in the English chalk. In themselves, these plates are insufficient to throw any light on the question as to whether there is more than one species of *Marsupites.* On the other hand, they do not show any differences that are not covered by the range of variation in specimens of *M. testudinarius* from the English chalk. The Australian plates are therefore here referred to the same species.

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A New Cirripede from the Upper Cretaceous of Western Australia.

Since the publication of my paper (1924, Journ. Roy. Soc. W.A., X, Pt. ii, p. 64) on the Cirripede *Calantica* (*Scillaelepas*) *gingin-nsis* (Etheridge, jun.), Mr. L. Glauert, F.G.S., has sent to me from ime to time further Cirripede remains which he has collected in the Jpper Cretaceous (Santonian) beds in the neighbourhood of Gingin, Vestern Australia. These remains come from One Tree Hill and Iole Cap Hill, at Gingin, and others come from the same horizon at Round Hill, Dandarragan, some fifty miles north of Gingin. Nearly ll belong to the above-mentioned species.

A very interesting new species, the second species of Cirripede o be described from the Cretaceous of Australia, is represented by wo terga from Dandarragan, and a scutum from One Tree Hill probably belongs to the same species. The terga are V-shaped owing to the deep emargination of the scutal side of the valve, and hey evidently belong to some Scalpelliform barnacle in which lecalcification of the valves has set in. Among recent forms there s a tendency towards decalcification of the valves, and this occurs n more than one stock, but it is as interesting as it is unexpected, o find it had already appeared in the Upper Cretaceous.

Scalpellum Leach, 1817.

Sub-genus **Neoscalpellum** Pilsbry, 1907.

Valves only partly calcified, the calcareous part of the tergum V-shaped; infra-median latus narrow, higher than wide; scutum with apical umbo.

Subgenotype **Scalpellum dicheloplax** Pilsbry.

Most of the recent species of Scalpelliform barnacles showing im-perfect calcification of the valves are grouped in the sub-genus *Neoscalpellum* of the genus *Scalpellum*. It seems very probable, however, that imperfect calcification of the valves appeared in different stocks at different times, and the occurrence of this form in the Upper Cretaceous shows that the tendency occurred early in the group. The grouping of these forms does not seem to be a natural one, but to draw attention to this Cretaceous form, it is included in *Neoscalpellum*.

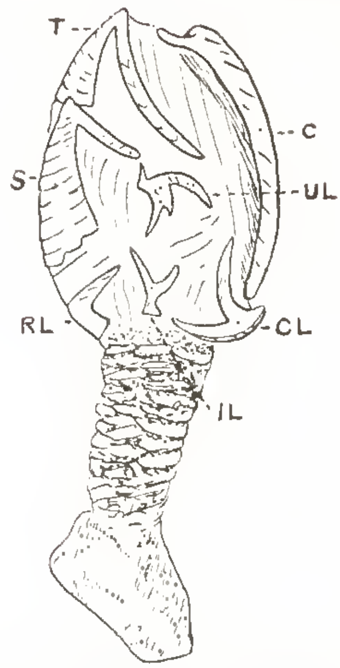

FIG. 2.—*Scalpellum (Neoscalpellum) dicheloplax* Pilsbry. (After Pilsbry). Recent. Lateral view of holotype. Two-thirds nat. size.
C, carina; CL, carinal-latus; IL, infra-median latus; RL, rostral-latus; S, scutum; T, tergum; UL, upper latus.

In the tergum of any Scalpellid barnacle, the scutal margin is hollowed out to some extent, and this varies in the different species, so that a deep emargination of the scutal margin is not an unexpected modification. The present terga are normal in growth to about half their length, and then there is an abrupt change of growth, the emargination of the scutal margin becoming rapidly deeper. In its early stage the valve is very like that of *Calantica (Scillaelepas) ginginensis*, for it has a similar, wide, flat-topped ridge as in that species, and, in fact, at the base the whole of the carinal limb of the valve is formed by the ridge. This wide, flat-topped ridge is characteristic of *Scillaelepas*, and it may be that the present form is a derivative from some species of *Scillaelepas* such as *C. (S.) ginginensis.*

Scalpellum (Neoscalpellum) glauerti sp. n.
(Plate XI, figs. 1-6.)

Diagnosis.—Tergum V-shaped, with a prominent, wide, flat-topped apico-basal ridge, forming almost the whole of the base of the carinal limb of the valve.

Distribution.—Upper Cretaceous, Middle Senonian (Santonian); Round Hill, Dandarragan, 50 miles north of Gingin, Western Australia. Also probably at One Tree Hill, Gingin.

Material.—Two right terga. One, the holotype (Pl. XI, figs. 3, 4) is in the Western Australian Museum, registered 4194, and the other (Pl. XI, figs. 5, 6) in the Geological Department of the British Museum, registered In. 25,978. A scutum referred provisionally to this species (Pl. XI, figs. 1, 2) is in the Western Australian Museum, registered 4461.

Measurements.—The holotype is complete and has a length of 17.8 mm. and a breadth of 11 mm. The paratype has an incomplete length of 19.7 mm. The scutum has a length of 22.5 mm., and a breadth of 8.8 mm.

Description.—Tergum V-shaped. with a prominent, wide, flat apico-basal ridge, sloping towards the scutal side, and widening gradually towards the basal angle, which is obliquely truncated. Upper carinal margin short, little more than one-third the length of the lower carinal margin. Scutal margin deeply excavated, leaving a narrow limb of the valve on the occludent side, and this is only a little wider than the carinal limb. In the larger valve the carinal limb is rather narrower than in the smaller valve, and is only about the width of the wide apico-basal ridge. These terga vary also in that the smaller tergum has the carinal limb inclined away from the carinal margin, while in the larger valve it is inclined towards the carinal margin; this influences the curvature of the apico-basal ridge and of the lower carinal margin. The emargination of the scutal margin abruptly takes place in the lower half of the valve, for the earlier stages of growth are quite normal. The outer surface is marked by obscure longitudinal ridges.

A scutum from the same horizon as the above terga, but occurring at One Tree Hill, Gingin, may, in the absence of further evidence, be referred to this species. It has the following characters:—

Scutum thick, surface with slightly raised growth-ridges, crossed by obscure longitudinal ridges; triangular, much elongated; strongly convex transversely, rather more steeply on the occludent side; umbo apical. Occludent margin slightly convex; tergal margin slightly convex; basal margin convex, and extending upwards in a wide curve to the tergal margin. On the inner surface the pit for the adductor muscle is large and deep, and takes up almost the whole of the lower half of the valve. The inner occludent edge stands out prominently and is much produced just below the apex; owing to the prominence of this ridge at the apex, there is a deep triangular depression on the tergal side presumably for the reception of the scutal angle of the tergum; the occludent edge is divided by a deep, narrow, longitudinal furrow for the whole length of the valve.

Remarks, and comparison with other species.—Since this type of tergum is unknown among Cretaceous and later fossil species, it cannot be compared with any, and from the recent species it appears to differ in the presence of the wide, raised, apico-basal ridge.

There is no direct evidence for the reference of the scutum to the same species as the terga, and it shows no sign of decalcification; its narrowness suggests such a probability, however, even apart from the agreement in ornamentation, and the association in the same beds of such large valves. This scutum somewhat resembles the elongate scutum believed to have come from the Lower Chalk of Stoke Ferry, Norfolk, and named by Darwin *Pollicipes acuminatus* (1851, Monograph Fossil Lepadidae of Great Britain Pal. Soc. London, p 56, pl. iii, fig 6), although it differs greatly in detail. *P. acuminatus* is markedly curved inwards, and the basal margin much less convex; the basi-lateral angle is acutely angular instead of forming a wide curve, and the valve is much thinner and differs greatly in the details of the inner surface.

EXPLANATION OF PLATE XI.

Scalpellum (Neoscalpellum) glauerti sp. n.

Middle Senonian (Santonian): near Gingin, W. Australia.

Fig. 1. Scutum (right). Outer view. One Tree Hill. W. Austr. Mus., 4461.

2. Inner view of same.
3. Tergum (right). Outer view. Round Hill, Dandarragan. W. Austr. Mus. 4194.
4. Inner view of same.
5. Tergum (incomplete right valve). Round Hill, Dandarragan. Brit. Mus. (Nat. Hist.), In. 25,978.
6. Inner view of same.

All figures x2 diam.

Marsupites testudinarius (v. Schlotheim).

Middle Senonian (Santonian): near Gingin, W. Australia.

Fig. 7. Worn plate x2 diam. Compton's Chalk. W. Austr. Mus., 3935.

8. Inner view of same showing stereom structure.
9. Plate (probably basal). x2 diam. One Tree Hill. W. Austr. Mus., 3957a.
10. Plate (radial). x1.5 diam. Mole Cap Hill. W. Austr. Mus. 3939a.
11. Plate (probably basal). x1.5 diam. Round Hill, Dandarragan. W. Austr. Mus., 4208.

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Contributions from the Department of Biology, University of Western Australia. No. 3.

Description of a new Genus and two new Species of Blind Freshwater Amphipods from Western Australia, by George E. Nicholls, D.Sc., F.L.S., Professor of Biology in the University of Western Australia.

(*Read* June 8, 1926. *Published* July 12, 1926.)

In the collection of freshwater Amphipods which has accumulated as one result of a number of trips made into different parts of this State, are a number of specimens taken at many localities, closely akin to the form recently described by Chilton in this Journal, and named by him *Neoniphargus westralis*, (1925).

The specimens which Chilton examined were some which had been taken by myself, early in the winter of 1922, from a small spring in a valley just immediately east of Darlington Railway Station. In the first instance they were sent to Dr. Calman of the British Museum by Mr. Glauert, to whom I had submitted the specimens for identification. As Dr. Chilton notes, these specimens were returned to Perth and forwarded to him in 1923*.

These first specimens were white in colour and slightly translucent in life, rarely with faint traces of vestigial eyes occurring immediately behind the base of the first antenna; in preserved specimens these vestiges are no longer to be made out.

Specimens obtained later, from other creeks emptying into the Helena River below Darlington, as well as from springs and creeks discharging into the Mundaring Reservoir, while closely resembling in many points, the bleached specimens first obtained, differed visibly in colour, varying from brownish yellow to pink. In these,

* The small collection was supplemented, as I learn from Mr. Glauert, by specimens which the latter had himself collected in the meantime.

however, the eyes though obviously much reduced were clearly visible in life as pinkish white patches of variable shape and size.

From a dam at Katanning a few specimens were obtained of gray green colour, apparently eyeless but with some of the appendages remarkably setose.

Recently, when Dr. Chilton's paper came into my hands, I turned out my material in order to label it and I was then impressed with the obvious differences exhibited by the Katanning specimens. Further investigation showed that the coloured specimens from Darlington and Mundaring were, also, unlike in quite important characters the description given of *N. westralis* by Chilton. For the purpose of confirmation, some fresh material was obtained and examined in the living condition and it appeared evident that the Darlington material comprised two distinct but closely related species both akin to the darker specimens from Katanning.

Chilton, while assigning his new species provisionally to *Neoniphargus*, notes that in a number of points it departed from the condition shown by all of the Eastern Australian and Tasmanian forms, referred to this genus.

The two new forms, to be described below, differ in precisely the same way in respect to these same characters as well as in certain others not recorded for *N. westralis.* Accordingly I have decided to separate the three species in a new genus for which I propose the name *Uroctena*. having reference to the remarkable and distinctive comb-like seta-bearing plate on the proximal joint of the third uropod of the male.

UROCTENA gen. nov.

Near to *Neoniphargus* (?) but with Antenna 2 in the male very stout and almost pediform; side plates not very deep, fourth little excavated behind, with gnathopod 2 much larger than gnathopod 1, particularly in the male; accessory gills on several peraeon segments. Uropod 3 with peduncle broad, inner ramus small; outer ramus moderately elongated, 2-jointed; in the male, proximal end of first joint produced into a flange-like projection set with numerous stout setae, forming a comb-like structure.

With three species:—

U. affinis sp. nov. (sp. typ.).
U. setosa sp. nov.
U. westralis (Chilton), *Neoniphargus w.*, Chilton Journ. Roy. Soc. W.A., Vol. 11, p. 81-84, 1925.

U. setosa sp. nov. (Pl. XII, Figs. 1-6 and Pl. XIII, Figs. 7-9).

Specific diagnosis:—Segments of the urus with a few delicate setae. Eyes absent. Antenna 1 rather less than half the length of the body. Antennae 2 very stout; in the male almost pediform, extremely setose; moderate in the female; gnathopod 2 much larger than gnathopod 1 in the male and, to a lesser degree, in the female; without spinous rows on second joint but very setose on next four joints; carpus triangular with distal lobe well developed, propod oval, palm shorter and less oblique than in *U. westralis* with irregular lobing little developed. Uropod 3, with basal joint broad, outer ramus moderately elongated, two-jointed; the proximal joint bearing, in the male, a narrow flange-like expansion set with long setules. Telson as wide as long, cleft slightly more than half its length.

Length.—All much curved but, measured along the mid-dorsal line, largest male, 9 mm., largest female, 7.5 mm.

Colour.—In life, grayish green; in spirit, dull brown.

Habitat.—Amongst *Chara sp.* growing near edge of a large reservoir at Katanning. Eighteen specimens were taken, of which four were females with well developed brood pouch; one large and eight smaller males; five were immature.

Detailed description:—The first antenna is slightly stouter in the male than in the female, having a flagellum (26 joints in the large male examined) 1¾ the length of the peduncle; in the female, the flagellum (24 joints) is exactly double the length of the peduncle but in neither is it very setose. The accessory flagellum, in both sexes, is 4-jointed and equals in length, approximately, the first four articles of the primary flagellum.

The second antenna is, in the female, (Pl. XII, Fig. 2) markedly setose; in the male (Pl. XII, Fig. 1) it is extremely so; in the latter, also, it is very much stouter than in the female and the flagellum (of ten joints) is distinctly shorter than the combined length of the two more distal joints of the peduncle. The width of the second joint of the peduncle is equal almost to half the length of the flagellum. From a comparison with the figures given by Chilton of *U. westralis* it will be evident that the flagellum in that species is, relatively, even shorter still. In the female the two more distal joints of the peduncle (which is not disproportionately stout) are scarcely longer than the flagellum; as a whole the appendage (in the female) is more slender than the first antenna of the male, whereas in *U. westralis* this does not appear to be the case (Chilton, 1925, Figs. 2a & 3a).

In the peraeon the side plates are relatively short with the inferior margin rounded and closely set with long setae which appear to be much more numerous than in *U. westralis*. The first gnathopod of the female (Pl. XII, Fig. 6) as compared with the second gnathopod, has the carpus considerably longer, but not so distinctly widened distally, and the propod smaller. In the male (Pl. XII, Fig. 3) the first gnathopod seems not to differ very markedly from that of *U. westralis*. The second gnathopod of the female (Pl. XII, Fig. 5) agrees quite closely with that of *U. westralis* except that the basos of the former is relatively shorter and stouter and the limb as a whole immensely more setose. A very large marsupial plate, a large branchia and a small simple accessory branchia are found related to the basal joint of this limb. In the male (Pl. XII, Fig. 4) this appendage exhibits a number of minor differences in the several joints from the corresponding structures in *U. westralis*, the meros of the appendage being relatively shorter and broader, the carpus much less evidently triangular in outline, the propod more nearly oval, the dactyl longer and not so strongly curved. There is no extension of the palmar edge beyond the tip of the dactyl such as Chilton shows for *U. westralis*. The outstanding difference, however, is due to the remarkable development of long setae, arranged in bunches upon the terminal joints.

A largely developed setosity is shown in some others of the freshwater Amphipoda recorded from Eastern Australia, as in *Atyloides gabrieli* and *Gammarus australis* (Sayce 1901) but in none of these does it attain such an extreme development as in this Western Australian form. The sexual difference noted by Chilton (1925) in the third uropod of *U. westralis* is equally well marked in *U. setosa* (Pl. XIII, Fig. 7-8) the male alone bearing upon the distal end of the outer ramus a comb-like plate with 12-14 stiff setae. In its proportions, as compared with the third uropod of *U. westralis*, the peduncle is, perhaps, slightly larger, and is as broad as long, whereas in *U. westralis* the breadth is much greater than the length; both rami being relatively shorter. The inner ramus is smaller generally, the outer less than twice the length of the peduncle, with the distal joint quite half the length of the proximal. The telson (Pl. XIII, Fig 9) is as broad as long and cleft scarcely more than half its length, the two portions bearing, sub-apically, two or three spines and several longer and more slender setae, in which arrangement it differs from the other species of this genus.

U. affinis, sp. nov. (Pl. XIII, Figs. 10-15).

Specific Diagnosis.—All the pleon segments except the last with at least a pair of dorsal or dorso-lateral setules; fourth and fifth segments with two and three pairs respectively.

Somewhat degenerate eyes distinctly to be made out in life, not readily to be observed in specimens preserved in spirits. Antenna 1 about half the length of body, accessory flagellum 4-6 joints. Antenna 2 not so stout as in *U. westralis,* 10 jointed flagellum relatively shorter and more slender with an olfactory cylinder on the penultimate joint.

Gnathopod 2 larger than gnathopod 1. Upon the inner aspect of the basos of this limb is a series of four transverse ridges each bearing from three to five stout spines. Distal lobe upon carpus well developed, propod oval, oblique palm separated only from convex posterior border of the joint by a triangular projection bearing two stout spines between which the tip of the dactyl is received; accessory gills considerably branched are found on some of the appendages of the peraeon. Uropod 3 with basal joint nearly as long as broad; inner ramus small, outer two jointed; comb-like plate on proximal joint, bearing from 18-21 stiff, closely-set setae; terminal joint as long as inner ramus and less than one fourth the length of entire appendage. Telson, cleft almost to the base, three-fourths as long as broad and equal to length of proximal joint of third uropod; a small basal portion curved into a shallow hood-like piece continuing the dorsal surface of pleon from which the cleft portion projects at a sharp angle.

Length.—Not exceeding 9 mm.

Colour.—In life yellow brown, somewhat translucent, chalk-white eyes sometimes appearing faintly pink tinted; in females the ovary is discernable through the body wall and gives a faintly pink tint which is much more noticeable when the brood pouch is filled with large eggs of salmon pink colour.

Habitat.—Found abundantly near the origins of many small springs around Darlington and Mundaring; usually hiding under decaying vegetable matter or actually burrowing in the sandy or gravelly soil beneath the flowing water.

Remarks.—*U. affinis* may be distinguished from *U. westralis,* to which it is closely related, by its distinctive colour, and the presence of degenerate eyes. It appears to differ from that species also in the slightly more slender second antenna (Pl. XIII, Fig. 13-14), and telson (Pl. XIII, Fig. 15).

I had at first supposed that the armature of spines upon the inner surfaces of the basos of the second gnathopod (Pl. XIII, Fig. 12) was a distinctive character, as it was not mentioned by Chilton as occurring in *U. westralis.* I find, however, that it is present in that species also, but is absent in *U. setosa.* Of these three species, all of which are obviously closely related, *U. affinis* may be regarded as the least modified, still continuing to lead a life in more or less open water. The water courses it inhabits are, however, quite liable to dry up, and a habit of burrowing has been formed resulting, in the course of time, in the partial obsolescence of the eyes. It is highly probable that in more permanent waters a still less modified form yet remains to be discovered in which the eyes are well developed and functional.

Uroctena westralis, judging from its bleached appearance and practically eyeless state, is a truly subterranean form probably derived from *U. affinis* and found at the surface now, only when washed up by the stronger flowing of the springs in exceptionally wet weather. *U. setosa* apparently leading a life in surface water, at the present time, is remarkable for the striking development of the setae which are presumably sensory. It is to be regarded as a blind species becoming readapted to surface conditions and may be supposed to have been derived directly from a surface living form rather than from *U. affinis,* lacking as it does the armature of spines on the bases of the second gnathopod. It would appear that the genus has its closest affinities with *Neoniphargus* but has become modified as a result of adaption to burrowing habits and subterranean life. It is noteworthy, however, that in the Victorian species, *Neoniphargus obrieni,* we have a form practically blind which has nevertheless departed very little from the typical Neoniphargid condition.

In the remarkable sex distinction which *Uroctena* exhibits and also in the condition of its mouth parts, there is shown a wide divergence from all existing species of *Neoniphargus.* The mouth parts, indeed, seem to resemble more nearly those of *Niphargus,* to which genus there are resemblances, also, in the elongation of the carpus of the gnathopods and the shallowness of the side plates.

The members of the genus lack, moreover, the dactylar sensory seta, which is so constant a feature in *Neoniphargus.* In *U. setosa,* this is found, in a little developed state, on one appendage only, the second peraeopod.

It is of interest that no fewer than five species of blind Amphipods and Isopods are now known from Western Australia; this number will almost certainly be considerably increased as our knowledge is extended for, in a country such as this, with so little permanently standing fresh water, many aquatic forms could survive as such, only by having recourse to the habit of burrowing and remaining underground in subterranean moisture throughout the long dry season.

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EXPLANATION OF PLATES.

PLATE XII.

(All figures of *Uroctena setosa*)

Fig. 1 First Antenna, male.
Fig. 2 First Antenna, female.
Fig. 3 First Gnathopod, male.
Fig. 4 Second Gnathopod, male.
Fig. 5 Second Gnathopod, female.
Fig. 6 First Gnathopod, female.

PLATE XIII.

Fig. 7 *U. setosa*, third uropod, female.
Fig. 8 *U. setosa*, third uropod, male.
Fig. 9 *U. setosa*, telson,
Fig. 10 *U. affinis*, first antenna, male.
Fig. 11 *U. affinis*, first gnathopod, male.
Fig. 12 *U. affinis*, second gnathopod, male.
Fig. 13 *U. affinis*, third uropod, male, inner view.
Fig. 14 *U. affinis*, third uropod, male, lateral view.
Fig. 15 *U. affinis*, telson.

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Contributions from the Department of Biology, University of Western Australia. No. 5.

Description of a new Species of Uroctena from South-Western Australia, by **George E. Nicholls,** D.Sc., F.L.S., Professor of Biology in the University of Western Australia.

(*Read* July 13, 1926. *Published* July 20, 1926.)

While the plates were in preparation for my paper on the genus *Uroctena*, read at the recent meeting of this Society, I chanced to obtain a number of specimens of yet another species of fresh water Amphipod, referable to this genus. It may be readily distinguished from those previously described by the possession of well developed eyes and the much less strongly developed second antenna.

The species is named in compliment to Mr. H. C. Yelland, M.L.C., in whose company this particular collecting expedition was made and to whose most enthusiastic assistance on several recent occasions I am much indebted.

Uroctena yellandi sp. nov.

Plate XIV. Figs. 1-10 and Text Fig.

Specific diagnosis.—Near to *U. affinis* but with conspicuous white eyes. Segments 2-5 of the pleon with long delicate setae. a lateral tubercle near margin of pleon segments 1-3, the urus with laterally placed spinous setae.

Antenna 1 nearly three fourths the length of the body; accessory flagellum with four to six joints.

Antenna 2 only moderately stout in the male, flagellum ten jointed relatively longer than in *U. westralis*. Each segment with a terminal ring of fine setae, the terminal joint of the peduncle with four such rings of setae. The appendage is shorter and more slender in the female.

Gnathopod 2 differing from gnathopod 1 little in size or shape in the female, but in the male much larger. The armature of spines on inner aspect of the basos of gnathopod 2 little developed; more distal joints not markedly setose; distal lobe on carpus very large, widely separating meros from propod and masking the sub-triangular shape of the joint; propod relatively longer and narrower, palm convex with more regular lobing and marked off from convex posterior border of joint by a pair of large spines between which the tip of the dactyl is received.

Two or three of the peraeopods bear simple (unbranched) accessory branchiae; the dactyl may bear a feebly developed sensory seta.

Uropod 3, with basal joint as long (male) or longer (female) than broad; inner ramus small, with two or three terminal spines outer ramus not markedly elongated, 2 jointed, with the usual comb-like plate on proximal joint in the male; both joints with spines and long setae.

Telson slightly broader than long, scarcely as long as peduncle of uropod 3, cleft for three fifths of its length, a small basal portion bent at an angle to the rest of the piece. The distal lobes are truncate set with a number of long setae and two or three quite stout spines, each notched and with a cilium.

Length.—Not exceeding eight millimetres; females somewhat shorter.

Colour.—In life, palely brown, translucent; in spirit, straw coloured to white. The large chalk-white eyes readily distinguished, even in preserved material.

Habitat.—Found in a creek some miles south of Armadale, harbouring under stones and in tufts of grass. About three dozen specimens, of which almost all were females, were taken on June 28 of this year.

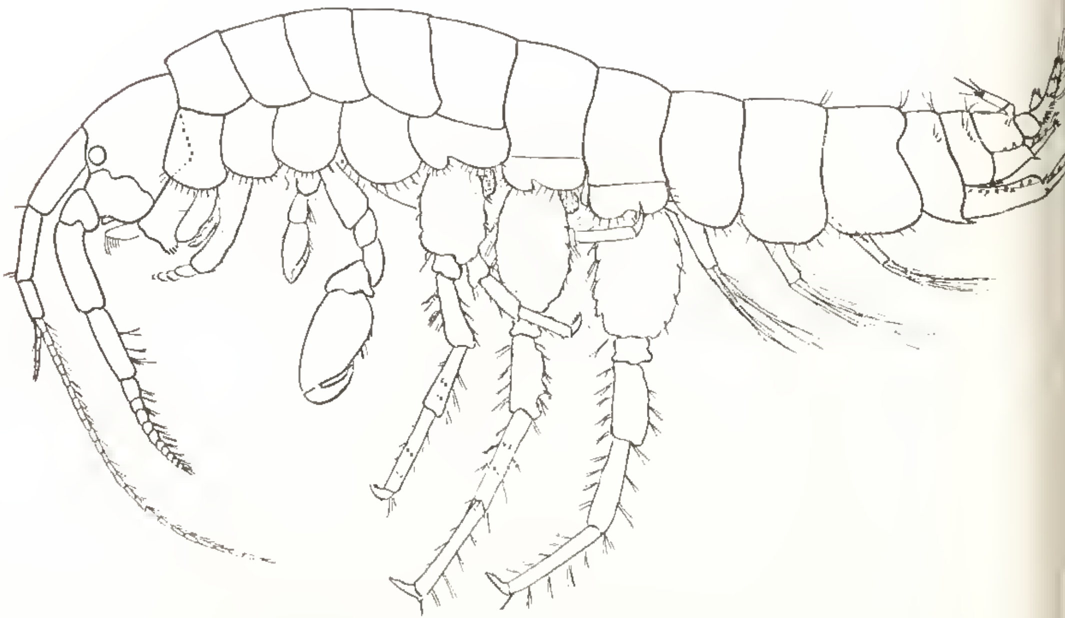

FIG. 1.—*Uroctena yellandi*, male. Side view of whole animal.

Remarks.—In the retention of large and conspicuous eyes, this species appears to be more primitive than the other members of the genus. Associated with this character is the more moderate development of the 2nd antennae (Text Fig. and Pl. XIV, Figs. 2, 2a) which are scarcely stouter than the first antennae in the male, while in the female they are more slender. Nor is there any marked development of the setae such as is found in the blind *U. setosa.*

Accessory gills are present, as in all members of this genus, but are small and apparently unbranched. The armature of spines upon the basos of the second gnathopod in the males of *U. westralis* and *U. affinis* is much less prominent in *U. yellandi* (Pl. XIV, Fig. 5) but upon the inner face of the first joint of the peduncle of the first antenna (Pl. XIV, Fig. 1a) as also upon the carpus of the first gnathopod (Pl. XIV, Fig. 3) and in several of the joints of 3rd, 4th and 5th peraeopoda there is a somewhat similar arrangement of spines.

In other respects, however, the first gnathopod (Pl. XIV, Figs. 3, 4) is much as in *U. westralis*; the propod of the second gnathopod (Pl. XIV, Fig. 5) is more slender than in *U. affinis* and has a pair only of spines, as in *U. setosa,* to receive the tip of the dactyl.

In the female the difference in size of the "hands" (Pl. XIV, Figs. 4, 6) of the first and second gnathopods is but little marked.

The third uropods (Pl. XIV, Figs. 7, 8) are relatively shorter and broader than in the other species, but are perhaps rather more setose. In the male, however, the seta-bearing expansion may have as few as nine setae, a smaller number than is found in any other species.

The telson (Pl. XIV, Fig. 9) is rather shorter and broader and more deeply cleft than in *U. setosa;* rather less deeply cleft and relatively longer than in *U. westralis* and *U. affinis* and distinctly more setose terminally than either of those species.

Upon the whole, it seems to occupy a position intermediate between *U. setosa* on the one hand and *U. affinis* and *U. westralis* on the other. Indeed it is probable that it differs very little from the form from which the three blind or purblind forms have been derived.

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EXPLANATION OF PLATE XIV.

(All figures of *Uroctena yellandi* sp. nov.)

Fig. 1 First antenna (part)

Fig. 1a Inner aspect of the basal joint of the same more highly magnified.

Fig. 2 Second antenna

Fig. 2a Second antenna (same magnification as fig. 2).

Fig. 3 Carpus and "hand" of gnathopod 1

Fig. 4 Carpus and "hand" of gnathopod

Fig. 5 Gnathopod 2, with side plate and branchiae

Fig. 6 Carpus and hand of gnathopod 2

Fig. 7 Third Uropod

Fig. 8 Third Uropod

Fig. 9 Telson dorsal view, highly magnified.

Fig. 10 Dactyl of peraeopod 4, showing slight development of sensory seta.

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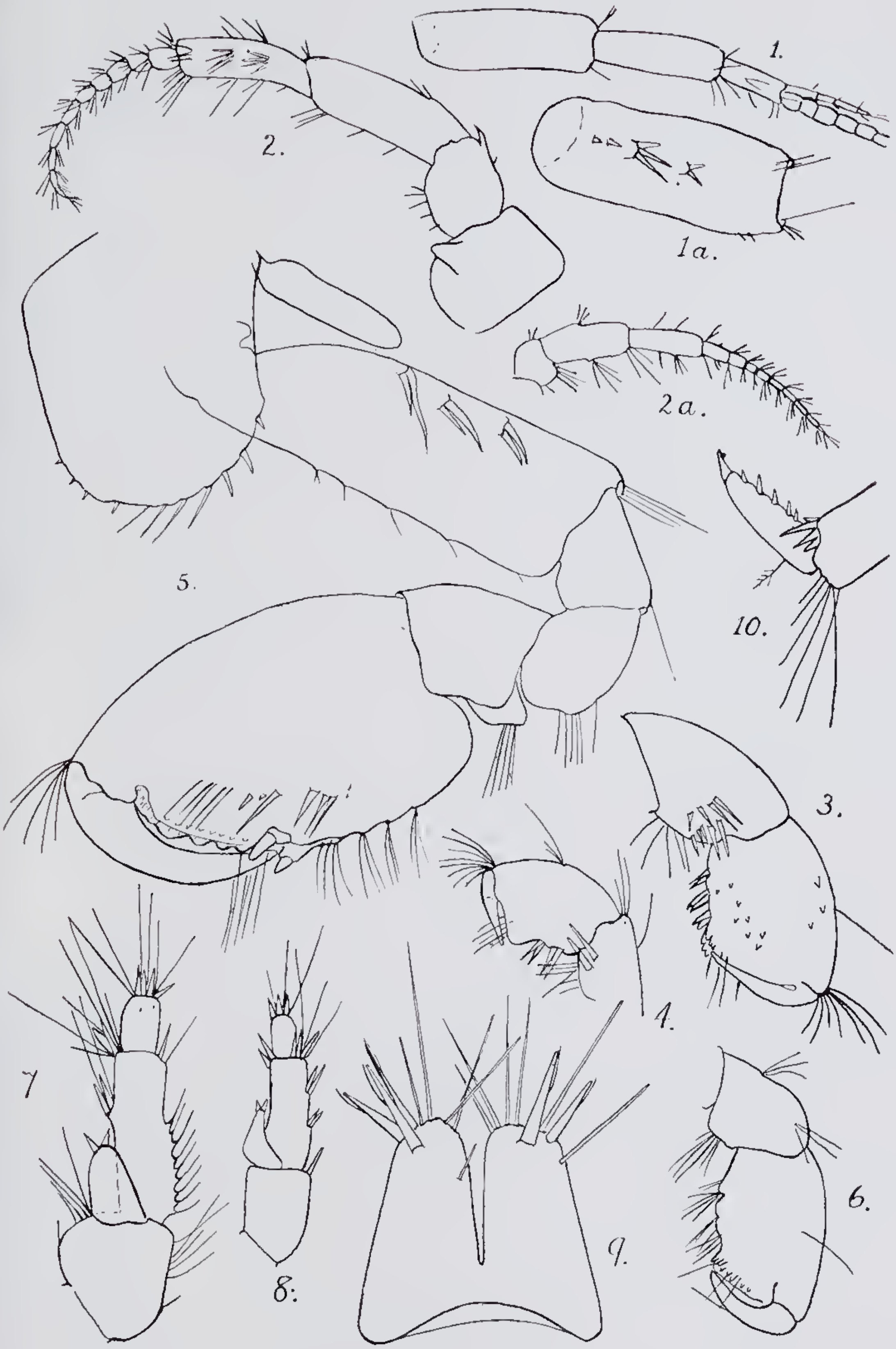
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Natural Regions in Western Australia, by E. de C. Clarke

Lecturer in Geology, University of Western Australia.

(*Read* July 13, 1926. *Published* July 30th, 1926.)

Contents:—

I. Introduction.

"A land of sin, sand and sorrow"—this alliterative misnomer is still, half in jest, often applied to Western Australia. Many in this State and a few outside it know that it is a land of considerable, yet only partly explored possibilities and one which cannot be justly described or appraised in a phrase, however catching. It is, in fact, divisible into a number of "natural regions," each more or less clearly marked off by a combination of circumstances, climatic, geographic and geologic.

This paper is an attempt at such a sub-division, made in the hope that it will arouse some interest and discussion, and not in the belief that it is in any sense final. Such discussion will be of practical value if it draws attention to the unsuspected possibilities of some little known area, or even performs the thankless, but none the less useful, task of pointing out the "nakedness of the land" to the over-optimistic.

Among the many who have helped in various ways, I am especially indebted to Messrs. T. Blatchford and H. W. B. Talbot for information regarding many little known parts of the State, to Mr. E. J. Nankivell for a description of the Carnarvon region, to Miss L. V. Hosking and Messrs. G. S. Compton and Wallace Clubb for reading the paper in manuscript and making many helpful suggestions, and to Dr. Dudley Stamp for invaluable advice regarding the form of the paper.

II. Method of Division.

The natural regions distinguished in this paper are selected in the following way:—

A. The State may be primarily divided into *major physical regions.*

B. It may again be divided into *major geological regions.* These may be expected to effect a sub-division of the major physical regions, but to harmonize broadly with those physical regions.

C. *Climatic considerations,* chiefly the amount and season of rainfall, will be found to necessitate further division of the areas arrived at by A. and B.

By this stage we should have arrived at a classification into natural regions and our result should be in harmony with the distribution of distinctive plant associations.

A. In the broadest way this State can only be divided into two physical regions (Jutson, 1914, p. 19): (1) A low lying narrow strip running almost continuously along the coast from near Albany to Broome. (2) A tableland occupying the whole interior of the State.

B. Geologically Western Australia may be divided broadly into:—

(1) Western coastal strip of Carboniferous or later age.

(2) South-central Pre-Cambrian (chiefly Archaeozoic) shield—mineral bearing, especially in its eastern part.

(3) South-eastern area (Cretaceous and later), which may be sub-divided into a northern part, in which the rocks are mainly sandy, and a southern, in which they are calcareous.

(4) Eastern Pre-Cambrian area.

(5) North-western Pre-Cambrian area, predominantly Proterozoic, which is further divisible into an eastern section, devoid so far as known of mineral deposits of economic value, and a western, containing patches of earlier Pre-Cambrian which carry minerals of value.

(6) West Kimberley—predominantly Proterozoic or lower Cambrian.

(7) East Kimberley—Cambrian-Carboniferous with very large development of basalt.

(8) Area between (5) and (6)—Cambrian-Carboniferous (predominantly Carboniferous), but with minor development of Mesozoic and Cainozoic rocks.

C. Climatic (rainfall) considerations, together with vegetational characteristics lead to further sub-divisions, which need not be particularised since they are shown summarily in the following tabular arrangement:—

Physical	Geological.	Climatic.	Natural Region.
Coastal Strips.	Tertiary and later at surface underlain by Mesozoic and Palaeozoic (artesian).	Northern Summer Rain.	Carnarvon (8)
		Southern Winter Rain.	Perth (4)
	Palaeozoic and Mesozoic Coastal tableland.	Southern Winter Rain.	Greenough (5)
Plateau.	Palaeozoic (chiefly Carboniferous) central belt.	Southern, low rainfall.	Canning (12)
		Northern, monsoonal.	Fitzroy (13)
	Palaeozoic (chiefly Cambrian) N.E. area	Monsoonal	Antrim (15)
	Later Mesozoic and Tertiary: Calcareous (upper) portion (sub-artesian).	Winter rain.	Nullarbor (1)
	Later Mesozoic and Tertiary: Sandy (lower) portion.	Summer rain (small).	Carnegie (9)
	Younger Pre-Cambrian or Lower Cambrian (no known minerals of economic value).	East-Central, dry.	Carnegie (9)
		North Kimberley. monsoonal.	North Kimberley (14)
	Older Pre-Cambrian Central Shield (minerals of economic value).	Northern, mainly summer rain, predominant Mulga vegetation.	Murchison (7)
		Central, winter rain predominant Eucalypt vegetation.	Kalgoorlie (6)
		South-western, winter rain, 10in.-25in., Salmon, York and Morrell association.	Wheat Belt (2)
		South-western winter rain, 25in. or more, Jarrah association.	Jarrah Belt (3)
	Older Pre-Cambrian eastern area.		Warburton (10)
	Mixture of Older and Younger Pre-Cambrian (minerals of economic value).	Summer rain.	North-West (11)

III. Description of the Natural Regions.

1. *Nullarbor.* Geologically, this region is very simple and uniform, being composed of Tertiary limestones underlain by sandy rocks (Maitland, 1919, a., p. 48), from which in places is obtained sub-artesian water of poor quality. Equally simple is the topography of the great treeless plain traversed by the Trans-Australian railway. The vegetation, at least from the general observer's point of view, is sparse and uniform. The rainfall is less than 10 inches except along a narrow coastal strip which is neither large enough nor sufficiently distinct in its possibilities to be separated regionally from the limestone country farther inland. The Nullarbor Region seems unlikely ever to support more than a very sparse pastoral community.

2. *The Wheat Belt.* This region includes the Yilgarn Goldfield with the mining centres of Southern Cross, Bullfinch and Westonia of which complete geological surveys are available (Blatchford and Honman, 1917, and literature there cited), but most of the remainder, except the gold-copper centre Ravensthorpe, has still to be prospected and geologically surveyed. So far as known, the area is composed of crystalline rocks, chiefly acid, but with minor developments of dark coloured basic rocks in which most of the mineral wealth occurs. These rocks are supposed to be Pre-Cambrian, although there is no clear proof of their age (Clarke, 192-, p. 15). Along the southern coast are patches of Tertiary or still later rocks covering areas too small to be separated in this discussion. Topographically this region is the southern part of the Great Plateau of Western Australia (Jutson, 1914, p. 19), and presents the usual characteristics of that upraised peneplain, including the oft-described salt "lakes." Near the coast the topography becomes more varied, with several inlets indicating recent depression, and with conspicuous east-and-west trending ranges (the Barrens). In this southern part of the region Mallee thickets (Gardner, 192-25, Vol. VII, p. 43) are perhaps more abundant than elsewhere in the State. The soil is more fertile than that of the Nullarbor region—as follows from the nature of its constituent rocks. The average annual rainfall ranges from 10 to 20 inches, and most of it falls in the winter. The predominant vegetation of this region is the Salmon Gum-Morrel association to the east, passing into the Wandoo on the west, which in turn grades into the Jarrah forest of the "South-West" outside the limits of the region (Gardner, Vol. VII, p. 40). The eastern portion of the wheat belt is, despite a slightly smaller rainfall, more easily settled than the Wandoo section, which suffers from the disability of being the chief "poison country" of the State. "Nearly all the known poison plants belonging to *Gastrolobium* and *Oxylobium* are characteristic of Wandoo under-

growth and consequently the country has not been settled to the same extent as the Jam country or the Salmon Gum country farther east'' (Gardner, Vol. VII, p. 40). The extent of this region, shown on the accompanying map (Pl. XV), is greater than that of the Wheat Belt on the Agricultural Department's map (Sutton), or in McLintock's ''Swan Geography'' (p. 116), but there seems no reason, having consideration for annual rainfall, time of incidence of rain, and regularity, for regarding the eastern boundary of profitable wheat-growing as coming much short of the 10″ isohyet.

A serious drawback shared by several regions to be later described is the saltness of the ground-water and the absence of any artesian supply. The supply of water is therefore entirely that which is held by surface storage—natural or artificial.

3. *The Jarrah Region.* This region has been geologically mapped only in small patches. It appears to consist essentially of metamorphic rocks (gneisses, etc.) seamed with basic dykes, the complex being thought to be of Pre-Cambrian age. The higher ground is nearly everywhere capped with laterite. Lateritic deposits, indeed, occur in many other parts of the State, but they are most extensively developed in the Jarrah Region. The soil formed by the weathering of the basic rocks is the most fertile. Over incoherent laterite the soil is slightly better than that derived from the more acid rocks, but where, as is usually the case, the laterite is cemented into a ''cuirass''; it bars the downward growth of the roots of most cultivated plants and consequently laterite country is generally unsuited for cultivation. It is, however, on the laterite that the Jarrah (*Eucalyptus marginata*) grows best (Gardner, 1923-25, Vol. VI, p. 104). The region is named after its most important product, but includes more than the ''prime'' Jarrah area (see Gardner, op. cit.).

Comparatively small areas of down-faulted Permo-Carboniferous sediments carrying coal seams occur at Collie and at Wilga (a few miles south of Collie), and are of economic importance (Maitland, 1919, (a), p. 38, 1919, (b), p. 3).

The western part of this region is the dissected western margin of the Great Plateau of Western Australia (Jutson, 1914, p. 19) bounded on the west by the Darling Fault. The topography near the fault-line scarp is somewhat rugged, passing in a distance of 5 miles or so to the east into the more gently undulating contours of the eastern part of the region, which in turn merge into the still more monotonous landscape of the Wheat Belt. This region has a rainfall, predominantly winter and remarkably regular, of between 25 and 40 inches per annum.

The most valuable forests of the State occur in this region, Jarrah and Karri being of greatest importance.

Climate and topography combine to make the Jarrah Region almost immune from the water supply problem. The streams traversing the line of the Darling fault, in deep, steep-sided valleys, are admirably suited for the construction of dams which will furnish water to the region described next. Many of these streams are perennial. Well water of fair quality, but limited quantity, is also available in many places. In this region, however, as also in the main Wheat Belt, clearing and cultivation lead to an increase in soil salinity (Wood, 1924).

4. *Perth Region.* Geologically, this region consists of practically undisturbed sands, clays and limestones, of Recent and Tertiary age, over-lying Mesozoic and Palaeozoic sediments, which are thought to dip gently S.W., but are not known to outcrop in the region. The most important water carriers of the artesian province which is roughly coterminous with the Perth Region, are thought to be the Jurassic sandstones (Maitland, 1919 (a), p. 6).

The country is undulating, with inconsequently scattered sandhills now fixed by vegetation or cemented by carbonate of lime, except along the actual sea margin. The limestones formed by this cementation resist rain-wash better than the sands and stand up as low hills. Many ponds and small lakes occur in chance hollows among the sand dunes, and some of these have advanced to the stage of peat swamps, which form rich soil when drained.

The sub-recent elevation which was responsible for the emergence of the coastal plain has been followed by a slight depression giving shallow estuaries at many of the river mouths.

Very few of the rivers carry any fresh water to the sea during the summer. As a result of this intermittent flow, sea-built sand bars obstruct the estuaries, whose value as harbours is thus much lessened. Moreover, the consequent ponding back of the river water causes rise of the water table and water-logging of the neighbouring low-lying country (Shields, p. 2). Water for use in the more densely settled parts is being increasingly drawn from reservoirs in the Darling Range (Jarrah Region). The Perth region is however an artesian water basin (as already noted), and, moreover, has an abundant supply of ground water at shallow depths.

The eastern margin of this region, where the soil is partly derived from acid and partly from basic rocks, is fertile (Woolnough, p. 16), being the chief vine-growing belt in the State. The outer portion, although excessively sandy, is nevertheless stated to be suitable both for dairying and market gardening when worked in conjunction with the intervening swamps.

5. *Greenough Region.* This may be described as a tableland of Jurassic sandstone dissected by well-defined watercourses which have in places reduced the tableland to groups of mesas and buttes overlooking plain country formed of older rocks. The sandstones produce a poor soil, and it is the more fertile areas of exposed Permo-Carboniferous and older rocks that are settled. On the seaward side of the dissected Jurassic tableland is a rather narrow fringe of lower-lying ground, which probably has, except for its lighter rainfall, the same characteristics and possibilities as the Swan Region. In places where the Jurassic rocks have been removed, ancient "Pre-Cambrians" are exposed, in which, in the Northampton district, are notable occurrences of lead ore.

The annual rainfall of the Greenough Region is 15-20 inches, nearly all of which falls in winter. The region therefore comes climatically within the Wheat Belt. On the Jurassic rocks there is good ground-water close to the surface, but on the more fertile older rocks the ground-water is saline and generally unusable. In this portion reliance has to be placed on excavated tanks.

Some fodder plant may yet be found which will grow freely in the sandy soil yielded by the Jurassic rocks, but until such a discovery is made the region must remain almost uninhabited.

Coal seams are known in the Permo-Carboniferous rocks (Campbell, 1910), but their economic possibilities have yet to be proved.

6. *Kalgoorlie Region.* This part of the State is composed of ancient crystalline rocks, mainly acid, through which are scattered lenses of basic rocks which cover about one-fifth of the region and carry the chief gold deposits of Western Australia. The topography and vegetation are like those of the Wheat Belt, except that in the Kalgoorlie Region the ranges of N.W.-trending hills marking lenses of basic rock are somewhat more prominent and abundant. It is marked off from the Nullarbor Region by geologic, and from the Wheat Belt by climatic characters, its rainfall being less than 10 inches.

Considering its climate, the Kalgoorlie Region has been very fortunate in having, in the Salmon Gum forest ample supplies of good mining timber and firewood. Without these the difficulty and expense of mining development would have been so much greater that one is almost justified in saying that there could not have been a "Golden Mile."

Salt "Lakes" (Jutson, 1914, p. 20) are the most marked physiographic feature of the region, but this it shares with the Wheat Belt and with the Murchison Region to be next described. Defined watercourses are rare, inconspicuous, and very seldom contain water.

The ground water is almost everywhere too salt for use. The majority of the population obtains water from the Mundaring Reservoir in the Darling Range (Jarrah Region), whence between 3 and 4 million gallons are pumped daily. The total length of main pipe line is 380 miles and it supplies en route 30 towns and has 493 agricultural extensions. Away from the pipe-line, water must be obtained either from natural reservoirs (gnamma and rock-holes and intermittent soaks—Jutson, 1914, p. 129 and literature there cited) or from artificial reservoirs.

The rainfall is best estimated at less than 10 inches per annum. It is true that several places show an average, calculated from records over a number of years, of 10 inches or more, but this is probably due to local thunderstorms. It seems unlikely that any activity requiring more than a 10-inch rainfall can be permanently established. When the forest is removed for mining firewood and timber the soil supports a more abundant and attractive growth of the salt-bush and grass on which sheep and cattle thrive. This region is, therefore, destined ultimately to become a sparsely settled pastoral area, but at present its mineral production is more important. From the beginning of mining activity up to the end of 1925, the East Coolgardie Goldfield, i.e., mainly the mines of the "Golden Mile," had produced, from nearly 31 million tons of ore, 19½ million fine ounces of gold, valued at 82¾ million pounds sterling. Although for many years production has declined for various reasons—some not connected with the value of the mineral deposits—it will long remain an important gold producer.

This region, with the Wheat Belt region, constitutes the most important sandal-wood area of the State.

7. *Murchison Region.* In geology and topography this is essentially similar to the Kalgoorlie Region, but the relief is somewhat more pronounced, "breakaways," for example, being a far commoner feature (for general discussion of breakaways, see Talbot, 1917, p. 43). Rainfall differs little in amount from that of the Kalgoorlie Region, but we are now passing into the regions of summer rainfall. In vegetation and water supply, moreover, there is marked contrast to the Kalgoorlie Region. Throughout "the Murchison," except of course right on the margins of salt lakes, potable water can almost invariably be obtained at depths of less than 100 feet, and the predominant plant association is the Mulga (Gardner, 1923-25, Vol. VII, p. 256), in contrast to the Salmon

Gum association of the Kalgoorlie Region. It should be noted, however, that the Spinifex association so characteristic of the country to the east, makes considerable inroads into the Murchison Region.

Although much mineral wealth has been and will be obtained in this region, it was first settled by pastoralists and is now the most important sheep-carrying area of the State. It has greater drought resistance than the Kalgoorlie Region because of the almost universal presence both of good well-water and edible shrubs. The N.E. boundary has been extended to long. 124°, lat. 26°, into an area of probably Proterozoic rocks, so as to include the good pastoral country of Wongawall (Talbot, 1920, p. 16), which seems less out of place here than in the Carnegie Region.

8. *Carnarvon Region.* This region is entirely composed of sedimentary rocks with, generally, a gentle westerly dip, but there is, according to Mr. E. J. Nankivell, gentle folding along a N.N.W. axis between the Wooramel and Minilya rivers. It coincides with the North-West Artesian Basin (Maitland, 1919, c.), and is thus very definitely distinct from the country to the north. Its oldest and easternmost rocks are "Permo-Carboniferous," followed by Jurassic, which are in turn overlain by Cretaceous and younger rocks.

Its southern portion, lying on the border between areas of summer and winter rain, has an average annual rainfall of less than 10 inches, and the rainfall shows wide variation from year to year. The northern portion has an average of more than 10 inches, and lies distinctly within the area of summer rain. However, in view of the persistence of other characters, this difference in rainfall is not sufficient ground for dividing the area into two regions.

I am indebted to Mr. E. J. Nankivell for a description of the topography and vegetation. The region seems particularly difficult to describe in a general way. Its relief is mild, the hills, which are residuals of erosion of the cuesta or escarpment or butte type, are neither lofty nor numerous, but, though they rise only in a few places as much as 1000 feet above sea-level, they are very conspicuous because of their steepness. The soil is predominantly sand or sandy loam, but clay soils are fairly common in the southern portion, and in some places are areas of limestone-derived soil. Much of the country is therefore very porous, and consequently reticulation from artesian wells is costly. The entire region is described as excellent pastoral country, although in parts there is the water-supply difficulty just mentioned, and in the northern section the water so far obtained is said to be generally saline.

The covering of shrubs—chiefly Mulga and other Leguminosae—is fairly dense in the southern portion, and is of value as fodder, particularly in times of drought. North of the Wooramel River (lat. 26°) the country, though still excellent pastorally, is more sparsely shrubbed.

It is generally thought that this Region will remain a lightly settled pastoral area, although a map (1924) and pamphlet (1924, p. 25) issued by the Department of the North-West, suggest the possibility of the development in its coastal portion of tropical agriculture by means of irrigation.

9. *Carnegie Region.* This area may be known by the name of the first explorer to traverse it thoroughly (Carnegie, 1898). Its southern part is, so far as known, made up of late Mesozoic or early Tertiary sediments, which dip gently south and are the water-bearing beds of the Nullarbor Region (Maitland, 1919 (a), fig. 70, p. 46 and p. 49). The northern part, which has not been geologically mapped, is probably in part composed of the same Mesozoic and later rocks and, in part, of the much older Nullagine System. As noted later, its western boundary, against the Canning Region, has not yet been defined.

The rolling sandhill country, clothed with spinifex, dotted with "desert gums," and interrupted here and there by "breakaways," was described with much aversion by its first explorers. Those who have more recently crossed it, well-equipped both materially and also with the experience of the pioneers, have not found the "hateful spinifex" country as forbidding as might be expected (Talbot, 1917, pp.16-17, 22-38).

A few salt lakes are known to occur in this area. We are too ignorant regarding their outline to attempt the reconstruction from them of a dismembered river system, as has been done by Gregory (1907) for the Kalgoorlie, Murchison and other regions. Water-courses are absent except in and near the "breakaways." The natural waters are gnamma- and rock-holes and a few evanescent soaks. The absence of native wells is in strong contrast to their abundance in the adjoining Canning Region to be presently described. No wells have been sunk in this country and we have, therefore, no direct knowledge of the nature of the water supply. From what is known of the geology, it would appear that, being situated partly on the intake beds of the Eucla artesian basin, this region will not yield artesian water.

Our knowledge of the Carnegie Region is very meagre. What we do know indicates that it is an area of no mineral wealth and is pastorally practically valueless.

10. *Warburton Region.* This region, which possibly extends as far north as Lake Macdonald (lat. 23° 30′) is mainly composed of

acid metamorphic and gnessic rocks, supposedly Pre-Cambrian, together with a minor amount of Nullagine (?) sediments, but there is amongst them a notable development of two types of basic igneous rock, one a "Greenstone," similar to the greenstones of the Kalgoorlie and Murchison regions, the other unaltered dolerites and gabbros (Talbot, 1917). In the character of its vegetation the Warburton Region recalls the Murchison. Topographically, the tableland of the Carnegie Region is continued into the Warburton, but above the general level rise ranges, some in the old crystalline rocks, some in the later dolerites and gabbros, some in the hard Nullagine sandstones. Draining from these hills and losing themselves in the sandhill country of the Carnegie Region to north, west, and south, are several well-defined watercourses.

One shallow well with a large supply of potable water is known, and good springs have been noted in several localities. Probably good stock water is easily obtainable in most parts of the Region.

The region would be as successful pastorally as the Murchison (Talbot, 1917, p. 118), and there are hopes that payable deposits of gold will be discovered, but its relatively small size and inaccessibility will hinder its development for many years.

11. *North West Region.* This large area, traversed by several more or less parallel rivers (De Grey, Fortescue, and Ashburton), includes a variety of geological formations of assumed Pre-Cambrian age, namely, the almost horizontal Nullagine System which occupies about three-quarters of the region, the more steeply inclined but little metamorphosed Mosquito Creek Series, and the highly altered "greenstones" and intervening granites composing the northern portion, in which there are widespread and varied mineral deposits, including copper, tin, lead, tantalite, asbestos, and gold.

The topography of the area is naturally a reflection of its geology, so that whereas in the southern part mesas and buttes are characteristic, in the northern part the scenery varies. As in the Kalgoorlie and Murchison Regions, granite country is flat or gently undulating; "mineral belts," such as Marble Bar, Nullagine, Braeside (lat. 21°, long 121°), and Lionel, near Nullagine, are, in a small way, very rugged.

However, these geological and topographical differences are too intermingled to justify the separation of the area into two or more regions of individuality equal to the others described in this paper. Perhaps the factor which overrides geological differences is the prevalence throughout the region of uncertain summer rainfall.

As to vegetation, the region is characterised by the predominance of the Spinifex association, the Mulga, so characteristic of the

Murchison, being here only sporadic. The northern boundary of the Mulga is approximately (Gardner, 1923-25, Vol. VII, p. 256) marked by a line from the junction of the Lyons and Gascoyne rivers to Wiluna. The Spinifex is largely of the "soft" variety, which I am told by Mr. C. A. Gardner is probably a different species from the "buck" spinifex (*Triodea pungens*) and which has considerable fodder value. However, the comparative absence of shrubs and trees, edible or shade-giving or both, makes this region far less drought-resistant than the Murchison. Water is obtained from wells and pools in the watercourses; there is no artesian water in the region.

The chief industries of this area are and will continue to be pastoral and mining, although, according to the map (1924) issued by the Department of the North West, the coastal portion may be suitable for tropical agriculture under irrigation.

12. *Canning Region.* Almost all our knowledge of this region, called after Mr. A. W. Canning, who laid out a practicable stock route across it, is derived from Talbot's report (1910). Geologically it is an area of Permo-Carboniferous and older sediments, arranged in gentle folds. These rocks are largely masked by a covering of sand-dunes. How far it extends eastward is unknown (Clapp, p. 226). As already noted, this region is distinguished from the Carnegie by its sprinkling of "native wells" which, though perhaps mostly mere "soaks," at any rate indicate a more accessible water supply (cp. Clapp, p. 230). The most hopeful feature of this Region is that it is an artesian basin (Maitland, 1919 c., pp. 4 and 5), and may, therefore, become sparsely settled by pastoralists. Of late, also, it has been reported to possess some of the structural characters of an oil-bearing region.

Wallal Sub-Region. This narrow belt of sandy country bordering on the "Ninety-Mile Beach" has been mapped as Tertiary and Recent in age. Topographically it seems distinct from the Canning Region, from which it also differs in that its ground water is shallow and abundant, and by the fact that it supports a good growth of couch-like grass. This sub-region is all selected by pastoralists (Station Map, 1924), in striking contrast to the Canning country inland. Further description will be found in Clapp's paper (pp. 212, 228, 229, 230).

The portion of the State which still remains to be regionally classified is the Kimberley Land Division. For the western part we have recent botanical reports by Gardner (1923 and 1925, Vol. VIII), who recognises seven plant formations:—

(a) Savannah Woodlands covering country east and north of the King Leopold Range except that occupied by (d).

(b) River forest—along the river beds in (a).

(c) Mangrove forest—along the coast line.

(d) Northern sclerophyllous woodlands—in the north-west corner of (a).

(e) Littoral forest—a narrow coastal strip particularly marked near the Prince Regent River.

(f) Grasslands—principally on the plains of the Lennard, May, Meda, and Isdell rivers.

(g) Pindan (low sclerophyllous woodland) characteristic of the south-west part of the Kimberley, east of Broome.

Of these the River, Mangrove, and Littoral forest cover small areas and can hardly be said to constitute natural regions, but the savannah woodlands, northern sclerophyllous woodlands, grasslands, and pindan should be useful guides.

It is suggested that in the Kimberley the following regions may be recognised:—

13. *Fitzroy Region.* This area is essentially composed of Permo-Carboniferous rocks. However, a very large part is covered with a superficial layer of alluvial material brought down by the Fitzroy River and its tributaries. Thus the fertile flats bordering on the Fitzroy and lesser streams (Gardner's "grasslands") differ markedly from the sandier pindan country, which southwards merges gradually into the sandridges of the Canning Region and northwards into the foothills of the Napier and other ranges. Like the Canning region, from which it is distinguished by its greater rainfall, its eastern limit is unknown.

In normal years there is sufficient surface water in the form of "billabongs," etc., for pastoral requirements. The region also has artesian water, being on the northern edge of the "Desert" basin (Maitland, 1919 c., fig. b), but its artesian supplies have been only slightly explored.

This region carries large cattle runs, but is also marked by the Department of the North-West as suited for tropical agriculture, and has for some years been systematically prospected for petroleum with fairly satisfactory results.

14. *North Kimberley Region.* The greater part of this region, which is vividly described by Easton (1922), is occupied by sandstones and basic igneous rocks, either later Pre-Cambrian or Lower Cambrian in age (Maitland, 1919 a., Geological Map; Wade, 1924, p. 14 and Geological Map). There is, however, a southern fringe of ancient crystalline rocks, in which in 1884 was made the first im-

portant gold find in the State. Jutson (1914, p. 76) terms the region an uplifted and dissected peneplain. Later subsidence has "drowned" the rivers for many miles above their mouths and has produced several good harbours, which are of little present value owing to the inaccessibility of the tableland from the deep gorges (Easton, 1922, p. 25). The annual rainfall is at least 20 inches, practically all of which falls in summer. Gardner describes the region under the general term of Savannah Woodland. Feed is abundant, varied, and of better quality than that of other pastoral areas in the Kimberley (Easton, 1922, p. 7). This region will not long remain unsettled by pastoralists, despite the difficulties of transport and the wild character of the aborigines. It does not hold out much prospect of mineral wealth (Easton, 1922, p. 40), but it must be noted that no detailed geological survey has ever been made, and that published information (Maitland, 1902, pp. 8 and 9) is small. In this connection Wade's remarks (1924, p. 39) may be noted.

In the north-west corner of this region is an area marked off by Gardner (1923, p. 19) as sclerophyllous rain forest, which is distinguishable from the savannah woodland by its more slender and more abundant trees, by the presence of harsh Xerophilous shrubs in its undergrowth, and by the comparative scarcity of grass. Pastorally, this area is inferior to the savannah country, and should possibly be separated as a sub-region.

15. *Antrim Region.* In strong contrast to the rugged topography of the North Kimberley are the open "downs" of this region (named from the Antrim Plateau, which constitutes most of it), which no doubt extend far into the Northern Territory. The western boundary, I am informed by Mr. T. Blatchford, follows closely the line separating the rugged Pre-Cambrian or older Cambrian from Upper Cambrian and later rocks, which tend to wear away into great open rolling expanses above which rise a few buttes and small mesas like Mt. Panton. The rainfall ranges from 20 to 40 inches and is, as elsewhere in the Kimberley, of the summer monsoonal type. It seems possible that, in the northern part, the alluvial flats will prove suitable for tropical agriculture. At present the sole industry is the raising of cattle. Like the Fitzroy region, this area, also, may yet prove to contain oil in payable quantities.

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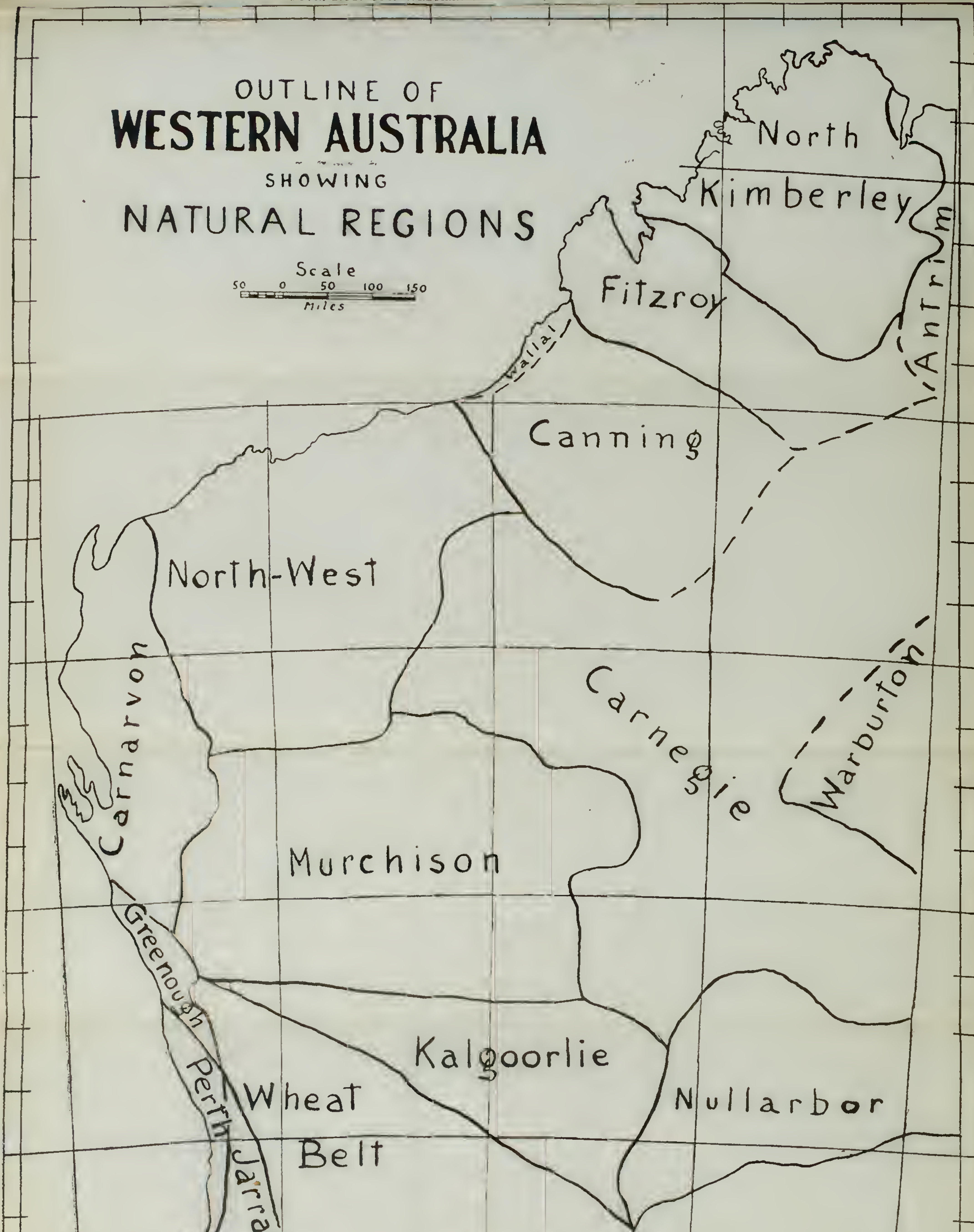
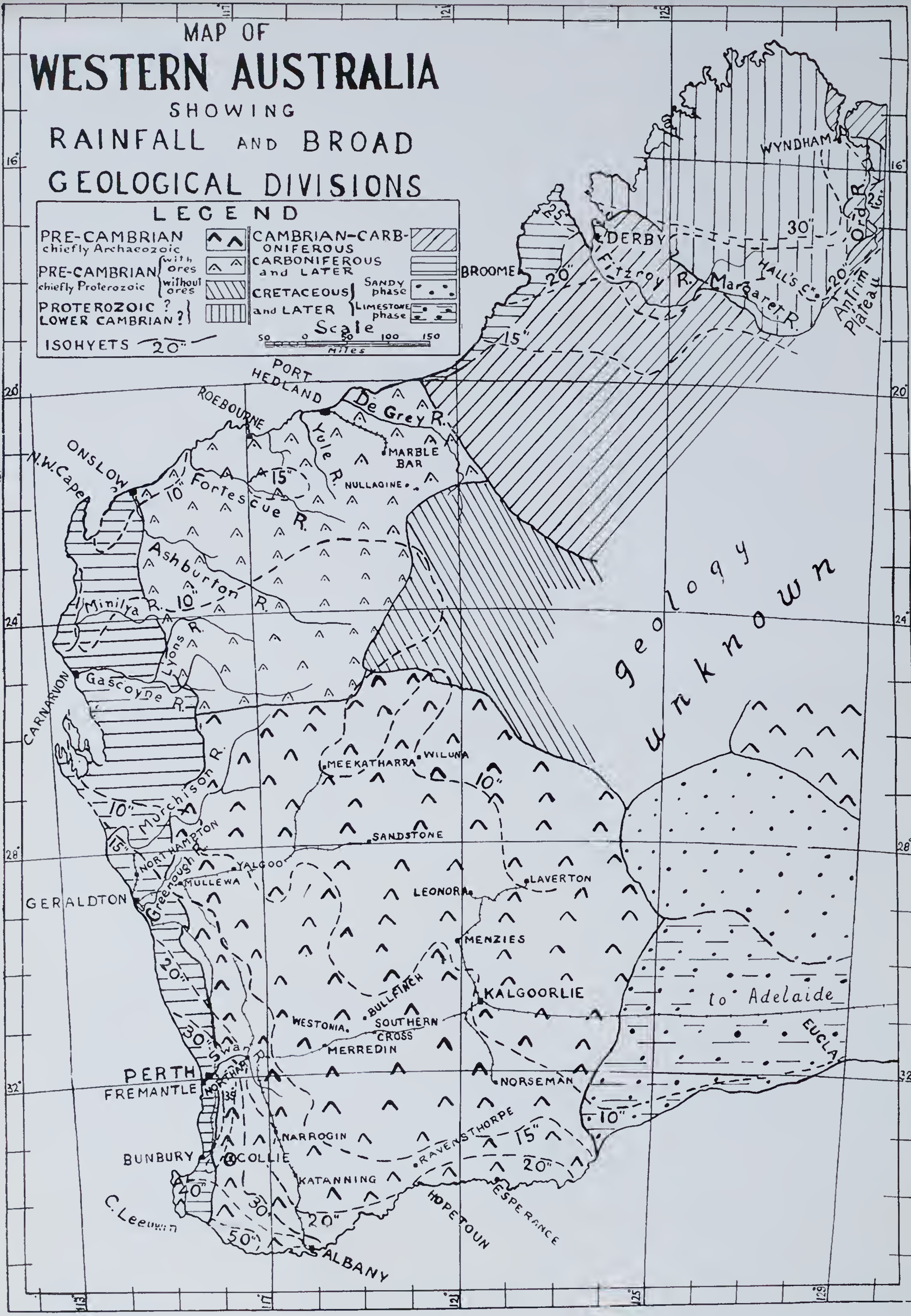
EXPLANATION OF PLATE XV.

Outline of Western Australia, showing Natural Regions, to be placed over map of Western Australia showing Rainfall and broad Geological Divisions.

Printed for the Royal Society of Western Australia by R. S. Sampson, 971-973 Hay Street, Perth.


OUTLINE OF
WESTERN AUSTRALIA
SHOWING
NATURAL REGIONS
Scale
50 0 50 100 150
Miles
North
Kimberley
Antrim
Fitzroy
Wallal
Canning
North-West
Carnarvon
Carnegie
Warburton
Murchison
Greenough
Kalgoorlie
Perth
Wheat
Belt
Jarrah
Nullarbor


MAP OF
WESTERN AUSTRALIA
SHOWING
RAINFALL AND BROAD
GEOLOGICAL DIVISIONS
LEGEND
PRE-CAMBRIAN chiefly Archaeozoic
PRE-CAMBRIAN chiefly Proterozoic with ores
without ores
PROTEROZOIC ? LOWER CAMBRIAN ?
CAMBRIAN-CARBONIFEROUS
CARBONIFEROUS and LATER
CRETACEOUS and LATER
Sandy phase
Limestone phase
ISOHYETS 20"
Scale
50 0 50 100 150
Miles
geology unknown
WYNDHAM
DERBY
BROOME
Fitzroy R.
Margaret R.
HALL'S Ck.
Ord R.
Antrim Plateau
PORT HEDLAND
ROEBOURNE
De Grey R.
Yule R.
MARBLE BAR
NULLAGINE
ONSLOW
N.W.Cape
Fortescue R.
Ashburton R.
Minilya R.
Lyons R.
Gascoyne R.
CARNARVON
Murchison R.
MEEKATHARRA
WILUNA
SANDSTONE
NORTHAMPTON
Greenough R.
YALGOO
MULLEWA
GERALDTON
LEONORA
LAVERTON
MENZIES
BULLFINCH
KALGOORLIE
WESTONIA
SOUTHERN CROSS
MERREDIN
to Adelaide
EUCLA
PERTH
FREMANTLE
Swan R.
NORTHAM
NORSEMAN
NARROGIN
RAVENSTHORPE
BUNBURY
COLLIE
KATANNING
HOPETOUN
ESPERANCE
C. Leeuwin
ALBANY
10"
15"
20"
25"
30"
40"
50"
16°
20°
24°
28°
32°
113°
117°
121°
125°
129°

Contributions from the Department of Biology in the University of Western Australia. No. 7.

A Description of Two New Species of Acrotelsa by Professor G. E. Nicholls, D.Sc., F.L.S., and K. C. Richardson, B.Sc.

(*Read* July 13, 1926. *Published* August 2, 1926.)

The only work which has appeared, hitherto, dealing with the Thysanura of Western Australia, is that of Silvestri (1907), who described a collection made by the Hamburg Expedition in 1905 under Drs. Michaelsen and Hartmeyer. Silvestri states that although Western Australia was at one time regarded as almost lacking in Thysanura, no fewer than sixteen species were represented in this collection, fifteen being referable to the family Lepismatidae and one to the Japygidae. Of the former, twelve species proved to be new, and for one a new genus (Trinemura) was established. Of the fifteen genera of Lepismatidae mentioned by Escherisch in his monograph on the group, the genus Acrotelsa, to which belong the two new species here described, is almost cosmopolitan. It is of interest that the first Thysanuran recorded from Australia was a specimen of the genus (*Acrotelsa producta*) from the Peak Downs in Queensland.

The classification of this family is based largely on the following characters:—The distribution of the setae and the tufts of setae or combs; the shape of the tenth tergite and the arrangement of the setae thereon; the number of abdominal styles, and the form of the genital appendages, body scales and palps. Very little importance seems to have been attached to the structure of the mouth parts, perhaps because of the general similarity that exists between those of the different species and of the difficulty of dissection. In this contribution an endeavour has been made to give a more complete description of the appendages, with a view to assisting in identification, though differences in the structure are not always very marked in closely related forms. Silvestri has attached importance to the metasternite, both as to its form and the arrangement of the setae upon it. An account is here given of the condition of the mesosternite as furnishing a further aid to identification.

The specimens described form part of the collection of the

Western Australian Museum, and our thanks are due to Mr. Glauer, the Assistant Curator, for the opportunity to examine this material.

Acrotelsa splendens sp. nov. (Plate XVI, figs. 1-10.)

Specific Diagnosis.—Body elongate, dorso-ventrally compressed anteriorly; subcylindrical posteriorly; thorax scarcely wider than the abdomen. Head prominent, well marked off from the body and bearing anteriorly two very conspicuous tufts of setae, the large black eyes posteriorly situated. Tergite ten sharply terminated, the converging edges concave outwards and with groups of setae arranged alternately on each side. The entire body, including the legs, covered with scales. Antennae about as long as the body. Median anal cerci as long as the abdomen. Metasternite sub-triangular in shape, with two closely approximated rows of setae one each side of the apex. Mesosternite smaller, more pointed, and with two rows of setae on each lateral margin. Ovipositor without small tuberculate spines at its apex.

Colour (in spirit) pale yellow with a dense covering of reddish brown and black scales.

Length: male 9 mm.; female 7 mm.

Locality: Mount Nairn, and the Milly Milly district.

Detailed Description.—The *Body* (Pl. XVI, fig. 1) is distinctly more flattened in the thoracic region than in the abdominal, the thoracic tergites being laterally less closely adherent to the body, making it approximately as wide as the abdomen. The entire surface is covered with scales, which appear much denser in the lateral regions than dorsally, owing probably to their being shed from the central portion of the segmental plates.

The *head* is semicircular in outline anteriorly, the eyes set well back from the origin of the antennae. The cephalic setae are stout, pectinate and radially arranged, whilst the mandibular setae project far beyond the outline of the head. The intersegmental neck region is well defined, giving the head a detached appearance.

The *prothorax* is about half as long as broad, the posterior margin of the tergite being excavated by a deep, almost semi-circular notch. The lateral margins are fringed with stout, pectinate setae, and the posterior margin has two symmetrical combs of similar bristles.

The *mesothoracic tergite* is the largest, its posterior margin not being excavated but rather convex, and carries two combs of setae similar to those upon the preceding segment. The lateral margins are setose, but less conspicuously so.

The *metathorax* is similar in shape to the mesothorax, but orter, with typical combs of setae.

The *abdomen* may be described as almost barrel-shaped, widest the region of the fourth segment and tapering slightly towards e tenth. The scales are more abundantly present here than on e thorax. The anterior abdominal sternites have a straight sterior edge, and two combs, of about ten setae in each, are set a slight inclination to the edge in a lateral position (figs. . and 1b). The tenth tergite, or telson (fig. 2) is elongated and arply pointed, the width being 1.4 times the length; the lateral argins are concave outwards, giving it a more pointed appearance. nis feature serves to distinguish it from the species described by lvestri, *A. devriesiana* and *A. devriesiana* sub-sp. *perspinata*, the argins of which tend to be slightly convex outwards. Further, the our paired tufts of setae on the telson are arranged asymmetrically, lvestri figuring in his species six pairs of symmetrical combs in the ne and two similar pairs in the other.

Head appendages. The antennae (figs. 9 and 9a), have an enrged basal joint, the second joint being only slightly larger than iose immediately following. Each segment bears two rows of tae, the proximal row circumferential, the other terminal, scales eing present in transverse rows. Towards the apex of the antenna, onstrictions appear at intervals of 6 segments, dividing the antenna ito zones.

The *Mandibles* (fig. 7) are strongly convex, with the cutting lge bearing three distinct teeth on the inner margin, with the naracteristic groups of long and short setae. The outer surface is overed over its proximal half with numerous long, stout, pectinate etae. Silvestri makes no reference to the mandible and gives no gure of it in the species he describes.

The *maxilla* (fig. 6) is characterised by the length of the palp, ut is otherwise typical, having the two terminal segments shorter han those preceding it. The setae of the palp are simple and pirally arranged, and, on the third segment, much more numerous han on the two preceding; on the basal segment there is but a ingle row, whilst the second has two rows. Four stout bifid setae re borne on the basal portion of the maxilla or stipe, proximal to he origin of the palp. The galea is pointed, fringed with short, imple setae. The lacinia is produced distally into two prominent eeth, below which are five curved plate-like processes; marginally here are five stout equidistant bristles.

The *labium* (fig. 5) is large and well defined. The lobes of the sub-mentum are produced laterally to give the appendage a width which is about twice as great as its long axis. The sub-mentum has a deeply concave postero-lateral edge and bears a single row of bifid setae at a short distance from its suture with the mentum. The well developed mentum has a similar transverse row of bifid setae. The lobes of the glossae and paraglossae are rounded and of approximately equal length, forming a subconical extension to the labium. The stout palp is approximately equal to the greater width of the labium and is closely covered with spinous setae. On the third segment the inner margin bears distally a small group of pectinate bristles. The terminal segment is oval or subglobular in shape; densely clothed with short simple setae and bearing apically a number of sensory papillae in a sub-circular row.

Thoracic Appendages.—The legs (fig. 4) are stoutly developed and project well beyond the lateral margins of the thorax. The femur is slight, short, and has a group of three pectinate setae immediately external to its articulation with the tibia. The serrations are developed on both margins of the setae and along their entire length, differing, thus, from those of the head and mandible. The tibia and tarsus are moderately elongate, the latter bearing symmetrical, elongate and only slightly curved claws (fig. 4a). A short median pulvillus is present as a reduced, inwardly curved hook.

The *mesosternite* (fig. 3a) is small, obtusely pointed and set with two double rows of setae on each side.

The larger *metasternite* (fig. 3) is rounded apically, slightly emarginate, and bears a single set of combs arranged on each side. The setae of both meso- and metasternites are typically pectinate.

Abdominal appendages.—Ventral styles occur only on the eighth and ninth sternites. Those occurring on the eighth segment are large and about two-thirds the length of those on the next segment. In the female the latter pair are slightly shorter than the extended processes of the ninth sternite (figs. 1a and 1b).

The *ovipositor* (figs. 1a and 8) is elongate and but slightly shorter than the extended processes of the ninth sternite. Both dorsal and ventral valves carry fine bristles only.

The *penis* (fig. 1b) is typical, short and profusely bristled.

Remarks:—This species appears to have its closest affinities with the species *A. producta* described by Escherisch (1904). From that species it may be readily distinguished by the length of the ninth sternite, the processes of which in *A. producta* are extremely elongate, being shown in his illustration as more than twice the length of the accompanying styles. The tenth tergite of *A. splendens*, too, is more pointed and has a different arrangement of setae.

Acrotelsa devriesiana has a long acute telson and apparently wholly lacks the extended processes on the ninth sternite. It exibits also a number of other minor differences. The specific name plendens is chosen for this new species on account of the showy nulation of the filiform appendages and the mottled condition of ie body.

Acrotelsa westralis sp. nov. Plate XVII, figs. 11-20.)

Specific diagnosis.—Body moderately elongate, dorso-ventrally epressed, smaller in girth than *A. splendens* and tapering ightly posteriorly. Head depressed and closely attached to the iorax. Tufts of setae less developed. Eyes slightly anteriorly tuated and less conspicuous.

There is no visible neck region. Thorax as wide as abdomen, iort and little constricted posteriorly. Tergite ten equilateral, less cutely pointed than in *A. splendens*, converging edges almost raight and each bearing setae in three prominent, symmetrically rranged, short combs of not more than two or three setae. Body itirely covered with scales. Antennae not as long as body, and erci as long as the abdomen. Metasternite short, with an almost emi-circular posterior margin with three single rows of pectinate etae on each side. Mesosternite slightly larger and more acute, ith three pairs of similar combs. Legs stout though not prominent, ie femur only visible in part from the dorsal aspect. Claws asymietrical, the outer one strongly hooked.

Colour (in spirit) purplish grey with brown scales; legs dark rown to black.

Length: male, 7 mm. Antennae, 5 mm. Caudal styles, 5 mm.

Locality: Beaconsfield, one specimen only, male.

Detailed description.—The *body* is less elongate than that of l. *splendens*, being about three times as long as wide. The thorax ; only slightly depressed, giving the body a more cylindrical apearance. The head is less prominent, with the anterior margin ess convex in outline. There is no visible inter-segmental region or eck.

Thorax.—The thoracic tergites are moderately developed, short, rith the posterior margin characterised by an angular excavation a the pro- and meso-thoracic tergites. The posterior margin of the ietathoracic tergites is concave posteriorly. The lateral margins of he thorax are strongly setose and the characteristic combs of ristles are in laterally situated rows which are inclined to the nargin of the tergite.

Abdomen.—There is little variation in the length of the abdominal tergites, all of which bear a symmetrical pair of setose ombs towards the lateral margin. The sternites of the eighth and iinth bear styles; those of the eighth are small and reduced, whilst those occurring on the ninth are abnormally elongate and slender. The posterior margin of the sternal plates is slightly concave, with combs consisting of about sixteen setae set at each side of the concavity. The tenth tergite is almost equilateral and less pointed than that of *A. splendens* and with the lateral margins crenate. There are three conspicuous symmetrical groups of setae on the telson and the number of bristles in each does not exceed three. The margin is set with fine setae, giving it a serrate appearance.

Head appendages.—The *antennae* differ little from those of *A. splendens,* except in the distinctly deep reddish brown colouring, zoning by constrictions appears at intervals of five segments (fig. 19).

The *Mandibles* (fig. 17) are shorter and slightly more convex, and with the first marginal tooth shorter than those following it. Setae are found in the characteristic positions.

Maxilla (fig. 15): There is a short stout maxillary palp, the terminal segments of which are shorter than those near the base. The spiral arrangement of the setae is less marked and they are more evenly distributed on the various segments. There are three stout, bifid setae on the stipe posterior to the base of the palp. The galea is blunt and irregular, whilst the lacinia is slender and rather acute.

Labium (fig. 16) the sub-mentum approaches a rectangular shape with the lateral lobes blunt cornered, and giving the labium a breadth of about twice the length of the long axis. The posterior margin of the sub-mentum has an angular concavity similar in shape to that occurring on the posterior border of the mesothorax. The mentum is distinctly reduced and divided into two lateral portions. It carries the typical row of stout, bifid setae. The stout palps have the terminal segment slightly elongate and the sensory papillae at their apex fewer than in *A. splendens* and arranged in a circular group.

Thoracic appendages.—The *legs* (fig. 14) are distinctly stout, with the coxa, femur and trochanter very strongly developed. The pectinate setae on these segments are long and coarse, and the serrations are confined to the apical region. The tibial spur is terminated in a hook. Asymmetry occurs in the claws, the outer one being strongly curved and the inner one strong and comparatively straight. The pulvillus is large and conspicuous on the second and third legs (figs. 14a, 14b). The *mesothoracic sternite* (fig. 18a) is larger than that of the metathorax and both have similarly arranged combs on the posterior margins.

A reduction occurs in the abdominal styles (fig. 12) of the eighth sternite, whilst an elongation is noticeable in those on the ninth sternite. The penis (fig. 12) is short and strongly setose, but presents no marked peculiarities.

Remarks.—This species shows most affinity with the sub-species *A. devriesiana* var. *perspinata.* The telson, though slightly longer in the former, has a similar number of symmetrically arranged bundles of setae. The differences, however, occurring in the legs, the metasternite, and particularly in the arrangement of the sensory papillae are, in our opinion, too considerable to permit of this form being treated merely as a variety.

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EXPLANATION OF PLATES XVI AND XVII.

Plate XVI.

1. Dorsal view of *Acrotelsa splendens* (female), antennae and cerci abbreviated.

1a. Ventral view of the posterior portion of the abdomen (female), showing the ventral styles, ovipositors, etc.

1b. Ventral view of the posterior portion of the abdomen (male), showing the ventral styles, penis, etc.

2. Dorsal view of the tenth tergite.

3. Median portion of the metasternite.

3a. Median portion of the mesosternite.

4. Third thoracic leg.

4a. Portion of the third tarsus and the claws.

5. The labium.

6. The maxilla.

7. The mandible.

8. Terminal portion of the ventral valve of the ovipositor.

9. Basal segments of the antenna.

9a. Typical antennal segments.

10. Type of body scales.

Plate XVII.

11. Dorsal view of *Acrotelsa westralis.*

12. Ventral view of the telson region (male).

13. Dorsal view of the telson.

14. Third thoracic leg.

14a. Portion of the tarsus of the third leg.

14b. Portion of the tarsus of the second leg.

15. The maxilla.
16. The labium.
17. The mandible.
18b. The median metathoracic plate.
18a. The median mesothoracic plate.
19. Typical antennal segments.
20. Typical scales.

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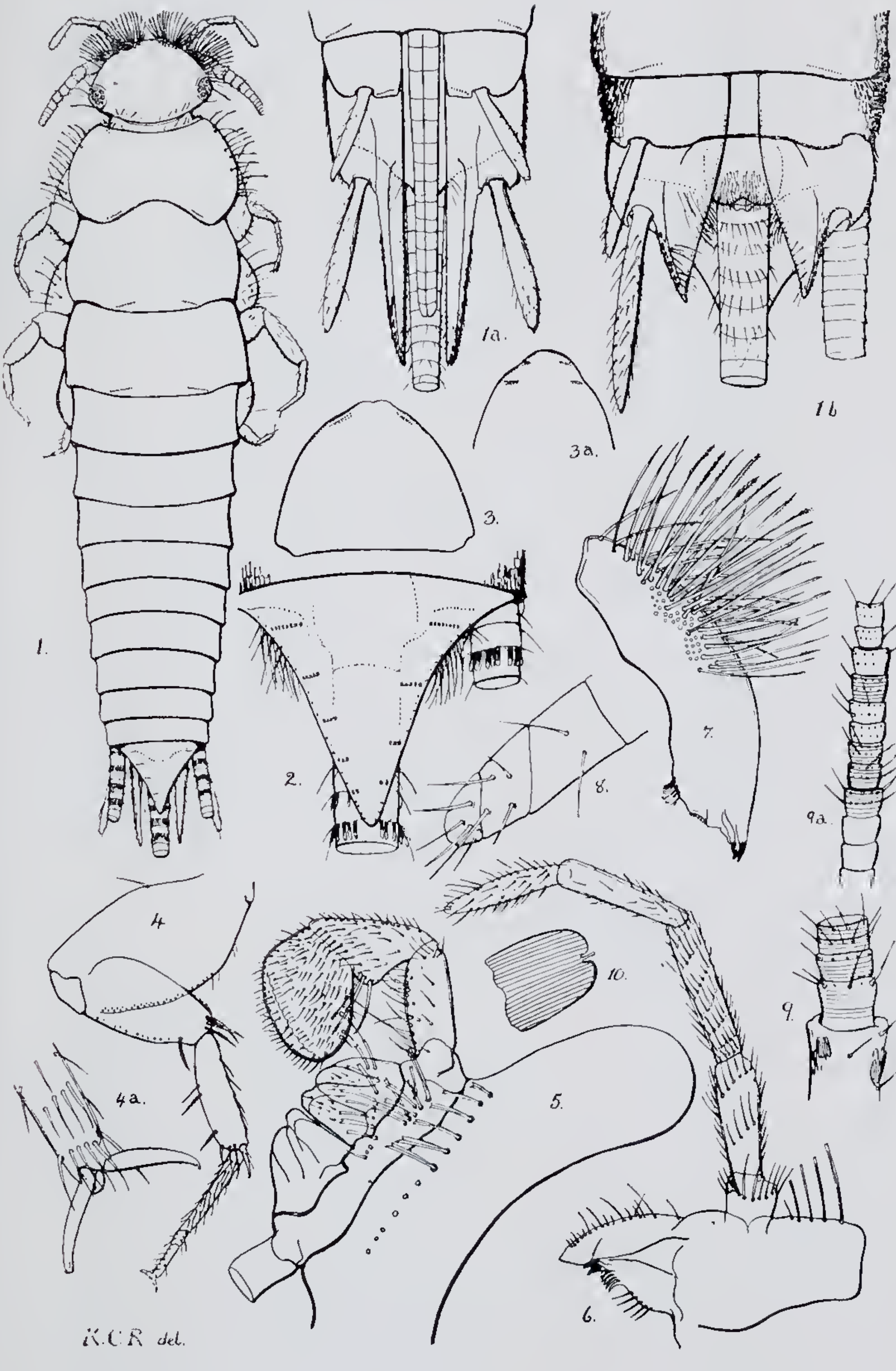
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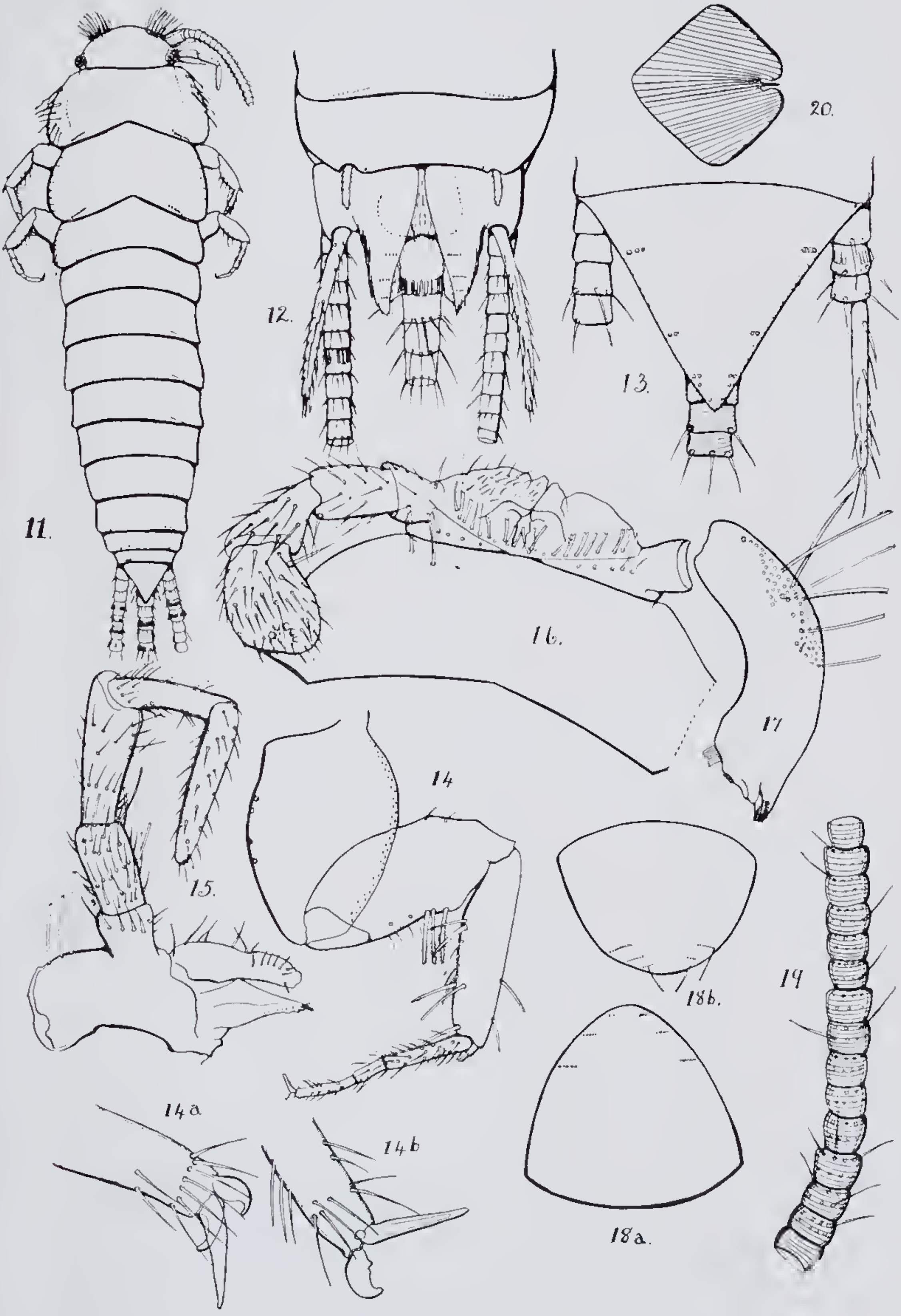

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Contributions from the Department of Biology, University of Western Australia, No. 7.

Some New Species of Megascolex from South-Western Australia,

by **Professor G. E. Nicholls,** D.Sc., F.L.S., and **Ada A. Jackson,** B.Sc.

(*Read* July 13, 1926. *Published* August 10, 1926.)

Until the visit of Drs. Michaelsen and Hartmeyer to Western Australia in 1905 no attempt seems to have been made to collect earthworms in this part of the Continent. The report by Dr. Michaelsen on this portion of the collection made by the German South-West Australian Expedition constitutes Part II of the first volume of "Die Fauna Sudwest-Australiens, 1909." In this paper is recorded the finding of no fewer than fifty-two species, referred to eighteen genera, and of these, thirty-four endemic species were previously undescribed. These new species all belong to the family Megascolecidae and are noted as being of quite small size.

The stay made in Western Australia by the members of this Expedition was of very limited duration and the search covered but a comparatively small area of the State. It was highly probable, therefore, that many more species remained to be discovered. At the end of the last University session a Field Instructional Class was held for a fortnight, in the region of the Nornalup Inlet, and a large amount of material, much of it apparently new, was obtained. Two of the worms here described were secured at this time, both of them being remarkable for their relatively large size. Others which were also obtained in this locality are now being investigated.

It has already been pointed out (Nicholls, 1922) that, as regards fluviatile forms, Michaelsen's statement that these are very rare does not prove to be correct. Some, such as *Pristina*, are everywhere, others, as *Dero*, *Chaetogaster* (several species of each), *Aelosoma*, etc., are quite common, and representatives of other families, such as Tubificids and Enchytraeids, are comparatively abundant.

Megascolex longicystis sp. nov.

Plate XVIII, Figs. 1, 2.

A number of specimens of this worm were collected at Armadale by Miss Fordham and one of us (G.E.N.). It is obviously closely related to *Megascolex collinus*, described by Michaelsen from Broome Hill (1905), resembling that species closely in the extreme development of the diverticulum of the spermatheca, which in both forms is from five to six times as long as the spermatheca itself. Close examination revealed, however, the following differences: the spermatheeal pores are closer together than in *M. collinus*, the pair of papillae on furrow 19/20 is wanting, and a third pair of sperm sacs is present in segment 10. Michaelsen had but one damaged specimen to work on and consequently was obliged to query one or two of his statements, but even after allowing for the possibility of incompleteness in the description from this cause, there seems to be here sufficient difference to require the establishment of a new species.

Specific Diagnosis. Length, 70-80 mm.; thickness, 3 mm.; number of segments about 100.

Colouring: Purplish-brown dorsally, fading to yellowish-white ventrally. There is a dark mid-dorsal line running the whole length of the worm, but the snout and posterior end are white tipped.

The clitellum is noticeable only as a slightly paler band covering segments 14-18. After prolonged preservation in spirit all colouring is lost and the clitellum becomes indistinguishable except for a very slight flattening of the ventral surface of those segments.

The setal line is unbroken. The setae themselves are slender and sigmoid, with a slight nodulus which is only occasionally noticeable.

The head is epilobate. The prestomium is rounded and has a somewhat V-shaped projection into the peristomial segment. The peristomial segment itself has a distinct ventral groove.

There are two pairs of spermathecal pores (Pl. XVIII, fig. 1) on the anterior margins of segments 8 and 9. These are invisible to the unaided eye, but under the microscope they are seen to lie in the third line of setae on each side.

The male pores are on a pair of small round papillae which take the position of the second seta on each side in segment 18.

Dorsal pores are present, the first one occurring between segments 4 and 5.

Anatomy. Gut: A large gizzard occurs in segment 6. There are no calciferous glands, and the mid-gut is without a typhlosole.

Circulatory system: The last heart is in segment 13.

Nephridial system: Micronephridia occur throughout the length of the worm.

Male reproductive organs: There are three pairs of sperm sacs projecting from septa 9/10, 10/11, 11/12 into segments 10, 11, and 12. They are slender and rather finger-like in appearance, the first pair being slightly smaller than the other two. The spermiducal glands lie in segments 18. They are flattened and leaf-like and have an S-shaped muscular duct.

The spermathecae (Pl. XVIII, fig. 2) are pear-shaped and have a long, slender diverticulum which is from five to six times as long as the spermatheca itself. This diverticulum is sometimes loosely coiled, and may extend straight backwards through several segments.

Megascolex swarbricki sp. nov.

Plate XVIII, Figs. 6-10.

Numerous specimens of this worm were found at Nornalup, under logs in swampy patches along the banks of the Deep River, and also from beneath logs in some of the damper valleys running down to the Frankland River. Their unusual size and glandular arrangement serve to distinguish them from any species previously described. The new species is named in compliment to Mr. T. H. Swarbrick, to whose enthusiastic assistance the field instruction class of the Biology Department of the University was greatly indebted.

Specific Diagnosis. Length, 160 mm.; breadth 5 mm.; number of segments, about 188.

Colouring: Dorsally, greyish-brown; ventrally, yellowish-white. The clitellum is saddle-shaped and extremely thick (Pl. XVIII, fig. 8), and extends over segments 13 to 19. In the anterior part of the 13th segment, and posterior part of the 19th, it is dorsal only, but in segment 18 it passes ventrally as far as setal line c.

In transverse section it is seen to consist of a thick layer of unicellular glands which open to the outer surface of the clitellum. Each gland consists of an oval nucleated cell and a narrow duct, which is of course much longer in the case of the deep-seated cells than of those near the surface. Between the glands may be made out the many fine branching bloodvessels.

The head is tanylobate, the dorsal projection of the prostomium having a distinct transverse furrow at the base.

The first dorsal pore lies between segments 4 and 5.

The male pores are very close together (Pl. XVIII, fig. 9) and are situated in segment 18 at the apex of an oval papilla, which has a transverse furrow both in front and behind the pores (Pl. XVIII, fig. 6).

The female pores lie in segment 14, near to the mid-ventral line, but they cannot readily be made out without having recourse to serial sections.

There are two pairs of spermathecal pores, between segments 7 and 8, and 8 and 9. They are mid-ventral in position, extremely close together, and lie in a small oval depressed area.

The accessory glands consist of two pairs of glandular papillae lying intersegmentally (19/20 and 20/21) and all equidistant from the mid-ventral line. In one specimen from the Deep River another papilla was found at 21/22, lateral but unpaired, which condition was observed, also, in several specimens taken from the Frankland River region. In others, again from the Frankland, the third pair of glands was complete. Where three pairs were present, the last two were always slightly closer together than the others.

Anatomy. None of the septa show any distinct thickening.

Gut: There is a large gizzard in segment 6. The oesophagus has a vascular swelling in each of segments 10-14, that in segment 14 being the largest.

Circulatory system: The last heart is in segment 13.

Nephridial system: Micronephridia are present throughout the entire length of the worm.

Male reproductive organs: Three pairs of sperm sacs are present on septa 9/10, 10/11, and 11/12, projecting into segments 10, 11, and 12. They are thick and seem to be made up of a number of small lobes closely pressed together and flattened. The sacs of the third pair are the largest. There is a pair of free testes and related funnels, in both segments 10 and 11. The spermiducal gland is flat and leaf-like, very little longer than wide, and projects into segments 17 and 19. The duct opens into the posterior lobe of the glandular mass.

The spermathecae (Pl. XVIII, fig. 7) are sac-like, with a spherical enlargement. The diverticulum is usually about two-thirds the length of the main body, although in some specimens it reaches an equal length. In opens from the spermathecal duct, which is very short. In section, the ducts from each side are seen to open to the exterior side by side on the mid-ventral line, so close as to make the opening almost appear to be a common pore (Pl. XVIII, fig. 10).

Megascolex affinis sp. nov.

Plate XVIII, Figs. 3, 4, and 5.

This worm comes from the South-West of Australia, but unfortunately the locality label has been lost; only one specimen was obtained. It approaches very closely to *Megascolex imparicystis,* the chief point of difference being the reduction of the accessory glands to what appear to be mere thickenings of the body wall in the median ventral region intersegmentally at 17/18 and 18/19. Dissection shows that a rudimentary third pair of sperm sacs is present on septum 12/13, projecting into segment 13. This is an unusual condition, for, as a rule, when three pairs of sperm sacs occur they lie in segments 10, 11 and 12. Other points of difference are: the length of the duct of the spermiducal gland, which is greater than that of the same duct in *M. imparicystis* as described by Michaelsen, being slightly longer than the glandular mass; the beginning of the mid-gut in segment 17 instead of in segment 18; and the occurrence of strongly developed muscle strands connecting the thickened septa in the anterior region. Michaelsen does not mention the occurrence of such strands in *M. imparicystis.* In the present species the strongly developed condition of these muscles and the cup-like shape of the thickened septa which they connect are very reminiscent of the same structures in *Megascolides australis.*

Specific Diagnosis. Length (in spirit): 140 mm.; breadth, 8 mm.; number of segments, 105.

Colouring: Greyish brown dorsally, yellowish-white ventrally. There is no visible clitellum.

There are five unpaired spermatheeal pores lying mid-ventrally in furrows 4/5 to 8/9 (Pl. XVIII, fig. 3).

The male pores are in segment 18, close to the mid-ventral line, and are not marked by the presence of papillae.

There are no obvious accessory glands, but there is an extremely small transverse swelling in the mid-ventral region of furrows 17/18 and 18/19.

Dorsal pores are present.

Anatomy. Septa 7/8 to 15/16 are thickened, and are connected by muscle strands. Of these, septa 7/8 and 15/16 are but slightly thickened, while the intermediate septa 8/9 to 14/15 are very thick.

Gut: There is an extremely large and well-formed gizzard in segment 6. The oesophageal wall is thickened and swollen in segments 10 to 14. The mid-gut, which is very distinctly marked off from the oesophagus, has no typhlosole, and begins in segment 17.

Circulatory system: The last heart is in segment 13.

Nephridial system: Each segment bears six micronephridia on each side, all disposed in the same plane.

Male reproductive organs: (Pl. XVIII, fig. 5). Three pairs of sperm sacs occur. They project from septa 10/11, 11/12, and 12/13 into segments 11, 12, and 13. The second pair is the largest, but they are all comparatively small. The third pair is little more than a slight finger-like projection from the septal tissue. The spermiducal glands are in the posterior half of segment 18, and have a distinct duct, straight, and slightly longer than the glandular region. The glandular region itself is irregular in outline, rather oval, and flattened.

The spermathecae (Pl. XVIII, fig. 4) are sac-like, with a short, stout duct into which the diverticulum opens. They are median and unpaired, and the diverticulum is about half as long as the spermatheca itself.

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1922 Nicholls, "Dero roseola." Journal Roy. Soc. W.A., Vol. VII.

Explanation of Plate XVIII.

Fig 1 *M. longicystis*, External view.

2 *M. longicystis*, Spermatheca.

3 *M. affinis*, External view.

4 *M. affinis*, Spermatheca.

5 Semi-diagramatic sketch of part of the internal anatomy of same.

6 *M. swarbricki*, External view.

7 *M. swarbricki,* Spermatheca.

8 Transverse section through clitellum of the same, showing the thickening of the glandular layer.

9 Transverse section through the male genital region of the same showing the openings of the spermiducal ducts.

10 Transverse section through the spermathecal region of the same showing the close approximation of the spermathecal pores.

REFERENCE LETTERS.

b. sp., base of spermatheca; br., brain; b.w., body wall; blv., blood vessel; c.m., circular muscle; ep., epidermis; giz., gizzard; gl.c., gland cells; l.m., longitudinal muscle; m.g., mid-gut; m.p., male pore; n.c., nerve cord; neph., duct of nephridium; oes., oesophagus; ph.gl., pharyngeal gland; sp., spermatheca; sp.d., spermiducal duct; sp.gl., spermiducal gland; sph., spermatophore; sp.p., spermathecal pore; sp.s., sperm sac.

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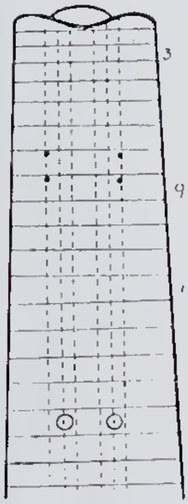

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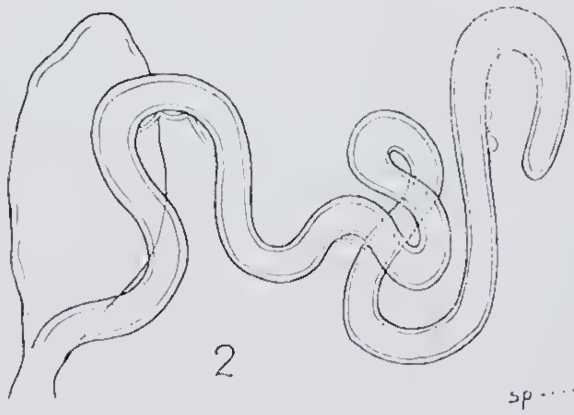

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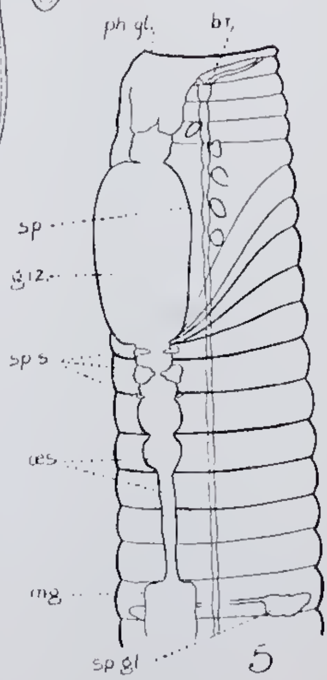

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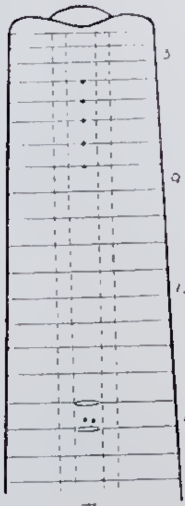

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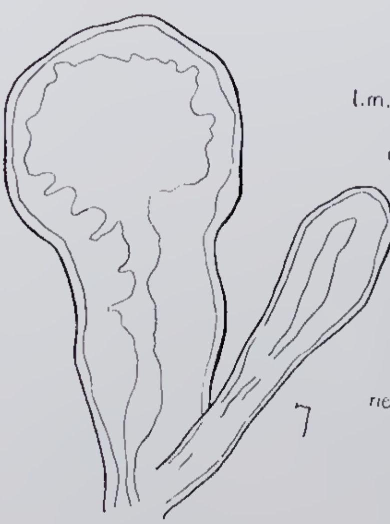

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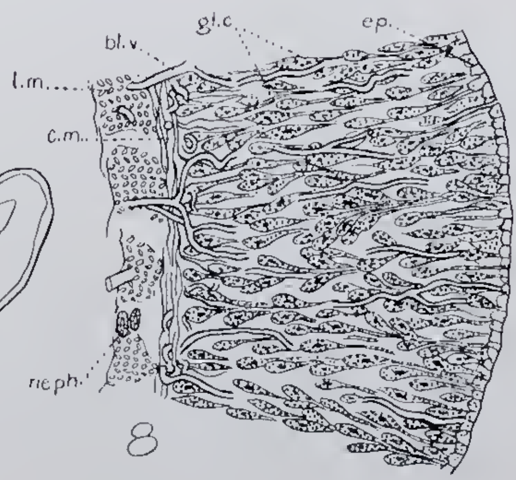

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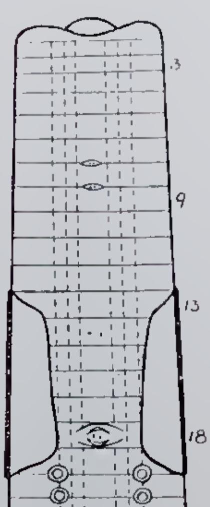

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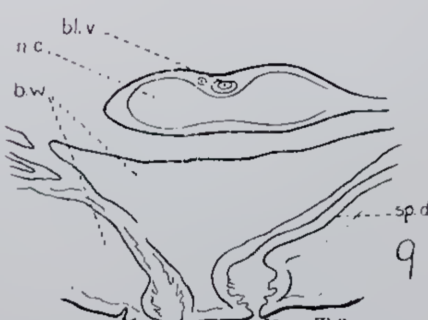

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Contributions from the Department of Biology, University of Western Australia—No. 8.

A Description of Two New Terrestrial Isopods from Western Australia, by Professor Geo. E. Nicholls, D.Sc., F.L.S., and Helena M. Barnes, B.Sc.

(*Read* July 13, 1926. *Published* August 10, 1926.)

A few specimens of one of the terrestrial Isopods which form the subject of the present contribution were first taken by one of us (G.E.N.) in January 1924. These were found hiding under moss growing upon the shaded side of a giant Karri. Nearly two years later (Nov. 1925), when a field instruction class was held at Nornalup they were obtained in larger numbers. The greater part were taken along the bank of the Frankland River under large logs in the immediate wake of an extensive and still burning bush fire, but they were nowhere really plentiful.

The animal is quite small and its inconspicuous colouring with its habit of curling up into a ball and rolling away when disturbed renders it by no means an easy object to collect. Its generally spinous condition also helps greatly to conceal it among the debris into which it usually falls.

Such a remarkable development of spines, it is worthy of note, appears to be paralleled only in a Natal species, *Akermania spinosa* Collinge, *Diploexochus* (*Cubaris*) *echinatus* Brandt, from Brazil, and *Cubaris longispinis* Richardson, recorded from Panama. Whether this has been independently developed in the four species and should be attributed merely to convergent evolution or whether it is to be considered as indicating community of descent is not easy to decide. The facts of distribution would perhaps favour the latter alternative and in this view, it is a question whether the South American and Australian forms, at least, should not be removed from Cubaris and assigned to a distinct genus. The South African species of *Diploexochus* described by Panning (1924), do not show similar development of spines. *Akermania* appears anteriorly, truncate and re-curved posteriorly and slightly excavate laterally. It bears two spines anteriorly.

The *Uropoda* (Pl. XIX, figs. 10 and 11) are short and small, not extending beyond the telson, and occupying the space between the epimera of the fifth segment and the terminal segment. The peduncles are large, broader than long and roughly pentagonal in shape. The whole surface is covered with overlapping scales which in one region form an oblique ridge, a number of layers in thickness. The exopodite, if present, should be situated on the distal end of this ridge, but is apparently absent or so very greatly reduced as to be unrecognizable. The endopodite does not reach to the end of the terminal segment, is slender and bears apically a long spine and two smaller ones. The whole of its surface is covered with fine setae.

The *walking legs* are all alike, ambulatory, and very feebly developed.

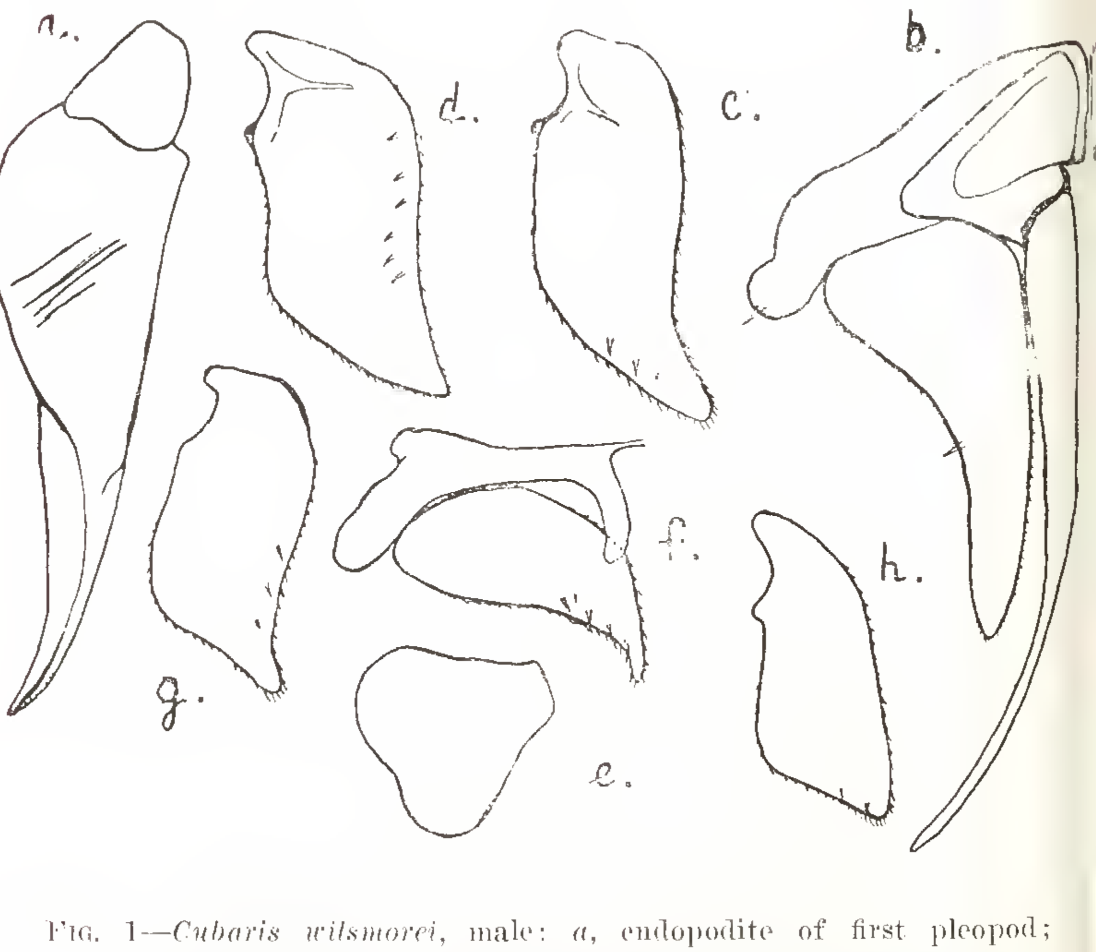

FIG. 1—*Cubaris wilsmorei*, male: *a*, endopodite of first pleopod; *b*, second pleopod; *c*, exopodite of third pleopod; *d*, exopodite of fourth pleopod; *e*, endopodite of fourth pleopod. Female: *f*, second pleopod; *g*, exopodite of third pleopod; *h*, exopodite of fourth pleopod.

The *pleopods* are arranged in a tile-like manner. Their shape and proportions can be made out most satisfactorily from the figures. In the *male* the exopodites on the first pair (of pleopods) are lacking, those of the second pair (fig. 1b) well formed and reaching practically to the end of the third pair. The third (fig. 1c), fourth (fig. 1d) and fifth pairs also have well developed exopodites, the fifth pair being similar in shape to the fourth, but smaller.

The endopodites of the first pair (fig. 1a) are broad at the base and narrow distally, those of the second (fig. 1b) very long, reaching almost to the end of the fifth pair of pleopods, and tapering to a point. The third, fourth (fig. 1e) and fifth are roughly triangular in shape, and branchial in function.

In the *female* the first pair has the exopodites in the form of very delicate chitinous plates. The second pair (fig. 1f) is well formed, the third (fig. 1g), fourth (fig 1h) and fifth, the fourth and fifth being similar in shape.

The first and second pairs (fig. 1f) of endopodites are represented by chitinous plates, the third to the fifth normal and similar in shape to those of the male. The margins of the second to the fifth pairs of exopodites in both the male and female are fringed with setae.

No trace of tracheae could be recognised in the exopodites notwithstanding a careful examination.

Colour, in life, creamy white with faint dark markings, some showing a pinkish tint. Little change occurs in preserved specimens.

Length, of the largest specimens obtained, six millimetres.

Habitat, within the bark of living trees, under fallen logs and in decaying stumps near the banks of Frankland River, Nornalup, S.W. Australia.

Remarks.

In its general appearance, with its strongly developed spines and scales and with its freely projecting epimera *C. wilsmorei* presents a marked resemblance to *Akermania spinosa* Collinge. A further resemblance is seen in the condition of the uropods of the two species, which while differing somewhat in shape are at least unlike those structures normally present in *Cubaris.* The terminal abdominal segments of the two, also, do not differ more than might be expected in two different but closely related species.

But by the possession of antennules and in the shape of the cephalon, *C. wilsmorei* is definitely excluded from the genus *Akermania,* the cephalon is, indeed, typically cubarid.

In other respects, however, this species differs from a typical *Cubaris* to much the same extent as does *Akermania*. The feeble development of the walking legs, the form of the terminal abdominal segment and uropods, the folded coxopodites of the mesosomatic segments are all more or less exceptional in this genus.

The great development of spines is, as already pointed out, paralleled only in the S. African and S. American forms. Budde-Lund's description of one of the latter *Diploexochus (Cubaris) echinatus* Brandt, is unfortunately not available, but from Miss Richardson's notes (1912, p. 479) it would appear to be remarkably like *C. wilsmorei*.

Cubaris longispinis Richardson, with which it has very evident affinities, has coxopodites upon the first and second mesosomatic segments, differing, however, in form and position. There are, also, minor differences, in the cephalon (which instead of being slightly excavate is raised), in the number and arrangement of the spines, and in the presence of the exopodite upon the uropod. No mention is made by Miss Richardson of scales, it is probable, therefore, that they are absent.

In the apparent absence of an exopodite on the uropods *C. wilsmorei* seems to differ from *C. longispinis*, *D. echinatus* and *A. spinosa*.

Concerning the respiratory organs nothing is stated in either *A. spinosa* or *C. longispinis*. In *C. wilsmorei*, as noted above, a most careful search and the cutting and examination of serial sections failed to reveal any trace of tracheae.

Thus, although in many features this Western Australian form does not conform strictly to the Cubarid type, it seems advisable for the present at least, to refer the species to that genus. It is possibly intermediate in character between the South American form *C. longispinis* and the South African *Akermania spinosa*.

The second of these new species is a member of the family Scyphacidae and of the genus Actœcia. It appears to be the first member of this genus to be recorded from Western Australia.

This species was first collected by one of us (G.E.N.) at Cottesloe, July 1924. Further specimens have since been collected at Leighton and Cottesloe, July 1925 and April 1926, but in very small numbers. Their colour and habits, as mentioned below, make them extremely difficult to find and probably account for the smallness of the collection.

It fits very well into Chilton's generic description of *Actaecia* (1901, p. 130), and appears to be intermediate in structure between the two species he has described (1901) *A. euchroa* and *A. opihensis*.

It is readily distinguished from both these species by the considerable development of the coxopodites on the first three mesosomatic segments, and the form and structure of the pleopods, as well as by differences in the mandibles and maxillipedes.

Actaecia pallida sp. nov. (Plate XX and Text fig. 2.)

The *body* (Pl. XX, fig. 1) is convex, almost exactly twice as long as broad, surface scabrous and covered with short scattered spines most evident upon the appendages and along the lateral margins of the body.

The *cephalon* is rounded with the frontal margin raised slightly, depressed in the middle.

The *eyes* are large, round, with numerous ocelli, and occupy the greater portion of the lateral region of the cephalon.

In the *antennules* (Pl. XX, fig. 3) three joints are distinguishable. The whole appendage tapers gradually to the apex, which bears two or three moderately long spines; laterally a number of shorter spines are present.

The *antennae* (Pl. XX, fig. 2) are extremely spinous. The flagellum is almost as long as the terminal joint and four-jointed, the terminal one being very slender, more than twice as long as broad, and bearing apically a number of setae.

The *upper lip* has the usual structure.

The *left mandible* (Pl. XX, fig. 14) has the outer cutting edge composed of three strong chitinous teeth, the inner of four. At the base of the inner row is the ciliated lappet which is extremely setose. Below this three penicilla are present (1 + 2) and a very long bushy seta.

The *right mandible* (Pl. XX, fig. 13) has three or four teeth in the outer cutting edge, but the inner is reduced, less chitinous, and consists of a number of small teeth. Below is the ciliated lappet as in the left mandible. Only two penicilla are present (1 + 1), and a similar long seta.

The *lower lip* is formed of two lobes, which have the apex and inner margin setose, and a central rounded, setose portion.

In the *first maxillae* (Pl. XX, fig. 12) the apex of the outer lobe is armed with a number of chitinous teeth, the inner group of which are bi-unguiculate, the inner lobe bearing apically two slender plumose setae, and its inner side produced into a small spine.

The *second maxillae* (Pl. XX, figs. 10, 11) are angularly produced near the base. The outer lobe is small and bears apically a few spines; the inner is rounded and has the inner margin and apex fringed with strong spinous setae.

The *maxillipeds* (Pl. XX, figs. 8, 9) are long and narrow. The epipodite is more than half the length of the basal joints. In the endopodite only the ischium is distinct, the other joints being indicated by lobes on the inner margin. The whole of the inner margin is fringed with stout setae but externally there are only two spines, the ischium, also, bears two spines. The endite is narrow and reaches more than half way up the endopodite, its inner margin is fringed with setae and apically it bears a long curved spine, in addition to a jointed setose lash.

The posterior margins of the first four segments of the *mesosome* are practically straight, those of the last three concave and produced backwards at the lateral angles.

The posterior corners of the first four segments are sub-quadrate, of the fifth rounded, and those of the sixth and seventh sub-acute. The epimera of all the segments are well developed. The first three bear on the under surface, definite coxopodites in the form of raised ridges.

All the walking legs are similar in structure and increase slightly in length posteriorly. The dactylar seta is distinctive in shape, setose, narrow proximally, expanded and thickened distally, and has a blunt apex. The first two segments of the *metasome* are without epimera and covered laterally by the last mesosomatic segment. The epimera of segments three to five are large, contiguous and slightly recurved, those of the fifth bordering the uropods laterally. The terminal segment is rounded posteriorly, very short, convex and much broader than long.

The *uropoda* project beyond the terminal segment occupying practically the whole of the space between the epimera of the fifth segment. The base is broad and rectangular, with the inner distal corner obliquely cut, the posterior margin crenate and bearing a number of stout short spines. The outer ramus is spatulate, inserted upon the upper surface near the mesial border, projecting posteriorly slightly beyond the base. The apex is armed with a number of long setae and a few smaller ones. The inner ramus rises from the under surface of the base far forward, is slender and scabrous, the apex bearing one long bristle and one or two smaller ones.

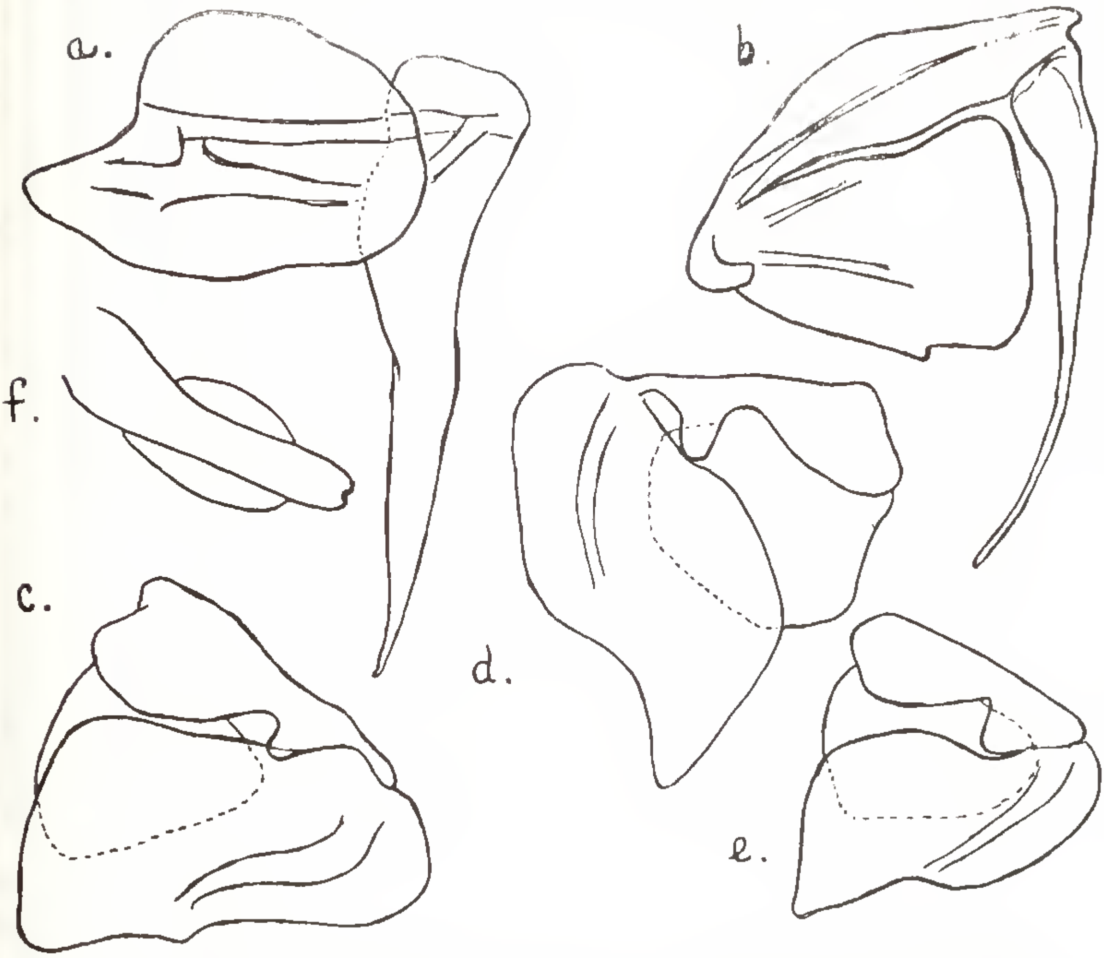

FIG. 2—*Actaecia pallida,* male: *a*, first pleopod; *b*, second pleopod; *c*, third pleopod; *d*, fourth pleopod; *e*, fifth pleopod; *f*, male organ.

In the male the exopodites of the *first pair of pleopods* (fig. 2a) are articulated along the middle line, the endopodites broad at the base and tapering to a point. The male organ (fig. 2f) is single, with a broad basal portion and notched at the end.

The *second pair of pleopods* (fig. 2b) has the exopodites roughly rectangular, the endopodites two-jointed, the first joint being long and at right angles to the second which is slightly more than twice the length of the exopodite and tapers gradually to a point.

The third (fig. 2c), fourth (fig. 2d) and fifth (fig. 2e) pairs of ploepods have the exopodites well developed, the endopodites branchial and roughly rectangular in shape. In all, the exopodites have thickened ridges and no setae are present on the margins.

Air cavities are absent.

None of the specimens can be definitely recognized as females.

Colour, dead white, with irregularly branched brown markings.

Length of largest specimen not exceeding 7 mm.

Habitat.—This species has been taken on the beach at Leighton and Cottesloe from tightly rolled balls of Cymodoce stalks washed up on to the shore. Probably it enters these from the sand at or near tide mark. They may be submerged at times. Their colour harmonizes wonderfully with the white sand of the sea shore and this, with their power of curling into a ball, makes them difficult to distinguish.

Remarks: This species appears to be intermediate in structure between *A. euchroa* and *A. opihensis.* In the general form of the body *A. pallida* resembles *A. euchroa* and, as in that species, the uropods have the outer ramus spatulate. In the condition of the eyes however, it resembles *A. opihensis.* The degree of development of the eyes is probably correlated with the habits of the animal and not to be regarded as of generic value, as Chilton seems inclined to assume (1901, p. 132).

The antennules have the usual three joints, the articulation of the third joint being very indistinct. In the antennae the fourth joint of the flagellum is similar to that of *A. opihensus,* being longer and more slender than in *A. euchroa.*

The first and second maxillae as in the other two species of *Actaecia,* resembles in general structure those of *Scyphax* as figured by Chilton (1901, Pl. XIV, fig. 2). In the mandibles the lower tuft of setae representing the molar tubercle appears to be in the form of a single brush-like seta, while the masticatory lobe of the maxillipedes has, in addition to a stout curved spine, a jointed lash differing from that figured for *A. opihensus.*

The dactylar setae on the legs are distinctive in shape.

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EXPLANATION OF PLATES XIX AND XX.

PLATE XIX.

All the figures refer to *Cubaris wilsmorei* and are drawn from a male specimen.

Fig. 1. Dorsal view of entire animal.

2. Anterior view of the cephalon.
3. Dorsal view of the telson, with uropods and the fifth metasomatic segment.
4. Underside of the lateral margin of the first and second mesosomatic segments.
5. Antenna.
6. Antennule.
7. Terminal portion of outer and inner lobes of first Maxilla.
8. Second maxilla, terminal portion.
9. Terminal portion of right maxillipede, ventral view.
10. Right uropod, ventral view.
11. Dorsal view of left uropod.
12. Spine from the mesosome showing the development of scales.
13. Terminal style of antenna.

PLATE XX.

All the figures refer to *Actaecia pallida* and are drawn from a male specimen.

Fig. 1. Dorsal view of the whole animal.

2. Antenna.
3. Antennule.
4. Under surface of the first, second and third segments of the mesosome showing the coxopodites.
5. Ventral view of the terminal segment and uropods.
6. First mesosomatic appendage.
7. Dactyl with dactylar seta.
8. Under surface of right maxillipede.
9. Terminal portion of right maxillipede.
10. Second maxilla.
11. Terminal portion of second maxilla.
12. Terminal portion of first maxilla.
13. Terminal portion of right mandible.
14. Terminal portion of left mandible.

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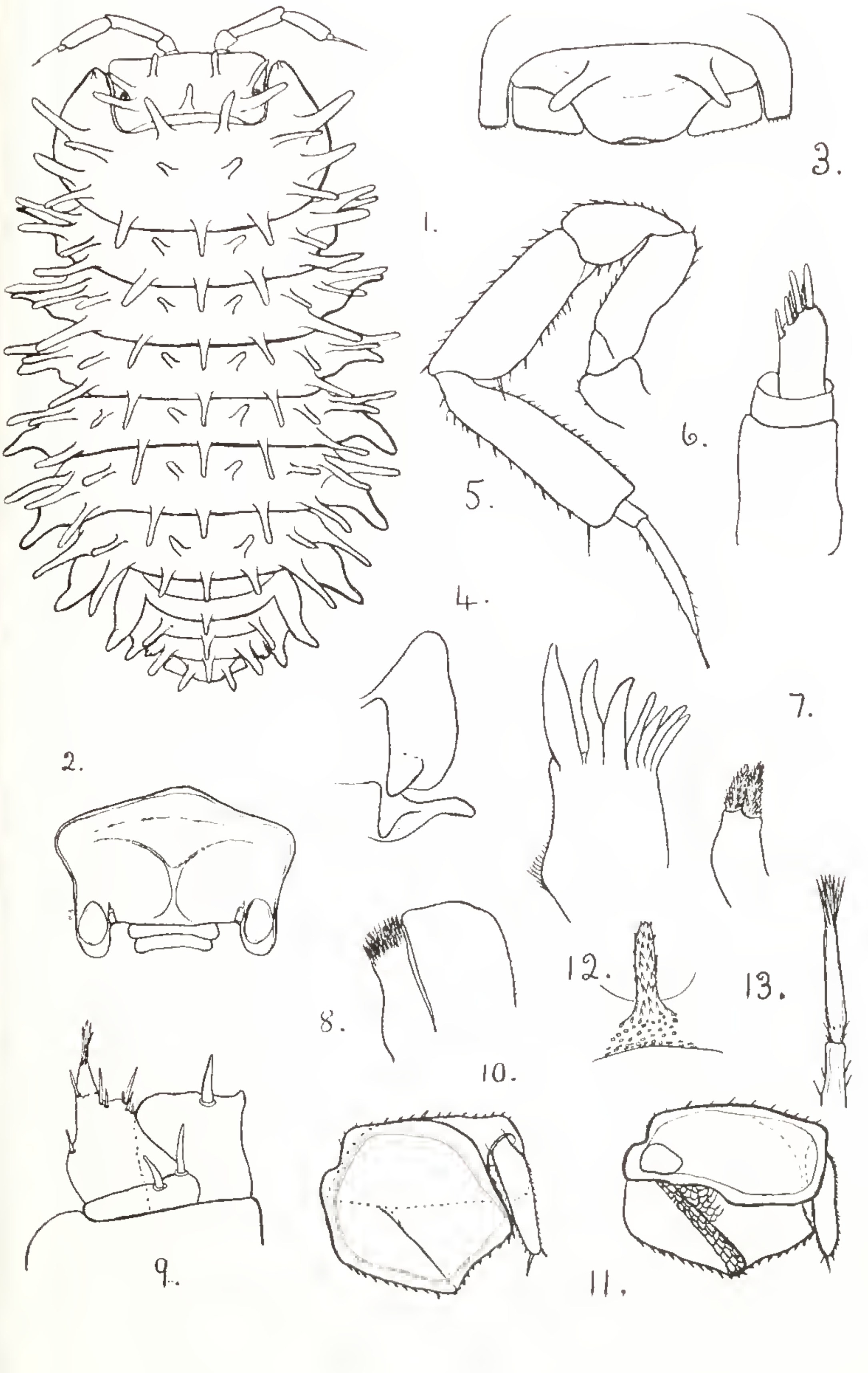
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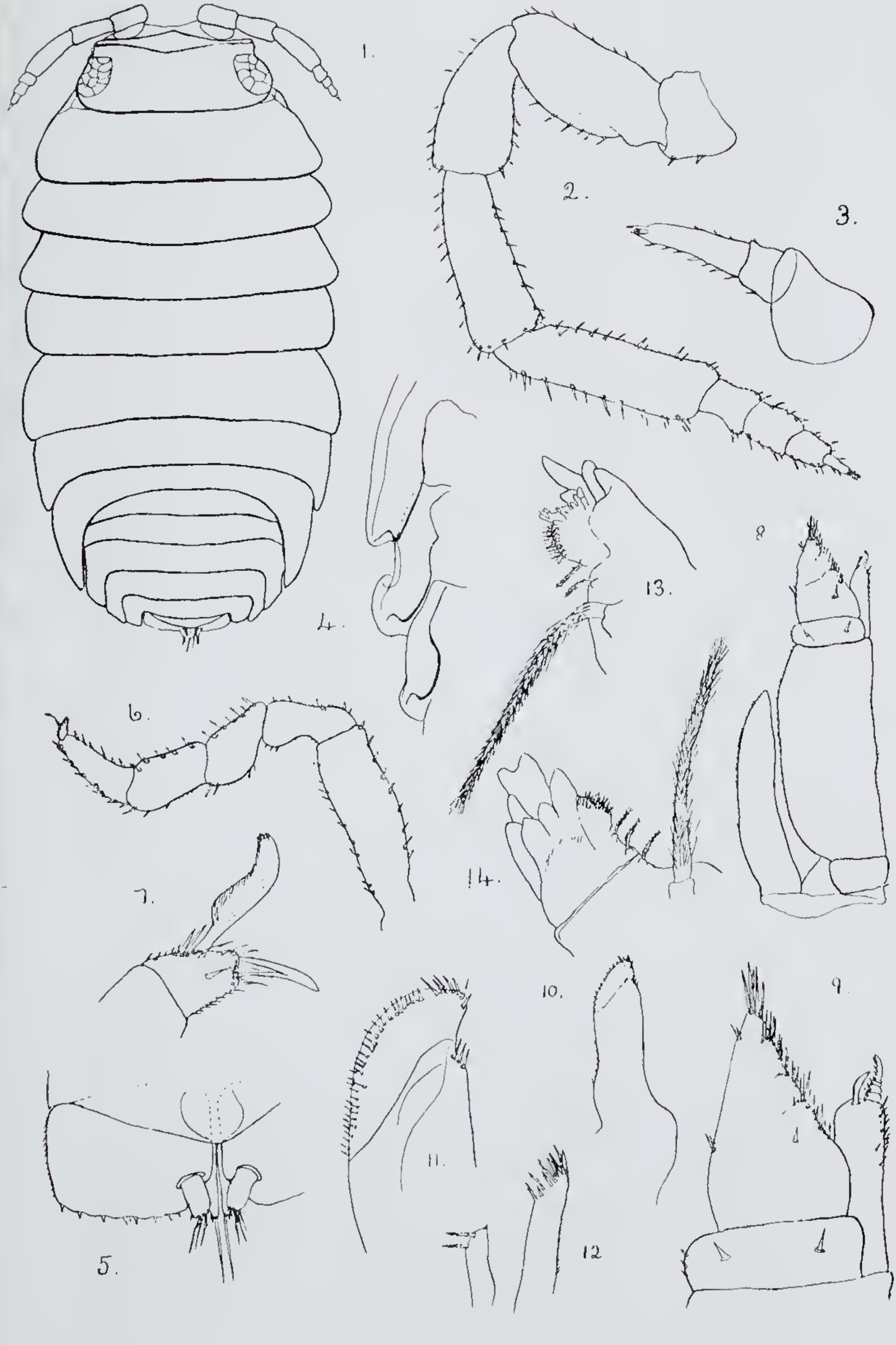

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The Geology and Physiography of Parts of the Darling Range near Perth, by **E. de C. Clarke,** M.A., Lecturer in Geology, University of Western Australia, and **F. A. Williams,** B.Sc.

(*Read* July 13, 1926. *Published* August 13, 1926.)

CONTENTS.

I.—Introduction.

The quarries of Boya, Stathams, Mahogany Creek and Parkerville in the Darling Range near Perth produced, in 1924, material valued at £68,973*, but apparently no geological map or systematic description of the surroundings of these sources of wealth has ever been produced, although many short papers on physiography or on details of geologic interest have appeared in scientific journals and government publications. This paper, a first move towards supplying this deficiency, might be described as "Notes to accompany geological and topographical maps of two typical areas in the Darling Range." It is a summary of the field-work done by many students at various times during the period 1921-1926. The field-work, which formed part of the course in geology in the University of Western Australia, was done partly by individuals working singly, partly by groups. It would be invidious to attempt naming all who took an active part in the work and we must content ourselves with mentioning those who have made independent maps and reports on certain sections, namely: W. Cohen, K. Finncane, F. Forman, I. Harms, A. Hill, J. Hosking, and E. Owen. The compilation of the map of the Darlington Area from data obtained from the Lands and Surveys and Land Titles Departments was done by Miss E. Lamborne, B.Sc., and Miss F. Armstrong. We are much indebted to Messrs. N. Bartlett and C. Hogarth of the above-named departments and to Mr. J. Parr of the Water Supply Sewerage and Drainage Department for placing at our disposal all available survey data regarding the areas with which we were concerned. One of us (F.A.W.) did all the field and laboratory work of Roleystone Area, mapped about one quarter of Darlington Area and is largely responsible for the petrological section of the paper.

As is well known, the higher levels of the Darling Range are almost everywhere laterite-covered, and information regarding the foundation rocks must be sought mainly in the valleys of streams which have cut below the laterite level. The Darlington

* Information kindly supplied by the Government Statistician.

Area, which occupies about 6 square miles in a broad portion of the Helena Valley 10 miles east of Perth and includes, or is near, the most important quarries, is the obvious place in which to begin any examination of Darling Range geology. Next to the Helena, the Canning and Swan Valleys seem likely to offer most information of the kind required. One and a half square miles of the Canning Valley, the Roleystone Area, 18 miles S.E. of Perth, have therefore been examined, and a beginning has been made on an area in the Swan Valley.

Both the Roleystone and Darlington Areas receive on the average about 36 inches of rain per annum, and in their natural state were covered with forest consisting mainly of Jarrah (*Eucalyptus marginata*) and Marri (*E. calophylla*). Much of the Roleystone area has been cleared and cultivated (fig. 1). The Darlington Area (Plate XXI) has lost most of its large trees by fire and felling, but only a small portion is cultivated.

FIG. 1.—The valley of Slab Gully Creek, a typical view in the Roleystone Area.

Both areas have been subdivided by accurate surveys made for the purpose of sale, etc., into blocks of a few acres. These blocks were plotted on our working plans and were used as a basis for geological and topographical mapping which was done either by pacing, by chaining, or by tacheometry. The form-lines were determined mainly by aneroid, corrected either by comparison with a barograph kept in camp or by frequent checking on known heights on pipe-lines or railways.

Although much of the matter set out below was collected by other workers we must be held responsible for everything which is not definitely attributed to some other observer. In the reports submitted by the various students are many interesting observations not reproduced here, partly because in this paper we try to emphasize only the outstanding geologic and topographic features. We hope that, a beginning having been made, further detail will soon follow from others.

II.—Physiography.

A. General.

The two areas under consideration lie in the valleys of the Helena and Canning Rivers, two of the westerly-flowing streams which according to Jutson (1914 p. 128) were consequent on the formation of the Darling Fault, and which, having steeper courses, were able to capture and dismember the senile north-south drainage. An account of the physiography therefore is mainly a description of the watercourses. It may be noted here that the only perennially flowing streams are the Canning River and Piesse Brook, though it is merely the presence of Mundaring Weir which makes the Helena dry during the summer months. Smith's Mill Brook usually carries water until December, all the other watercourses become dry in early summer, except in a few places where fed by springs which issue from the junction of epidiorite dykes and granite.

The Roleystone Area, being smaller and confined to one side of the valley, does not furnish any detail of special value, though features of interest in the Darlington Area occur in it also, in a less obvious manner. The remarkable bend of the Canning in the Roleystone Area is probably due to the capture of an old north-south stream, though clear evidence such as one gets higher up the Canning is lacking, because more extensive erosion has removed much of the evidence of the courses and levels of the older streams.

A reconnaissance for fourteen miles up the valley of the Canning shows that the main valley is mature for about two miles east of the Darling fault line scarp, above that, to the end of the traverse, the hills gradually close in and become steeper and the river is broken by cascades and rapids. There are also several right-angled bends in the valley, the north-south arms of which are probably portions of the older dismembered drainage system. The tributaries, which generally have a more or less north-south direction, flow for the greater part of their course through shallow wide valleys, but their lower parts flow through narrow deep valleys. What length of a tributary is thus rejuvenated seems to depend on the volume of water carried. Essentially young tributaries showing no sign of having been carved out of pre-existing valleys are rare. Obviously these features accord with Jutson's history of the Darling Range rivers.

No similar reconnaissance of the Helena has been made, but from scattered observations we believe that for a distance of about 12 miles above the Darlington Area the same features would be found. From detailed work at Gorrie's Farm, about 6 miles south of Chidlow and 16 miles by river above Darlington Area, we know that, in its upper reaches, the Helena valley is mature.

B. Physiography of the Darlington Area.

In contrast to the Roleystone Area the Darlington Area includes the full width of the Helena Valley for three miles and has several features of interest.

1. *Helena River.*—The river enters the Area flowing in a W.S.W. direction through a steep-sided valley with occasional broken water, but at its junction with Piesse Brook, which enters from the south, it turns to the N.W. and passes for more than a mile through a gorge-like valley, its grade still that of an immature stream. Shortly after emerging from the gorge it is joined from the N.E. by Smith's Mill Brook, and from here to the western edge of the Area has the characters of a mature stream. Half a mile beyond Smith's Mill Brook junction it turns sharply to the W.S.W. again.

2. *Tributaries.*—Three types of tributary are distinguishable:

(a) Wholly immature tributaries—All but six of the many watercourses which enter the Helena in the Darlington Area are of this type. They rise within the limits of the valley itself and are insequent, owing their existence simply to the deepening and widening of the main valley. Their courses are pretty evenly steep throughout, and waterfalls are rare; but owing to the shortness of their season of activity, they are unable to degrade as fast as the main stream, and several steepen visibly as they near the Helena River.

(b) Rejuvenated tributaries—Smith's Mill and Cohen Brooks and a stream which enters the Helena opposite the mouth of Smith's

Mill Brook flow in their upper parts through wide shallow valleys in the laterite-covered Darling Peneplain, but on reaching the slopes of the Helena Valley they have the same character as the wholly immature tributaries. The mature part of Smith's Mill Brook lies outside the Area. Piesse Brook is a much larger perennial stream, whose grade is only a little steeper than that of the Helena; in other words it has excavated a valley nearly as pronounced as that of the Helena. Its upper portion however, six miles south of the Darlington Area, has the same mature character as the other streams of this group.

(c) Beheaded tributaries—Greenmount and Hosking Brooks have little in common except their beheaded character. Greenmount Brook now has short immature insequent south-flowing head waters followed by a mile of meandering mature course running more or less parallel to the Helena. West of the Area it again becomes steep and immature. At the transition between head and middle waters is a broad flat wind gap, in which, in a deep railway cutting, is disclosed partially consolidated sandy alluvium. About a mile farther from Perth the railway, which is here following up Smith's Mill Brook, passes through a more extensive deposit of the same nature. It is probable, both from the unnaturally mature character of the middle-waters of Greenmount Brook, and from the occurrences of alluvium in general alignment with the upper part of Smith's Mill Brook, that the middle part of Greenmount Brook is a lower portion of Smith's Mill Brook, beheaded by a more actively corrading insequent tributary of the Helena. Hosking Brook is a short watercourse, mature except at its source at an abrupt saddle, from the other side of which a short immature watercourse drains into Piesse Brook. The course of Hosking Brook is straight, and in alignment with the mature portion of the Helena below Smith's Mill Brook, with which also its contours harmonize so well that anyone looking up the valley from below Boya would suppose it to be the main river valley, and would not suspect the existence of the narrow gorge to the left. Mr. J. S. Hosking, who mapped this portion of the Area, attributes this apparent case of river capture to the abnormal activity of Piesse Brook following on the uplift along the Darling Fault; this activity he ascribes mainly to Piesse Brook being situated in a zone of more easily corraded rock. This explanation must be tested by investigation of the country east and south of the Darlington Area and its publication should be an incentive to further work.

3. *Influence of geological structures on stream-direction.*—(a) Jointing and shearing—In some parts, particularly along the

gorge of the Helena, the courses of small streams are parallel to the major joints or to the occasional shear zones.

(b) Relative resistance of granite and epidiorite—The fact that in so many places prominent spurs have a core of epidiorite confirms Aurousseau's observation that epidiorite is as a rule more resistant to corrasion than granite. There is however considerable variation in the resistance to weathering shown by various epidiorites. So far it has not been possible to ascribe this to variation in structure or composition.

4. *High level terraces of Helena Valley.*—The form-lines on the map (Plate XXIII), and also the photograph of the topographic model (Plate XXII) show that the steep slopes of the valley are in places interrupted by flattened areas, and that these fall into two series, one lying at about 450 feet, the other at about 250 feet above sea level. These are probably the remnants of two successive periods of long continued lateral corrasion, when the river had practically attained base level. In other words, they record two long pauses in uplift along the Darling Fault. Indistinct signs of similar terracing may be seen in the Canning Valley, and along the Darling fault scarp.

III—Geology.

A. General.

The areas under discussion are essentially composed of granitic rocks; almost entirely massive in the Darlington, predominantly gneissic in the Roleystone Area. The granites and gneisses are traversed by a great number of epidiorite dykes varying in width from a fraction of an inch to a chain or more, and traceable in some instances for more than a mile along their strike. Whether all these dykes are practically coeval is not certain. Shear zones traverse the granite and some of the epidiorite dykes, and along some of the shear zones there has been widespread replacement by silica.

B. Acid Rocks.

1. *Granite.*—The granite is a coarse-grained biotite variety, generally with porphyritic microcline. In the Roleystone Area it is more or less gneissic; in the Darlington Area no truly gneissic granite has been found.

Mineralogically the rocks from the two areas are identical. The microcline phenocrysts average about half an inch in length in the gneissic, and about [illegible] inch in the massive variety. Carlsbad twins are abundant. The crystal shape is well developed, but the edges often exhibit a peculiar nibbled outline, as if the crystal had undergone partial resorption. The cross-hatching is clearly defined, the lamellae being spindle-shaped. The inclusions comprise subidiomorphic to allotriomorphic crystals of oligoclase largely altered to scaly white mica and kaolin, rounded blebs of quartz and partly chloritised biotite. The turbidity of the oligoclase is in marked contrast to the comparatively fresh condition of the microcline.

The ground-mass is of coarse but variable grainsize and of the usual granitoid texture. Patches of a micropegmatitic intergrowth of quartz and plagioclase feldspar are not uncommon. The oligoclase is largely altered to small flakes of colorless mica and kaolin. The microcline of the ground-mass is of a later generation than the phenocrysts, and like the latter, is comparatively fresh. Biotite occurs as rather ragged crystals and aggregates, in part chloritised. Many of the biotite crystals contain inclusions, probably of zircon, surrounded by pleochroic haloes. The quartz does not call for comment.

The strongly gneissic varieties consist of alternate bands or lenses of biotite-rich and feldspar-rich rock. The longest axes of the microcline phenocrysts, and the cleavage planes of the biotite are parallel to the direction of the gneissic banding.

The development of both the porphyritic texture and the gneissic banding is extremely variable—one or both may be absent. Generally the more strongly gneissic varieties are the more conspicuously porphyritic. The trend of the banding in the Roleystone Area is approximately north and south.

Field-work has shown that the varieties merge gradually into one another; no definite boundaries can be drawn between them. Nor does microscopic examination of the entire range of gneissic and porphyritic varieties show any persistent differences by which the granites could be divided into two or more types. It seems therefore that the granites are a petrological unit showing wide variations from place to place in the development of porphyritic and gneissic textures.

2. *Fine-grained biotitic segregations.*—Small exposures of these are fairly common in the Roleystone Area. They are dark green, fine grained and megascopically of thoroughly basic appearance. Under the microscope they are seen to consist of a fine even-grained aggregate of biotite and quartz with microcline and plagioclase.

Most exposures show these segregations to be lenses parallel to the gneissic banding, less commonly they occur as subangular blocks strung out parallel to the gneissic banding. They are cut by both biotite pegmatite and quartz veins.

Segregations identical with those of the Roleystone Area are exposed in Statham's Quarry just west of the S.W. corner of the Darlington Area, but have not been noted in the Darlington Area.

3. *Acid and ultra-acid intrusions.*—These occur as veins, dykes and irregular masses in the granite, into which they merge gradually. The types represented are:—

(a) Aplitic biotite granite;
(b) Aplite;
(c) Biotite pegmatite;
(d) Muscovite pegmatite;
(e) Quartz veins.

None except the aplitic biotite granite shows any approach to gneissic structure.

Field-relations and microscopic features indicate that they should be placed in the above order in respect of age, the aplitic granite being the oldest. The position of the muscovite pegmatite is, however, uncertain.

(a) The aplitic granite occurs in irregular masses as much as two chains wide. It is a medium even-grained rock composed of microcline and oligoclase, with quartz and biotite.

(b) The exposures of aplite are generally smaller than those of the aplitic granite. The rock occurs in dykes and veins, and is in many places associated with pegmatites. Petrologically it differs from the aplitic granite in the very small development of biotite.

(c) Numerous veins of biotite pegmatite, up to a foot or so in width, cut the gneissic banding of the granite without being distorted by it. They also cut the aplite and aplitic granite. The chief mineral constituent is microcline in crystals up to six inches across. Oligoclase is subordinate to microcline. As in the granite the microcline is the less turbid of the two feldspars. Biotite occurs in "books" up to six inches across. The quartz is partly interstitial and partly intergrown with feldspar. Also quartz veinlets, not optically continuous, traverse cracks in the microcline crystals.

(d) Exposures of muscovite pegmatite are rare, except within a small area east of the creek shown on the western side of the Roleystone map. The minerals are microcline, oligoclase, quartz and muscovite.

(e) Quartz veins are found cutting all the above intrusives. They constitute the extreme acid member of the series.

All these rocks appear to represent the residual acid portions of the granitic magma, and to have been intruded before the complete consolidation and cooling of the main mass of granite.

A number of quartz veins associated with regions of shearing and fracture in the granite, and presenting well defined contacts with the latter are considered, for reasons to be given in the section "quartz reefs in shear-zones," to be later than the quartz veins just mentioned.

4. *Magmatic History.*—The features noted above may be tentatively ascribed to the following series of events:—

Magma of granitic composition welled up into the zone of crystallisation. The earliest minerals to form were biotite, plagioclase and quartz. The centres of crystallisation of the biotite, plagioclase, and quartz crystals appear to have been closely spaced, giving rise to a large number of small crystals. Microcline began to crystallise at more widely separated points, and grew to comparatively large crystals, which often included a number of small oligoclase, quartz and biotite individuals. This microcline is represented by the phenocrysts in the rock now exposed. The process continued until the crystallisation of portions of the magma was approaching completion.

Renewal of the activity of intratelluric forces then caused the further movement of this partly crystallised magma, and its injection into the position the granite now occupies. During this movement mixing of magma fractions in various stages of crystallisation took place. Those portions in the more advanced stages of crystallisation developed a gneissic structure, but those portions in which but little crystallisation had taken place could not retain the impress of the renewed movement, and solidified as massive rocks. The progressive stages of crystallisation are represented by the gradations from gneissic and porphyritic to even-grained massive granites as exposed to-day. Under these conditions no definite boundaries would exist between the different types of granite. The more rapid cooling of the magma in the second magma chamber—its present position—was responsible for the smaller size of the second generation of crystals which form the matrix of the porphyritic granites.

The residual ultra-acid liquors from the crystallising magma were then forced into the solidified, or partly solidified, granite to form the series of acid and ultra-acid intrusions, the texture of which is more or less continuous with the surrounding country.

Some of the aplitic granite was involved in the movements and received a gneissic structure. The other acid and ultra-acid intrusions were injected after the flowing of the granite ceased.

The fine grained biotitic segregations may perhaps represent portions of a derived magma, resulting from the gravitational segregation of the earliest formed minerals produced in the first stage of crystallisation of the magma.

C. Basic Rocks.

1. *General field-occurrence and petrology.*—The granite is invaded by a network of basic dykes referable to the epidiorite group.

The accompanying maps show that the size and disposition of these dykes in the Darlington and Roleystone areas, are similar.

Fig. 2.—Epidiorite dyke in contact with granite in Greenmount Brook near western edge of Darlington Area. White-barked eucalypts on the dyke visible in background.

Their mode of field-occurrence is mentioned in the physiography section. There is little difficulty in mapping them fairly accurately in the steeper parts of the areas; they can in many places be seen outcropping for many chains, and in the intervals their courses are indicated by the abundance of epidiorite boulders, by the dark red soil, and by the predominance of a white barked eucalypt which contrasts strongly with the dark trunks of the Marri and Jarrah which predominate on granite. However, on some of the high-level terraces, boulders of granite and epidiorite are promiscuously distributed, probably by the river corrading laterally during pauses in the uplift along the Darling Fault. On these areas, though much time was spent in trying to decipher the courses of the dykes, the mapping may be inaccurate.

Petrologically, average specimens of epidiorites from the two areas are identical, and there appears to be little variety except in coarseness of grain. Hand-specimens are of a uniform dark green colour, the feldspars only showing clearly in weathered specimens. In a few specimens small grains of pyrite are visible. The grain size varies with the width of the dyke. The margins are in every instance fine grained and more or less sheared, differing markedly in this respect from the acid and ultra-acid intrusions. Veins of epidote are common, both in the epidiorite itself and in the enclosing granite. It may be noted that irregular quartz veins of small size are not uncommon in the epidiorites.

In thin section the rock is seen to consist of lath shaped crystals of plagioclase, set in a ground-mass of uralite. Much of the plagioclase is zoned; in average composition it is a labradorite. The uralite forms a fibrous mat between the feldspars. It is partly chloritised. There are traces of ophitic structure, plates of uralite enclosing the plagioclase crystals.

The three analyses A, B, and C below of epidiorites from the Darlington Area were made by Mr. F. F. Allsop as part of his course in Geology in 1924.

The analyses D, E, and F of epidiorites from the Darling Range near the areas under discussion have been made available to us through the kindness of Dr. E. S. Simpson, Government Analyst and Mineralogist, in whose laboratory they were made.

	A	B	C	D	E	F
SiO_2	50.67	49.28	49.04	50.96	49.53	49.22
Al_2O_3	14.01	13.62	16.55	11.89	12.92	12.62
Fe_2O_3	1.38	3.13	2.52	2.54	2.60	3.16
FeO	5.20	11.92	9.84	13.64	11.40	11.09
MnO	not determined			.34	.35	.33
MgO	8.12	8.29	7.43	6.26	6.24	6.42
CaO	13.16	7.35	9.70	9.94	10.37	10.59
Na_2O	2.04	2.68	2.54	2.68	2.08	1.86
K_2O	2.32	.29	.28	.29	.36	.30
H_2O-	.23	.18	.18	.16	.09	.12
H_2O+	.70	.70	.61	.05	2.21	2.24
TiO_2				1.84	2.13	2.00
BaO					nil	nil
ZrO_2					nil	nil
CO_2				nil	nil	nil
P_2O_5	.12	.28	.25	nil	.16	.09
FeS_2				trace	.28	.22
Cr_2O_3, V_2O_3, Cu_2S					trace	trace
Total . . .	97.95	97.72	98.94	100.59	100.72	100.26

A—Darlington Area, 40 chains south of mouth of Smith's Mill Brook.

B & C—Boya Quarries.

D—Smith's Mill, 2 miles east of Darlington. Dr. Simpson notes that the rock is composed almost entirely of labradorite and hornblende.

E & F—Quarry at Bickley Brook Reservoir, near Roleystone Area. E is from the fine grained edge. F from the coarse central part of the dyke. Dr. Simpson finds that the minerals in order of abundance are: Hornblende, plagioclase, ilmenite, magnetite, quartz, leucoxene, apatite, epidote.

2. *Relation to other rocks.*—The basic dykes cut the acid and ultra-acid intrusions, and must have been injected at some period subsequent to the consolidation of the granite and its associated acid intrusions. The shear zones and related later quartz reefs are clearly seen to cut epidiorite dykes in several places. There are, however, three places (right bank of Helena 20 chains below mouth of Piesse Brook, ridge on left bank 50 chains below mouth of Piesse Brook, small creek which flows past east side of Boya Quarries) in which dykes were, with hesitation, mapped as passing unaffected through the shear zones. In each case the ground was obscured.

3. *Inter-relationships of the basic rocks.*—The weight of evidence favours the view that there is not more than one age of epidiorite in the areas described. It is true that instances have been seen of one dyke faulting and displacing another, that the surface of contact between granite and some dykes is a "head" along which the two rocks separate readily, while in others the two rocks are so closely adherent that they break more readily across than along the junction surface, and that there are a few dykes which possibly cross the shear planes which truncate other dykes; but unless more conclusive evidence of marked differences of age amongst the dykes is found it is best, in view of their petrological identity, to regard them as all of substantially the same age. In the country just east of Piesse Brook Mr. K. Finucane has found a number of instances of epidiorite invaded by small dykes and veinlets of epidiorite, and also of more acid rock. Further work in this neighbourhood will quite likely cause at least modification of our tentative conclusion as to the single age of the epidiorites.

D. Quartz reefs in shear-zones.

The occurrence of belts of shearing in the Darling Range has long been known, but the relation between these zones and certain quartzose rocks outcropping along the Darling Fault Scarp has not apparently been recognised.

The shear zones of the Darlington Area are of two types:

(1) Shear-zones without secondary quartz,

(2) Shear-zones with partial replacement of sheared rock by quartz.

1. A fine outcrop of the first type can be seen from the road 15 chains S.E. of Darlington railway station. The rock here is a sericite schist derived from the granite.

2. A good exposure of the second type occurs on the western edge of the Area 85 chains south of the Helena River, where a belt of sheared granite, associated with a quartz reef, can be traced along the strike for about 600 yards.

Detailed study of this outcrop in the field, and the examination of thin sections, indicate that the secondary quartz was formed in part by the metasomatic replacement of the original sheared granite.

The central zone, about 4 feet wide, consists of massive fine-grained sugary quartz containing scattered grains of clear quartz of larger size than the ground-mass. Under the microscope the ground-mass is seen to be a fine-grained aggregate of quartz showing no undulose extinction. The scattered fragments of clear quartz exhibit pronounced undulose extinction, and are similar in size, shape, and strain structure to the quartz grains in the unreplaced sericite schist. The largest quartz grains appear to have been original constituents of a schist the other minerals of which are now almost entirely replaced by secondary quartz.

The central quartz reef merges on either side into quartz rock with a well defined cleavage parallel to the schistosity of the whole belt, and containing lenses of much weathered sericite schist, some only a fraction of an inch wide, also parallel to the schistosity. Proceeding farther towards the edge of the belt, the amount of secondary quartz is seen to become less and less, the rock passing into a normal sericite schist. A network of quartz veins cuts both the replaced and unreplaced rock.

There are many similar quartz reefs in the district, several of which are clearly continuous across epidiorite dykes, but few of the exposures are good. The sheared granite generally weathers more rapidly than the more massive enclosing country, but the presence of the reefs is indicated by the abundance of quartz floaters, often associated with fragments of schistose rock. The larger pegmatite veins give rise to somewhat similar quartz blows, but the presence of fragments of kaolinised feldspar indicates that the underlying rock is pegmatite, whereas, if pieces of schistose rock are found, the underlying rock is a quartz reef.

After investigating the quartz reefs of the Darlington Area, a visit was made to part of the Darling Fault Scarp east of Gosnells, where there is a very conspicuous outcrop of quartz rock. This formation was found to be, in its essential features, identical with the Darlington Area type, but developed on a much larger scale. The belt of shearing varies in width from a few chains up to about a quarter of a mile and trends approximately north and south, i.e., parallel to the Darling Fault. The quartz reefs are several chains wide, but vary in width along the strike. Like the Darlington Area type, they are composed of massive sugary quartz in the middle, and grade through schistose quartz into sheared granite on either side. The whole belt is traversed by numerous quartz veins, disposed both parallel to and across the planes of schistosity. Several basic dykes were observed to end abruptly at the edge of the shear zone.

The unsheared granite of this locality is massive. The massive granite is continuous as far south as the Roleystone Area. Farther south, at Arundale, similar quartz reefs have been noted in gneissic granite about a hundred yards east of Coombs' Quarry.

The formation of these belts of shearing and silicification is of later date than the intrusion of basic dykes, across which, with the possible exceptions noted under "basic rocks," shearing persists. The basic dykes themselves are intrusive into the granite and its associated acid and ultra-acid derivatives. It seems most probable therefore that these quartz reefs were formed later on, and are quite distinct from, the quartz veins previously referred to as representing ultra-acid residual liquors from the granite magma squeezed into the consolidating granite.

E. Later Rocks.

1. *Laterite.*—Only in a few places do the Darlington and Roleystone Areas rise to the "Laterite Level" which in this region lies between 600 and 700 feet above sea level. The laterite of the Darling Ranges has been described and discussed elsewhere (Simpson 1912, Woolnough 1918, Clarke 1919) and we have nothing of interest to add.

2. *Alluvium.*—Two types of alluvium occur in the Darlington Area, that forming the flats in the lower part of the Helena, and high level alluvium in the former course of Smith's Mill Brook. The first does not call for comment, the second is described in the Physiography section.

3. *Talus banks.*—The tributaries of the Helena generally flow in narrow V-shaped valleys. In many of these, running parallel to the watercourse, and at heights varying from three to fifty feet above it, is a steep sided bank 1 to 3 feet high of angular rock fragments, the steep side facing the stream. Similar features were noted in the Roleystone Area. The origin of these banks is puzzling. They look at first sight as if of human origin—made in clearing a track—but the places in which they occur make that theory untenable. Possibly Jutson's explanation (1921)—differential erosion—of the parallel lines of rock debris on Lake Goongarrie which of course occur under very different climatic and topographic conditions is applicable to these banks. In the Darling Ranges the unequal erosion is due to the varying resistance to weathering of granite and epidiorite, at Lake Goongarrie wind-erosion of soft shales unprotected by quartz rubble is the agent.

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Explanation of Plates.

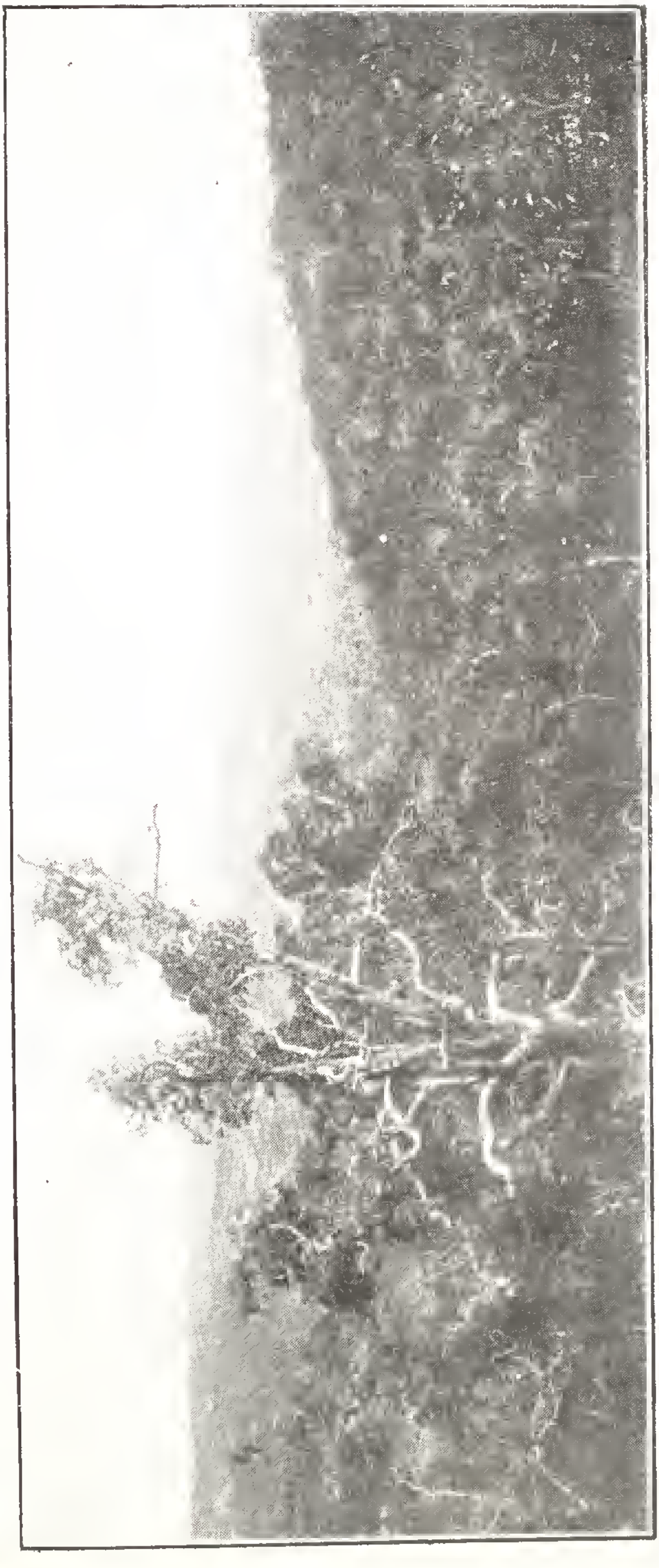
XXI—Looking west down Helena Valley from spur on left bank of Cohen Brook. Shows characteristic topography and vegetation.

XXII—Photograph of a model of the Darlington Area of which horizontal scale is 10 chains to 1 inch, vertical 200 feet to 1 inch.

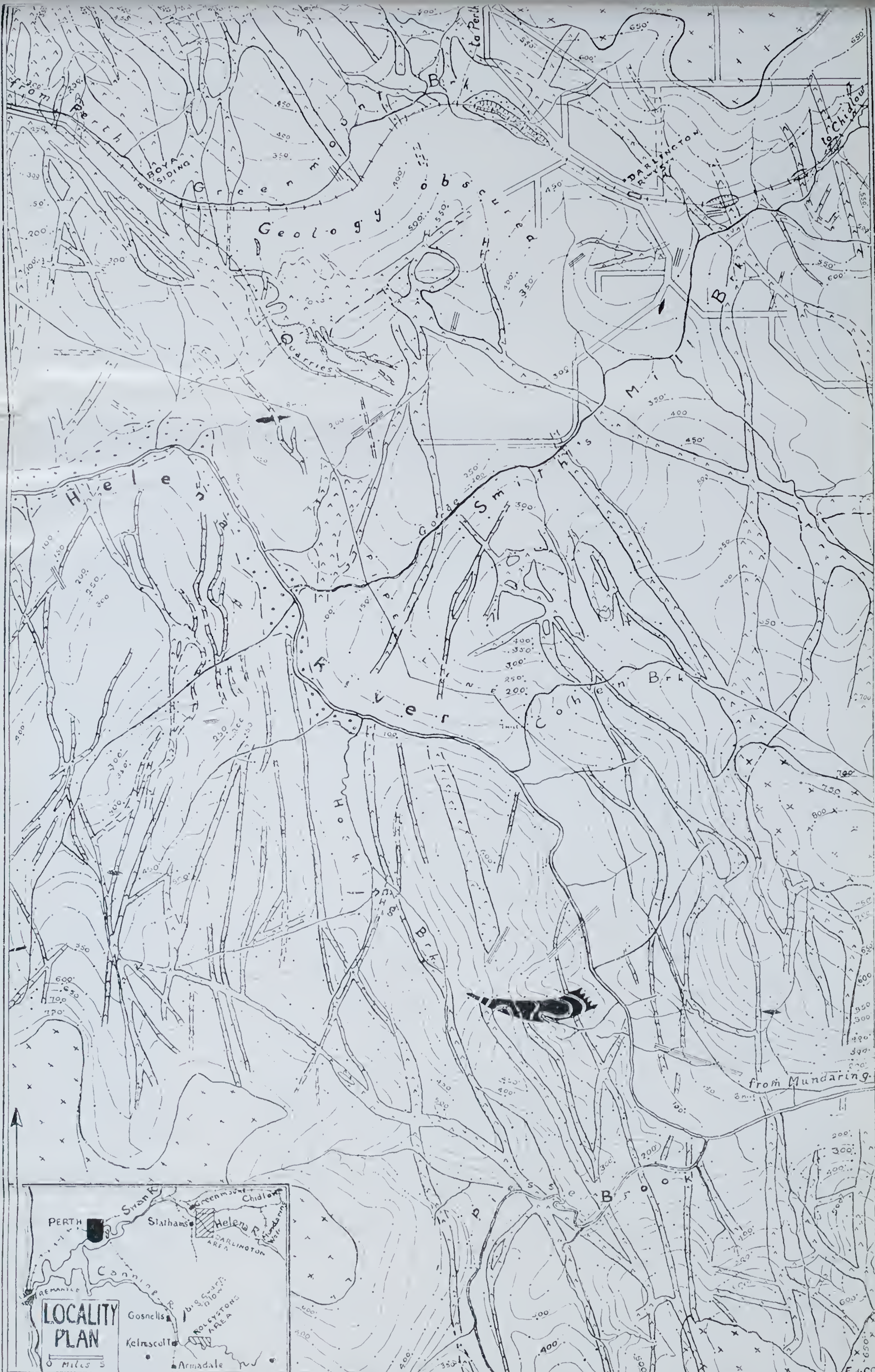
XXIII—Geological map of the Darlington Area.

XXIV—Geological map of the Roleystone Area.

Printed for the Royal Society of Western Australia by R. S. Sampson, 971-973 Hay Street, Perth.




MODEL OF THE DARLINGTON AREA
Piesse Bk
Helena R
Smith's Mill Bk



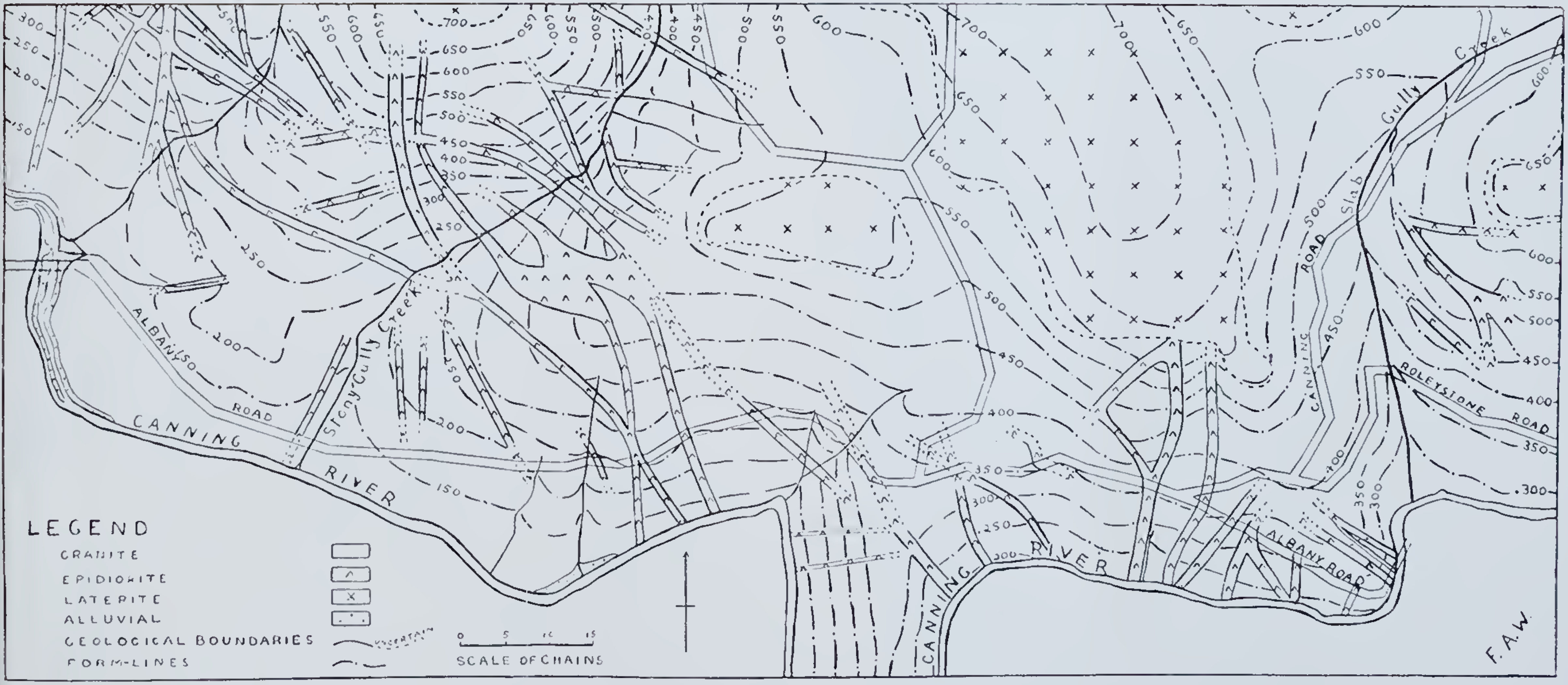
GEOLOGICAL MAP OF THE DARLINGTON AREA

Scale 0 10 20 chains

LEGEND

GRANITE	ALLUVIUM
EPIDIORITE	LATERITE
QUARTZ "BLOWS"	GEOLOGICAL BOUNDARIES
• SHEAR ZONES	

QUARRIES AND CUTTINGS
FORMED ROADS
RAILWAYS
FORM-LINES 500'



GEOLOGICAL MAP OF THE ROLEYSTONE AREA.

Contributions from the Department of Biology, University of Western Australia—No. 9.

A Description of Two New Genera and Species of Phreatoicidea, with a Discussion of the Affinities of the Members of this Family, by George E. Nicholls.

(*Read* July 13, 1926. *Published* August 31, 1926.)

CONTENTS:

On the occasion of a short visit made to Victoria in February of this year, I collected, during a week-end at Mt. Buffalo, a number of specimens of a species of *Phreatoicus*, with quite small eyes. These, while bearing a marked general resemblance to *P. australis*, seemed nevertheless to differ from that form in quite a number of features. Since but one other species (*P. shephardi*, which is eyeless), has been described, hitherto, from the eastern part of the Australian mainland, it was likely that these specimens would prove to be referable to a new species and, accordingly, as many as possible were secured.

They occurred in a variety of situations; the first, a solitary specimen, was caught in the waters of Lake Catani, its presence there probably accidental, for prolonged search failed to reveal others there or under similar conditions in the waters of the New Reservoir. They were discovered, however, quite abundantly, partly embedded in almost dry mud which had formed the floor of a shallow puddle, at a spot where, in wetter seasons, a small creek discharged into the Lake. Here, under one quite small piece of decaying bark, nearly forty specimens were found curled up and motionless.* This creek, on investigation, was found to serve, in normal seasons, as the drain for a peat bog, under the mossy surface of which and in a small spring-fed hollow yet other specimens were taken. On the following day, the "Crystal Brook" was followed to its source, near which, in tiny hollows between clumps of sphagnum, as well as in a narrow runnel emptying into the Brook, other, lighter-coloured specimens were captured. Another trip, this time to the "Horn," for the most part following the course of a small creek which proved to have its origin in a considerable bog that partly encircled the foot of the peak itself (where this rises abruptly from the Plateau), was equally successful. On this occasion *Phreatoicus* was taken at a number of different spots, as well as quite freely in the bog at the foot of the "Horn," practically at the highest part of the Plateau. Indeed, several of the localities must have been at altitudes closely approaching five thousand feet.

The specimens taken from black peaty mud or from beneath the surface of the bog were much darker in colour and for the most part were densely infested with attached Rotifers, as well as by disc-shaped bodies which I fail to identify. In some cases a single seta may have its half-dozen attached forms, and these may largely obscure the actual outline in setose regions. Others, taken from the open, are lighter coloured and much less heavily infested.

So plentiful as was this animal, of such conspicuous size (exceeding 14 mm.), and with so widespread an occurrence, it seemed almost incredible that it could have escaped earlier observation. Accordingly, on my return to Melbourne, I made enquiry at the Museum, where I learned that there were apparently no records of specimens of *Phreatoicus* from the Buffalo region. I was, however, very kindly permitted to examine the Museum Collection of Freshwater Crustacea and satisfy myself of the absence of any such material from that part of Victoria. While engaged upon this search I happened upon a tube containing another Phreatoicid, unnamed, but, beyond all peradventure, new. This bore a locality label which indicated that the contained specimens were collected in

*Some of these, kept under similar conditions, in a small wooden box, survived until my return to Perth, nearly three weeks later, when, on being placed in water, they shortly unrolled and resumed active existence.

the Northern Territory, the first instance of a Phreatoicid from the Tropics. Hitherto, the most northerly records for this family were the Barrington Tops in N.S.W., S. Lat. 32°, Perth, in W.A., in the same Latitude, while *P. latipes* from South Australia was found at Coward, 29° South Latitude. The fossil form, discovered at Newtown, Sydney quite probably ranged as far north as these.

At my request, I was most courteously allowed to remove certain of these Northern Territory forms for examination. They are described below, a new genus being required for their reception, the species being named in compliment to Mr. Kershaw. The species, taken at the Buffalo proved, likewise, to be new, this being named after my friend and enthusiastic fellow collector, Mr. A. E. Joyner, of Perth.

A consideration of these two new forms and a review of the structure of such other species as I have been able to examine, has convinced me that the Australasian species referred, hitherto, to the genus *Phreatoicus,* fall into two quite definite and readily separable groups, sufficiently distinct to warrant their assignment to separate genera.

As was stated in an earlier paper (1924), it was only after very considerable hesitation that I had referred the Western Australian form *P. lintoni* to the genus *Phreatoicus,* a hesitation which Dr. Chilton had previously experienced when describing *P. latipes.*

Accordingly, I now propose to establish for all the lowland forms from Western and Southern Australia, a new genus **Amphisopus,** all these species having in common a number of features elsewhere found together only in the Amphipoda. To this new genus, however, the species from the Northern Territory cannot be assigned, nor does it fall within the accepted definition of *Phreatoicus;* consequently the recognition of a second new genus seems necessary and for this I propose the name **Eophreatoicus.** The remaining forms, distributed in the subterranean and surface waters of New Zealand, the Highlands of Tasmania, and the Sub-Alpine regions of Eastern Australia should, so far as I can judge, be retained in the genus *Phreatoicus* Chilton, the new species *P. joyneri,* also, properly belonging here. The position of *P. capensis* Barnard is uncertain, and in the absence of material I can come to no conclusion, but, judging from Barnard's figures (1914, Pl. 23, 24) and his descriptions, I incline to the opinion that it will be found to occupy a position intermediate between *Eophreatoicus* and *Phreatoicus.* In some respects, indeed, it appears actually more primitive than either of these; a consideration of this matter is deferred, however, to a later chapter, where the inter-relationships of the several forms are discussed.

AMPHISOPUS, gen. nov.

Body long, peraeon sub-cylindrical, pleon markedly compressed. First segment short, more or less fused with the head, which lacks a vertical groove near its posterior margin. Upper antenna filiform, longer than peduncle of lower antenna, flagellum with ten or more joints. Lower antenna long, flagellum many jointed. Eyes large. Mandibles with an appendage, right mandible retaining a reduced secondary dentate edge. First maxilla with six or seven plumose setae on inner lobe. Legs divided into an anterior series of four and a posterior series of three, the coxal joints scarcely or not distinct. First pair of legs sub-chelate in both sexes, larger in the male than in the female; the fourth leg in the male not sub-chelate; basos of the three legs of the posterior series largely expanded. Pleon relatively longer than in *Phreatoicus;* the last segment almost, or completely, marked off from the telson. Coupling hooks on the basal joint of pleopods one and two; epipodites upon the third, fourth and fifth pleopods. In the male, a strongly curved penial filament on the endopodite of second pleopod, long and pointed, without terminal setae. Male appendage not setose. Uropods stout, biramous, styliform. Telson large, horse-shoe shaped in transverse section, in profile suggesting a sub-conical body, without terminal projection, the dorsal margin entire, emarginate or cleft.

With three species:—

A. lintoni Nicholls (sp. typ.), *Phreatoicus l.,* Nicholls, 1924, Jour. Roy. Soc, W.A., Vol. X, pp. 89-104, 1924.

A. latipes (Chilton), 1923, *Phreatoicus l.*, Chilton, Trans. Roy Soc. S.A., Vol. 46, p. 23, Figs. 1-14; *P.l.*, Glauert, Jour. Roy. Soc., W.A., Vol. X, pp. 49-57, 1924; *P.l.*, Nicholls, Jour. Roy. Soc., W.A., Vol. X, Pl. 8, Fig. 3a, pp. 98-104, 1924.

A. palustris (Glauert), 1924, *Phreatoicus p.*, Glauert, 1924, Jour. Roy. Soc., W.A., Vol. X, pp. 49-57; *P.p.*, Nicholls, Jour. Roy. Soc., W.A., Vol. X, Pl. 8, Figs. 2, 2a, pp. 98-104, 1924.

Distribution. At the time when the original description of *A. lintoni* was written I had obtained my material from but a single locality, a small creek emptying into the estuary of the King River in South-Western Australia. Subsequent collecting trips showed that this species occurs freely in and around Albany itself, one fine specimen actually being taken in the Marine Drive, and more than a dozen different spots yielded abundant material. In some case these were found plentifully in mere puddles along the railway line, or in larger hollows at the foot of the hill near the swamps at the landward end of the Deep Water Jetty. Some of my larger specimens were taken practically at sea level, in a tiny runnel of fresh water within a half dozen paces of the spot where this discharged into the sea. Yet others were secured from a small pool fed by a spring beneath a huge granite boulder, high up on the southern slopes of Mt. Clarence (Albany) and in its swampy overflow. A later trip made, in January, 1925, to Two People Bay, some thirty miles or so to the Eastward of Albany, resulted in the discovery of this species as an abundantly occurring form in that locality.

At Denmark, thirty miles to the West of Albany, and at other places still more westwardly, to Nornalup (nearly eighty miles), I have, however, searched in vain for this Phreatoicid, nor has it been found in the relatively abundant fresh waters of the Porongorup Ranges, some forty miles inland. Nor yet has any trace of it been seen in the Margaret River district at the southern end of the West Coast.

Amphisopus lintoni, then, may be considered as likely to prove a relatively widespread form occurring in shallow fresh waters *near to the Coast* of South-Western Australia from the vicinity of Albany eastwards, but probably not existing in the dark peaty waters (locally, "coffee" water) of the more western creeks and streams.

The known range of *A. palustris*, too, is now greatly extended. It has been taken freely in many of the shallow lakes in the environs of Perth. I have collected it, also, from swamps and ditches at Pinjarra, nearly sixty miles to the south, and near to York, some forty miles inland. In these two latter cases there are exhibited differences which may prove to be of varietal value.

Concerning *A. latipes* nothing further has been recorded since the publication of Chilton's paper in 1923.

Habits. An account of the habits of these and other Phreatoicids will be found below.

Phreatoicus joyneri sp. nov., Plates XXV, XXVI, and Pl. XXIX, Figs. 40-44.

Specific Diagnosis. Body robust, surface smooth, with very few scattered hairs. Head somewhat shorter than combined length of first and second peraeon segments, produced into postero lateral lobe, which touches maxilliped, with well marked vertical groove slightly proximal to hinder border. Eyes small, round, with few ommatidia.

Peraeon sub-cylindrical. Epimera (coxal joints) well developed. First segment very short in mid dorsal line, longer on ventral border, scarcely fused with the head, second, third, and fourth segments equal, fifth and sixth equal but shorter, seventh distinctly shorter.

Pleon moderately long, having, with the telson, a length almost exactly two thirds of that of combined cephalon and peraeon. First segment as short as first peraeon segment, second and third equal and longer than the first, fourth longer than preceding, the fifth deeply notched posteriorly and twice the length of the fourth. The setal fringe practically confined to inferior margin. The ventral border of the sixth pleon segment armed ventrally with stout pectinate setae, which give place to spines at the postero-lateral corner; its overlapping posterior pleural border fused with the telson and forming a short sutural line bearing but three fine setae.

Telson large, horse-shoe shaped in transverse section, a well developed dorsal transverse depression defining the tip-tilted terminal projection, the latter armed with spines and setae and flanked on either side, at a slightly lower level, with strong spines. Ventrally the pleural margin of the telson is free from setae or spines.

First antenna short, not as long as the peduncle of the second, with a flagellum of five joints in the male and but three in the female; second antenna nearly half the length of the animal, almost as long as cephalon and first five peraeon segments, peduncle barely half the length of the flagellum, which may have from eighteen to twenty joints. Right mandible without secondary cutting edge, both mandibles with well developed curved spinous plate bearing a double row of denticulate spines.

Gnathopods strongly sub-chelate, the palm oblique and armed with a series of spines which become broadened toward the proximal end of the joint into subtriangular serrated scutes. Second and third peraeopods appear to be slightly prehensile; the fourth, in the male, quite strongly sub-chelate; in the female, the fourth resembles the preceding; fifth, sixth and seventh legs increasing progressively in length, the subtriangular coxal regions distinctly marked off, but coloured exactly as the related segments; basal joints rounded, little expanded. Pleopods 3-5 with large endopodites; uropods long, peduncle bearing on its extremity, one thick and one slighter spine pectinated dorsally, rami slender, not very spiny.

Colour: Brown, generally very dark, with lighter (yellowish) markings; specimens taken in the open varying with the colour of the underlying mud, to light brownish or even yellowish grey. The legs may then be a light yellow in colour.

Length: Largest specimens (male) 14 to 15mm., none of the much less numerous females exceeding eleven millimetres.

Habitat: Taken in bogs, among the growth of sphagnum, also in weedy runnels among the tufts and roots of grass on the Mt. Buffalo Plateau, Victoria.

Detailed Description.—Eyes: Small, few (12-14) ommatidia, apparently undergoing degeneration. The *first antenna* (Pl. XXV, Fig. 2, 2a) remarkably short with, in the female, fewer joints than in any species of *Phreatoicus* described hitherto. There is very little to distinguish the peduncle from the flagellum, the penultimate joint of the latter being, in the female, relatively large and swollen, while the terminal joint is a mere knob. In the full grown male there may be either four or five joints, the second and third being subequal and larger than the other joints. Setae are not very abundant, but there is a small terminal tuft and an olfactory cylinder occurs upon both the terminal and the penultimate joint in both sexes.* The *second antenna* (Pl. XXV, fig. 1, and Pl. XXIX, fig. 44) is slightly less than half the length of the body, the peduncle, with five joints, being almost exactly half the length of the flagellum, which has eighteen to twenty long, slender, joints each set with a sub-terminal and incomplete circlet of setae; in the peduncle the first joint is short, the second, third and fourth increase progressively in length, the fifth being slender and as long as the third and fourth together.

The *upper lip* agrees closely with that of *P. australis* (Chilton, 1891, p. 156, Pl. 23, fig. 4). The *mandibles*, also are much as in that species, the right mandible having but three teeth in the cutting edge. The spinous plate, however, on both mandibles (Pl. XXVI, fig. 12, 12a) is a curved structure with a median groove running along its exposed face, on either side of which is a row of stout spines with well marked denticulations; on the left mandible these spines (16-18 in number) appear to be symmetrically arranged and similar, but on the right the spines along one edge (the posterior), are smaller and sharply bent. Between this plate and the molar tubercle are the usual pectinate setae (two or three). On a level with the tubercle are a number of short stiff setae. Upon the palps some of the stoutest setae (Pl. XXVI, fig. 12, s) are strongly serrate on one margin and fringed with fine closely set hairs on the opposite edge. The *lower lip* (Pl. XXVI, fig. 9) differs apparently from that of *P. australis* chiefly in that its inner margins are clothed with longer and stiffer setae.

The *first maxilla* (Pl. XXVI, fig. 8, 8a) also resembles closely that appendage in *P. australis*. Its outer lobe is broad with truncate apex set with eight or nine stout setae, some of which are denticulate. The inner lobe has the usual number (4) of plumose setae, agreeing in this with *P. shephardi*, *P. kirkii* and *P. assimilis*. *P. australis* is

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*In Pl. XXI, Fig. 1, the length of the first antenna, relative to the second, has been exaggerated—in its natural position, its apex rarely reaches the terminal joint of the peduncle of the second antenna, its total length only equalling the combined length of the three terminal joints of the peduncle of that appendage.

said to have four or five such setae. In the latter species and in *P. assimilis* there are in addition two simple setae, while in *P. shephardi* none are figured; *P. joyneri* has one only.

The plumose setae in this form, however, are unusually stout and densely set with a terminal tuft of setae (resembling rather the penicilla of Oniscids) and differing in this, if one may judge from the figures, from the other species of *Phreatoicus*. Another difference is furnished apparently by the presence of a curved ridge (Pl. XXVI, fig. 8a) stretching along the surface of the inner lobe and bearing numerous long setae. The structure of the *second maxilla* (Pl. XXVI, fig. 10) of *P. joyneri* is almost exactly that of the corresponding appendage in *P. australis*, excepting that the inner lobe is narrower distally, the outer lobe and the palp having fewer setae, which are pectinate in the usual manner; the usual tuft of setae at the base of the palp is not to be made out.

In the *maxillipeds* (Pl. XXVI, fig. 11) the epipodite is perhaps rather broader and bears but three lateral setae. Upon the inner plate two stout coupling spines only are present and along its whole free border it is fringed with long and stout plumose setae, the apical setae being feebly plumose or pectinated; the inner distal angle, in both meros and carpus is markedly produced.

The *gnathopod* (Pl. XXV, fig. 6) is of the usual sub-chelate type. The limb is stout, the basos having a length barely twice that of its greatest width; the anterior margin of this joint is wholly free from setae, whereas in the succeeding appendages the corresponding joint is strongly setose. In the adult male, the propod has almost exactly the form of the corresponding joint in *P. australis*, but is free from setae on the lateral surfaces, while the posterior border proximal to the palm is almost straight, whereas in *P. australis* it is figured as concave. The *palm* (Pl. XXV, fig. 6a) is raised into a narrow saw-like edge, the simple distal spiniform setae passing into broadened serrate scutes (Se) at the more proximal end. The *dactyl* has about ten, almost equidistant, setae on its concave (posterior) margin, with four or five on the convex surface. A similar setose condition of the dactyl is figured (Chilton 1894) for *P. assimilis* and described (1891, p. 161) in *P. australis*, but is otherwise unrecorded. There is a small terminal tuft of setae also, one of the these being somewhat similar to the sensory setae found on the first antennae and named "olfactory cylinder." This subapical tuft is present on the succeeding appendages (Pl. XXV, fig. 7a) and, indeed, appears to be of very general occurrence in the Phreatoicidea, though reduced apparently to a single seta in some species (cf. *A. palustris* (Glauert), 1924, fig. 3). In the female, the appendage is very similar, but the propod is rather less strongly developed.

In the male, the three succeeding *peracopods* have apparently developed a prehensile condition, though in varying degrees. In the second thoracic appendage the propod has a sub-rectangular outline, the anterior border being very slightly convex, the posterior with a small distal concavity furnished with setae. Proximally a couple of stout spines would meet the tip of the down-folded dactyl. This joint is stout and curved, its proximal end set in a groove between distally produced extensions of the propod. The propod of the third appendage is rather stouter, more convex anteriorly, its posterior border more concave and bearing two pairs of proximally situated spines to receive the dactyl, with better developed guides for the base of the dactyl. The fourth peracopod has a very stout propod, convex along both borders, greatly produced distally on either side of the dactyl, thus hiding much of the base of this joint, which appears short and is strongly curved. The tip of the dactyl has but a very reduced secondary unguis and is received between a pair of powerful spines on the propod. In all three of these appendages the anterior border of the basos is beset with setae, the posterior border of the entire limb being strongly setose.

The three legs of the posterior group are, also, markedly setose; the basos, narrow at its origin, shows an expansion which is little marked in the foremost, more pronounced in the posterior, limbs; the hinder margin of the joint being furnished with moderately long setae; the large ischios expanded about the middle of its length rather than distally; the meros widened distally; the two succeeding joints sub-rectangular, the propod being long and slender. The dactyl has a small secondary unguis which is flanked by a stout spine and a more slender seta. The coxal joints (epimera) of these thoracic limbs seem to resemble closely those of *P. australis* (Chilton, 1891, Pl. 23, fig. 1).

The paired male appendage (Pl. XXVI, fig. 13) on the last thoracic segment appears to differ from the organ as described and figured in *P. australis* in the possession of a number of setae regularly disposed along its mesial border. Such a condition is figured, however, for *P. capensis*.

Pleopods (Pl. XXVI, figs. 14-16). The branchial appendages likewise differ somewhat from these structures in other species of *Phreatoicus*. In the first pair (Pl. XXVI, fig. 16) the number (13-14) of plumose setae is rather greater than in *P. australis*. The endopodites of the second (Pl. XXVI, fig. 14) are relatively longer, reaching to the end of the proximal joint of the exopodite and are scarcely exceeded by the slightly curved penial filament, which bears a terminal tuft of four or five stiff setae. The distal lobe of the exopodite is fringed with about twenty plumose setae, while internal to its base, on the proximal lobe are eight plumose setae. Externally the proximal lobe is beset with long setae, of which only a few (12) of the more distal are plumose.

Upon the flattened face of this proximal lobe there is in one specimen a slight ridge, set with setae running obliquely inwards from the lateral border. It has the position of the ventro-mesial border of the epipodite of succeeding pleopods and might conceivably indicate the fusion of an epipodite with that plate. The basal joint (protopodite) has stiff plumed setae on its mesial border only, whereas the basal joint of the first pleopod has numerous setae both mesially and externally. Upon pleopoda 3-5, the epipodites are free and of relatively large size; the endopodites are long, extending to the base of the distal exopodite segment; the basal joint (protopodite) with a mesial lobe set with long setae. Upon the proximal exopodite joint of the third pleopod the number of plumose setae is increased to about 25. In life the pleopods are visible, their distal ends coming well below the inferior margin of the pleura of the pleon segments.* The ventral margin of the pleon segments 1-5 are fringed with long flexible setae which scarcely extend onto the posterior borders. Upon the sixth segment (Pl. XXIX, fig. 42) these seta are represented by serrations or short pectinate spines which give place posteriorly to a few (3-4) stout spiniform setae. The pleura of the latter segment slightly overlap the telson externally and are fused with it. The line of suture is quite distinctly raised and gives origin to but three delicate setae.

The *uropods* (Pl. XXV, fig. 1, and Pl. XXIX, figs. 42, 43) are well developed, a stout peduncle projecting backward to the level of the end of the telson. Ventrally there are two tufts of three setae, dorsally three or four almost equi-distant spines upon the outer border (fig. 43); two stouter spines upon the inner margin at its distal end (fig. 42).

At the extremity of the peduncle one or two spines are laterally placed, while ventrally are three spines—the innermost simple (fig. 42a), the middle very stout, with terminal pectination dorsally, and the outermost, smaller but also with terminal pectination (Figs. 43, 43a).

The rami are of nearly equal length, the outer slightly the shorter; each bears an apical spine and two or three setae, but the whole appendage is distinctly less setose than is usual in this genus.

*This is the case with all of the species of *Phreatoicus* that I have been able to examine in the living condition. In many preserved specimens also, the pleopods may be seen hanging downwards and then quite obvious.

Upon the dorsal surface of the large *telson* the presence of a deep transverse rounded depression emphasises the upturned end, which bears a number of setae and is flanked ventro-laterally by a couple of stouter spines on either side (Pl. XXV, fig. 1, and Pl. XXIX, figs. 40, 41).

While the telson as a whole is concavo-convex in section, this tip-tilted terminal part has, in cross section, the shape of a long ellipse.

Remarks. This, the third sub-alpine species to be recorded from Eastern Australia, is in many ways intermediate between *P. australis* and *P. shephardi.* So much is this the case that when, at first, I thought of the Mt. Buffalo form rather as a variety than a species, I could not decide to which of the two it should be referred. I have not, however, been able to examine any examples of *P. shephardi,* and the descriptions given by Sayce (1900) and by Chilton (1916) are too brief to make possible a detailed comparison between the two Victorian species. Judging from Smith's figures (1909, Pl. 12, figs. 1-4) the Tasmanian forms of *P. australis* are somewhat variable, and it may later become necessary to reduce *P. joyneri* to the rank of a variety of *P. australis,* but for the present it seems advisable to regard it as distinct.

The proportion of length of pleon to that of combined cephalon and peraeon is almost exactly that given by Sayce for *P. shephardi,* but this ratio, according to Chilton, holds only for the female (and, presumably, for the immature male) of that species. The spinous condition of the ventral margin of its 6th pleon segment, likewise, resembles closely that of *P. joyneri;* in the latter, too, the sutural line between the 6th pleon segment and telson is shorter and less distinct than in *P. australis;* in *P. shephardi* it is presumably absent, being neither figured nor described. The peduncle of the second antenna, inner lobe of the second maxilla, propod of first, fourth and seventh peraeopods in the male of *P. shephardi* all approximate closely to the condition found in *P. joyneri.* The pleopods of the former species are not described.

From *P. australis,* the new Victorian Phreatoicid differs in its larger size and more robust habit, its smooth body almost free from setae, the proportions of the pleon, the more elongated peduncle of the second antenna, the condition of the spinous plate of the left mandible, the more setose lower lip, the tufted condition of the plumose setae on the inner lobe of the first maxillae, the shape of the inner lobe of the second maxillae, certain details in the three posterior legs, the endopodites of the pleopods, the less spinous condition of the uropods, and the shape of the outline of the inferior margin of the telson.

In the possession of but very few joints in the first antennae, of a well marked vertical groove near the posterior border of the head, and of stout pectinate spines at the base of the rami of the uropods, in the well developed condition of the coxae of the peraeopods, and the pronounced terminal projection upon the telson, it agrees with *P. australis* and seems to differ markedly from *P. shephardi.*

In the reduction of the size of the eye and the fewness of the ommatidia, it represents a condition intermediate between the two Eastern Australian forms; in the smoothness of the body and the reduction of the setae it approaches the condition of *P. assimilis,* a state resulting probably from the operation of somewhat similar sheltered conditions of life.

Distribution. While *P. australis* occurs apparently widely spread in Tasmania at altitudes varying from sea-level to 4,000 feet, upon the mainlaid it seems to have survived only upon Mt. Kosciusko (5,700 ft.). *P. shephardi,* first recorded from the Plenty Ranges in Southern Victoria, was subsequently taken, apparently abundantly, upon the Barrington Tops, in New South Wales, some three to four hundred miles to the north. *P. joyneri* occupies a small sub-alpine region within the range of both of these forms. It is probable that all of these species are survivors of a once wide spread form living at lower levels, but later restricted, possibly due to secular climatic changes, to small and isolated sub-alpine regions where they have undergone specific differentiation.

EOPHREATOICUS gen. nov.

Body sealy, wrinkled transversely; head short, with well marked vertical groove near posterior margin; eyes large; peraeon slightly compressed, first segment short, more or less fused with the head; pleon relatively longer than in *Phreatoicus,* strongly laterally compressed, last segment scarcely marked off from telson, terminal projection slightly developed. Upper antenna as long as (longer than) peduncle of lower antenna, flagellum with numerous joints; lower antenna stout, about one-third length of body. Mandibles with appendage, secondary dentate cutting edge, spine row and molar tubercle. Legs divided into an anterior series of four displaying small coxal joint, and the meros with large anterior lobe; and a posterior series of three, with basos, ischios and meros strongly expanded. First pair of legs sub-chelate in both sexes, larger in the male than in the female, the fourth leg in the male sub-chelate. Pleopoda with exopodite and endopodite sub-equal, with epipodite on all but the first, without coupling hooks; with curved penial filament on second pleopod strongly setose, not exceeding endopodite. Uropod stout, slightly expanded, biramous, very setose. Telson, horse-shoe shaped in transverse section, with margin entire, not up-turned.

E. kershawi, sp. nov., Plates XXVII, XXVIII and XXIX, Figs. 34-39.

Specific Diagnosis. Body robust, surface scale clad with very few scattered hairs, dorsal surface transversely ridged; head considerably shorter than combined length of first and second peraeon segments and with strongly marked vertical groove near posterior border. Eyes well developed, strongly convex, with many ommatidia. Peraeon distinctly compressed, first segment narrow, widening somewhat ventrally, scarcely free from head; second, third, and fourth segments sub-equal, coxal plates small. Fifth, sixth, and seventh segments decreasing progressively in length, coxal plates scarcely distinct. Pleon long, having with telson a length slightly greater than four-fifths of that of combined cephalon and peraeon and a greatest depth equal to the combined length of third, fourth, and fifth pleon segments. Two or three stiff setae on ventral margins of pleon segments; without setae on posterior margins. Sixth segment fused with telson, with but very short sutural line which bears no setae. Telson large, horse-shoe shaped in transverse section, without up-turned terminal projection, margin entire, with four stout spinules.

First antenna stout, longer than peduncle of lower antenna, with as many as sixteen articuli, with sensory setae, but no olfactory cylinders; peduncle and proximal joints of flagellum with serrate margin (due to scales). Second antenna, two proximal joints stout, sub-equal, third and fourth slightly longer, sub-equal, fifth slender, long as third and fourth combined; flagellum with as many as twenty-two joints, somewhat longer than peduncle; margin of entire appendage serrated. Right mandible with reduced and modified secondary dentate cutting edge, with spine row, molar tubercle with setae, palp with broad second joint. Lower lip extremely setose, scale-covered. First maxilla, inner lobe with seven plumose setae and one simple seta. Second maxilla, short and stout, inner plate sub-triangular, outer plate and palp with mesial margin reflexed distally. Maxilliped with two strong plumose setae on distal end of second joint, just internal to inner plate, the latter with row of 4 or 5 coupling hooks. Gnathopod with stout rounded basos, large ischios, propod strongly convex anteriorly, palm set with stout spines, occupying entire posterior margin; dactyl long and straight, but sharply bent near base, with minute secondary unguis. Second, third and fourth peraeopods with stout rounded basos bearing anteriorly at the proximal end a small tuft of stout setae; ischios widest mesially owing to flattened expansion, meros produced into conspicuous antero-distal lobe, dactyl with secondary unguis. In the male, fourth peraeopod sub-chelate, a pair of stout spines on propod receiving tip of dactyl. In the posterior series of peraeopods, the length of the limb and the extent of the expansion of the three proximal joints increases progressively, the meros being produced into a notable distal lobe. First pleopod with endopodite and exopodite of equal length; pleopods 2-5 with endopodite overlapping distal joint of exopodite and with epipodite. Second pleopod, in male, with penial filament, moderately curved, concave laterally, strongly setose with a considerable row of stout setae apically. Uropod stout, peduncle expanded on inner margin, very spinose on both margins; rami expanded, spinose, inner the longer. Spine at base of rami not pectinate.

Colour: In spirit, yellowish-grey. The body generally is yellow tinted, with black dendritic spots scattered sparsely along the sides and still more sparsely upon the extremities of the limbs. In mid-dorsal line and on either side dorsally, these spots are closely aggregated to form three dark interrupted lines. In the peraeon these may be continuous and almost merge into one another, the marking then, in that region, may be described as consisting of a paired dark dorso-lateral line separated by a light median yellow line bearing a dark spot at the middle of each segment. Laterally (externally) the dark bands may be defined by a thin and wavy yellow line.

Size: The largest male measured 21 mm., the smallest but 12 mm., with a width of peraeon of 2.5 mm. About 25 per cent. of the specimens showed no male organ, the largest of these being 14 mm. in length, with a breadth of peraeon of 3.5 mm.; the smallest obtained measured 9 mm.

Locality: The collection of close upon a hundred specimens was made by W. McLennan (in November, 1915) and was presented to the Museum by H. L. White, Esq. The locality label indicates that the specimens were taken in a ''small pool'' at ''Sandstone Bluff,'' Northern Territory. From notes, made by the collector, it would appear that the spot was on, or near, the Wellington Hills, E. long. 133½°, S. lat. 12°. In other notes, kindly supplied by Mr. Kershaw, the pool is described as ''a fine rock hole of clear, cool water.''

Detailed description. This species apparently attains almost to the largest size recorded for living aquatic Phreatoicids.* Of the mature ovigerous female there are no specimens, the largest female in the collection reaching a length only two thirds that of the largest male. In this respect, this species appears to agree with

*Its length is equalled, perhaps exceeded, by large examples of *P. kirkii*, var. *dunedinensis*, Chilton, which is said to reach 22.5 mm., and by *P. spinosus*, Smith (15-25mm.). My largest specimen of *A. lintoni* measured 20 mm. The fossil form *P. wianamattenis* had an estimated length of 30 mm.

members of the genus *Phreatoicus*, whereas in *Amphisopus* the female is nearly as large as the male or may even considerably exceed that in length.

The *body* (Pl. XXVII, fig. 17) as a whole, appears to be covered with tiny flattened setae or scales, which seem to vary in shape from a broad triangular to nearly semi-circular, this covering giving everywhere to the body and largely to the appendages, when seen in profile, a serrated margin. This cannot always be made out at the extremities of the limbs, and is less evident on mandibles and maxillae, but is clearly visible on flattened surfaces of lips, inner plate of maxillipeds, etc. In addition to the scales, the body appears to have a scattered granulation, but the fine short setae that furnish a thin fur-like covering for the body in other species of *Phreatoicus* appear to be entirely absent.

A transverse corrugation of the surface is well marked, though less developed than appears, from Geoffrey Smith's figures, to be the case in *P. spinosus* and other Tasmanian species. In all of these latter, too (including *P. australis*), Smith notes a serration of the antennae which is probably due to a retention of scales upon those appendages, although this is not stated. In the mainland species of *Phreatoicus* and in *Amphisopus* the scales have apparently disappeared.

The body attains its full width at the level of the second peraeon segment and maintains a practically uniform thickness to the second pleon segment, behind which there is but a very gentle tapering to the end of the body, so that although the pleon is quite deep, its depth is nevertheless only $1\frac{1}{2}$ the thickness of the body in that region.

In yet another of the proportions of the body, this species is probably generalised—the length of the pleon and telson is rather more than four-fifths of the length of combined cephalon and peraeon, a condition contributed to partly by the unusual shortness of the head, but chiefly attributable to the relative uniformity in the length of the body segments. Measured along the mid-dorsal line the pleon and telson together have a length equal to that of the seven free peraeon segments.

The head is strongly convex dorsally from side to side, and in profile is almost the quadrant of a circle. The eye is very well developed, forming a hemispherical prominence with probably not less than one hundred ommatidia. The inferior margin of the head is slightly produced postero-laterally, where it touches the maxilliped. From the posterior margin, a well defined groove runs upward nearly to the dorsal line. In *P. australis*, this is stated to actually make a well defined transverse groove; in *P. joyneri* and *P.*

assimilis it is not completely transverse; in *P. shephardi* and *P. typicus* it is not figured, nor is any reference made to its presence in *P. kirkii.* G. Smith likewise makes no mention of it in his account (1909) of the Tasmanian species. In *P. typicus* I should rather expect it to have disappeared, but it will be surprising if it proves to be absent in the other species of *Phreatoicus.* In all three species of *Amphisopus* it is certainly wanting, but, as Chilton has pointed out (1891, p. 153) a quite similar groove is present in many species of *Idotea*, and it is reasonable to suppose that it marks the suture between the first peraeon segment (the maxilliped segment) and the head, a segment free in the Anaspidacea, but incorporated in the head in *Koonunga* and Isopods generally, all traces of its original anterior boundary having been lost in most of the members of this latter group. The first free segment of the peraeon of *Phreatoicus* is also by way of reduction and incorporation in the head, a condition which has actually come about in the Tanaidae.

In the peraeon the coxal joints are greatly reduced and the antero-ventral corner of the several segments is distinctly produced in front or perhaps is coming to lie external to the coxal joints. In the hinder series of legs a posterior cleft only partly defines the joint, which has become flattened externally and incorporated with the ventral margin of its related segment.

The pleon segments are relatively deep and unusually wide, the ventral borders almost and the posterior borders quite free from setae. The fifth segment is deeply notched behind and is slightly shallower than the segment immediately preceding; the sixth, marked off from the telson only by a short suture running almost vertically upward from the point of origin of the uropod. It makes with the telson a large piece terminating (Pl. XXIX, fig. 39) in a rounded projection which is not upturned as it is in most of the species of *Phreatoicus.* Its margin is entire and it is flanked laterally by a paired projection bearing a stout terminal and a slighter lateral spine. Ventrally the margin of the telson bears on either side one large spine and a much smaller spinule.

Appendages. The *first antenna* (Pl. XXVII, fig. 18) is well developed, the peduncle scarcely differentiated from the flagellum; the basal joint is large, the second as long but more slender, the third shorter, and little stouter than the proximal article of the flagellum. The flagellum may have as many as sixteen joints, nearly oblong in outline and diminishing fairly regularly in length, the terminal joint, however, being a mere knob. Sensory setae (Fig. 18, s) occur on most joints, but the "olfactory setae" so characteristic of *Phreatoicus* could not be recognised.

The *second antennae* (Pl. XXVII, fig. 19) are stout, of quite moderate length, with well defined peduncle (of a length approximately equal to the first antenna), of five joints, of which the slender fifth is much the longest. In profile, the flagellar joints are squarish, but a few of the more distal are quite slender; each is incompletely encircled by setae.

Neither upper nor lower lip calls for special comment. The *left mandible* (Pl. XXIX, fig. 34) has an outer cutting edge of four teeth and an inner series of three; immediately proximal to this latter is a curved spine row and beyond this the lower margin is setose. A well developed palp is present, the second joint, much the largest, being both broad and long. In the *right mandible* (Pl. XXIX, fig. 35) the outer dentate row shows three teeth only, the inner edge seems to be divided into two teeth, both of which are curiously denticulate, the denticles in their turn pectinate. In the natural position, this inner edge underlies a spinous row. In the figure, the molar tubercle is seen in profile and has two slender setae on its grinding face; internal to its base are numerous setae.

The *first maxilla* (Pl. XXVIII, fig. 29) is stout, the outer plate setose both laterally and mesially, and armed with an apical tuft of 10 or 11 stout pectinate spines in the usual double row, some being pectinated on both edges. The inner plate is strongly setose distally and upon its truncate apex bears seven terminal plumose setae, with one simple seta at its external end. Some of the plumose setae are of the type usual in *Phreatoicus*, but towards the mesial side some are apparently undergoing reduction, approaching a unilateral condition.

The *second maxilla* (Pl. XXIX, fig. 36) is also stout; it shows the inner plate triangular and closely set with bent setae (distally directed), along the entire mesial length of one edge of its border, which is apparently flattened, from the other edge projecting a series of stiff, feebly ciliated setae. At the apex the two series meet and pass into a terminal tuft of curved, plumed and pectinate setae (some plumose on one side of the axis and pectinate on the opposite). The palp appears to have a well defined joint and the entire outer border of the appendage is setose.

Maxilliped (Pl. XXVIII, figs. 27, 28). The epipodite is nearly round, with a few short setae inserted into its serrated outer margin, its mesial margin strongly setose. The second joint of the appendage bears two stout plumose setae and the mesial border of the inner plate is fringed with similar setae, which pass at the truncate apex into stiff curved setae. These are doubly, and then singly, pectinate, and at the external angle become more curved, passing by an easy transition into a series of five coupling hooks—strongly re-curved, with a forked apical hook and more proximal curved pectinations (fig. 28e); the scaly surface is well seen here.

The *gnathopod* (Pl. XXVII, fig. 20) is of the usual type, the propod unusually strong, the palm straight, extending along the entire posterior border of the joint; both ischios and meros are expanded and produced anteriorly into a lobe which is prolonged by a stout spine, the lobe of the meros being directed almost proximally. In the three succeeding appendages, also, these joints are notably produced, such considerable development of the meros being met with, so far as I can discover, in no other extant species of the Phreatoicidea. In the fossil form *P. wianamattensis*, however, a similar condition is clearly shown, Chilton (1918), calling particular attention to this feature (l.c., p. 368).

The *fourth peraeopod* (Pl. XXVII, fig. 21) is sub-chelate in the male, as in all species of *Phreatoicus*, differing in this from *Amphisopus*. It is noteworthy that in the perfectly preserved fourth peraeopod of *P. wianamattensis* there is no suggestion of a sub-chelate condition, but the impression may, of course, have been that of a female.

The *fifth*, *sixth*, and *seventh peraeopods* (Pl. XXVII, figs. 17, 22) show a rounded basos with a marked posterior plate-like expansion and a similar expansion is developed on ischios and meros of both the hinder appendages. In the fossil form a similar expansion is indicated (though less developed) in Chilton's figures 1, 2, 3, 7, and 10, and it is noteworthy, also, that in this species the ischios is relatively much shorter than is usual in this genus. In this extinct form, too, it may be noted that the segments seem to have had a much more uniform length.

The male appendage (Pl. XXIX, fig. 38) is a curved structure, relatively short and stout, bearing a few setae on its anterior (more convex) border and with evident serrated margin.

Pleopods. In the appendages of the pleon, the first point to be noted is that, in all, the two rami are approximately equal, in the sense that the endopodite extends distally practically as far as the exopodite, a condition found elsewhere, so far as I can discover, only in *A. latipes.* Further, in all but the first of these appendages a large epipodite is present. In two of the specimens examined I failed to find an epipodite upon the *third* pleopod, but the plate is very easily detached and possibly was lost in removal. In none of the specimens examined was an epipodite lacking from the second pleopod, having there a sub-triangular shape; on succeeding appendages this plate is much larger and roughly quadrangular, fringed with long setae, the postero-lateral corner crenate, with more closely set setae.

The endopodites are, as usual, thin transparent laminae without fringing setae, the exopodites (with the exception of that of the first pleopod) divided into a large proximal and an unusually short distal lobe. This latter is almost completely fringed with plumose setae, such setae being continued proximally along the greater part of the lateral border of the proximal lobe, passing presently into simple setae. On the mesial border a very few of the distal setae may be plumose, but the greater number are simple and these may extend from the edge on to the face of the plate as a thick bordering tuft (Pl. XXVII, fig. 25, ex.). In the male, the endopodite of the second pleopod is differentiated in the usual manner to form a penial filament. This consists of a stout basal piece and a semi-cylindrical distal portion, somewhat curved, concave laterally and fringed along both margins with fine setae. At the apex these pass into a curved line of exceptionally stout setae to form a conspicuous terminal tuft (fig. 26, s.).

Both rami, and the epipodite when present, spring from a basal piece or peduncle of rather indeterminate shape. In both first and second pleopods, however, it is bilobed and suggests a two-jointed structure; in the case of the first pleopod (Pl. XXVII, figs. 23, 24) long setae are present on both lobes mesially. On the lateral border but a single lobe is indicated. As regards size, the first pleopod is the smallest, the second somewhat larger, the third largest (Pl. XXVIII, fig. 31), the fourth and fifth progressively smaller (Pl. XXVIII, figs. 32, 33).

The *uropods* (Pl. XXIX, fig. 37) consist of a stout, relatively short peduncle, expanded dorsally on its inner border, both borders being produced into a continuous line of spines and setae. The inner ramus is also expanded and set with spines, the slightly shorter, outer ramus less expanded. Ventrally to the origin of the rami are a couple of setae, one being quite stout, but neither are pectinated as in *Phreatoicus*.

NOTES ON THE HABITS OF SOME OF THE PHREATOICIDEA.

Geoffrey Smith, referring to the habits of the Tasmanian species of *Phreatoicus*, remarks (1909, p. 71):—"Their movements are exceedingly sluggish, so that when alive they are easily distinguished from the rapidly moving Amphipods . . ." Of *A. palustris*, which I have kept under close observation for some time, it may be said that while they normally creep about slowly or lie upon the side at rest (their colour harmonising wonderfully with that of the debris upon, or beneath, which they rest while feeding, and rendering them almost invisible), if disturbed they are capable of swift movement, swimming rapidly with a quick, scurrying motion (effected apparently largely, if not entirely, by the uropods), remarkably like the jerky movement of an Amphipod. Indeed, a small specimen may readily be mistaken, in its sidewise motion, for an Amphipod. Like an Amphipod, too, it may swim in the erect position, this, by the movement of the pleopods. The larger Western Australian form is, perhaps, slightly less agile.

Glauert notes of *A. palustris* (1924, p. 49):—"The animals are fairly active and exceedingly quick at burrowing into the soft muddy bottom . . . . when not burrowing (they) prefer dark or shady corners. Their food seems to consist of animal and vegetable matter, and they make most effective scavengers." I have offered small portions of dead earthworms, insect larvae, etc., but have never observed that this material has been touched. The preference for dark spots is particularly noticeable in the females, and, in rounding up my specimens, those are practically always the last to be secured.

Pairing seems to extend over a comparatively long period, couples taken together have so continued for fifteen days subsequently, the brood pouch enlarging visibly during that period. In a small female of about 11mm. the brood were discharged on the twenty-eighth day after the separation of the pair, no fewer than fifty-one young issuing at that time. The male of this pair underwent ecdysis a couple of days prior to the emergence of the young, but the female had not shed her skin four weeks later when she was again pairing.

The process of ecdysis must have a considerable importance to these animals, even when full size is attained, if they are living in a comparatively small water hole, for, under such conditions, they become thickly covered with encrusting organisms, even to the plumose hairs of the pleopods. In *A. palustris* a small Vorticellid is very common and occasionally a Dendrocometes-like form may be found, best seen on the cast skin and apparently most affecting the antennae and the gnathopods. Barnard notes a similar infestation in *P. capensis* by "a short-stalked Infusorian," while Chilton, also, remarks upon the heavily infested condition of *P. australis*. The dense covering of Rotifers, etc., in *P. joyneri* has been mentioned above. That the instinct for concealment is apparently more strongly developed in the female is probably the explanation of the fact that collections usually contain a large preponderance of males unless the collecting has been accomplished by an indiscriminating use of the scoop or net in the muddy or weed-grown hiding places. Thus Chilton (1891, p. 165) notes of his material of *P. australis*, "nearly two-thirds were undoubtedly males." In the collection of *Eophreatoicus* which I have examined at least three-quarters were males, and in *P. joyneri* (where I took all that I could see) at least as large a proportion are of this sex. Of the *Hyperoedesipus* in my collection probably less than 5 per cent. are females, while of *Hypsimetopus* there is no record of the capture of females. The early collections of *Phreatoicopsis*, also, consisted wholly of male specimens, but it should be noted that, in most, if not all of these species, the male is the larger as well as less prone to concealment. In *Amphisopus lintoni*, on the other hand, my material showed an overwhelming preponderance of females. In this case, however, the female attains to a size nearly twice that of the average male, and is perhaps less able to effectively conceal herself. In the partly grown forms it is often not possible to distinguish between immature male and female by inspection only, and the disproportion in numbers between the sexes may not be as great as would appear from the composition of a given collection. In *P. typicus* the male is apparently unknown.

In pairing, as Glauert has noted (l.c.), the male of *A. palustris* makes use of his strongly developed gnathopods, the fourth pair of peraeopods not being especially modified in this genus. I have observed, however, that the rather hook-like peraeopods of the anterior series, may all, at times, be caught under the projecting epimera of the female. The structure of the second and third peraeopods of *P. joyneri* suggests that these have a somewhat prehensile character.

Of *Hyperoedesipus* it is worthy of note that the remarkably developed gnathopods of the male seem never to be used for this purpose, the hold being effected entirely by the fourth pair. An obvious explanation is, however, at once forthcoming. The greatest danger to which a blind, subterranean form such as this could be exposed, is that of being swept irrevocably to the surface, there to be washed out to sea, or, escaping that, almost certainly to perish in competition with, or a prey to, surface-living forms.* During pairing, when a double strain might be imposed upon its earth hold, there is clearly a need, *in the male*, for a greater muscular development of its gripping appendage. I have never seen *Hyperoedesipus* feeding on animal matter, and I believe that the great gnathopods are *not* raptorial. The fourth peraeopod appears to be but slightly

*In the tiny hollow, in which alone I have found these forms, they have been associated with three other obviously underground forms (a small Amphipod, a planarian, and a minute earthworm, probably a Phreodrilid), from none of which would they be likely to have much to fear in their subterranean haunts, excepting only for the competition for such food as there may be.

prehensile in *P. assimilis,* so that in this species one must suppose the gnathopods to be used in pairing. It would be of interest to know whether in *P. australis* and other surface-living forms the fourth peraeopod has superseded the gnathopod in this function or is merely auxiliary thereto.

A comparison of the size of the brood in *Amphisopus* and *Phreatoicus* is of interest. In *P. shephardi,* which reaches according to Sayce (1900) a length of 10mm., Chilton records that the brood pouch contained a dozen eggs, while from the pouch of an 11mm. specimen of *A. palustris* I have collected more than fifty just emerged larvae. In a second case there were counted forty-eight living young and one dead. From the brood pouch of *A. lintoni* there were extracted thirty-five large embryos. These facts suggest that adaptation to sub-alpine life has resulted not only in a stunting of the growth, but in a diminution, also, of the reproductive capacity. In none of my specimens of *P. joyneri* or *E. kershawi* do the brood pouches contain eggs or embryos, and nothing has been recorded for other members of the family. The accommodation of the body to subterranean life will probably have restricted still further the number of the offspring. In *Hyperoedesipus,* of which very few females have been taken (probably for the reason suggested above in the case of *A. palustris*), the normal number of eggs is round about four, though in one which paired in an aquarium, seven eggs were seen in the pouch when the animal was killed.

In *A. palustris* the embryos were a full 2mm. in length at the time of their emergence, with the six pairs of peraeopoda usual in larval Isopoda. The body was almost transparent, of a palely brown tint, and a large proportion of the larvae appeared to bear one or more of the infesting stalked Infusorian, these having evidently spread on to the young while still within the brood-pouch. The embryos of *A. lintoni* were more than 1½mm. in length when as yet only the rudiments of the limbs could be discerned, and it is probable that the larvae would be at least twice that length. The first antennae were short, consisting of a three jointed peduncle and a slightly clubbed flagellum with five joints, somewhat closely resembling the condition in adult *P. australis* or *P. joyneri,* which might be interpreted as evidence that, in this appendage, the sub-alpine forms have retained very nearly the larval condition.

After twenty-four days, the young died off quite suddenly, perhaps approaching the critical period of the first moult.

The brood pouch is composed of four pairs of lamellae, the first (internal to the gnathopods) being unequally bilobed, the anterior lobe the smaller and making up much of the anterior wall of the pouch. In all of these lamellae there is a central stouter axis, around which is a broad and transparent margin (respiratory ?), fringed with numerous setae. In the full sized males of *Phreatoicopsis,* there is a similar but smaller set of these lamellae, which are hard (appearing calcified) and lie closely adpressed to the ventral thoracic wall, of which they might be taken for mere thickenings. These appear to have been altogether overlooked in earlier descriptions of this form.

THE POSITION OF EOPHREATOICUS IN THE PHREATOICIDEA.

Eophreatoicus kershawi, the type of the new genus, is remarkable among known Phreatoicidea in the possession of a scaly covering, although, as pointed out above, it is possible that several species will be found to have retained vestiges of this condition.

A slightly wrinkled state of the body is described by Chilton as occurring in *P. australis* and is plainly figured by Smith for several Tasmanian forms. Barnard does not mention it as characteristic of *P. capensis,* and in all the species of *Amphisopus* the body is wholly free from wrinkling, nor does it occur in the subterranean (New Zealand) species of *Phreatoicus* and the allied subterranean genera.

The shortness of the head seems peculiar to this form, but is approached in *A. palustris.* The retention of large and prominent eyes, like those in *Amphisopus,* is doubtless indicative of continuous occupation of surface waters, the reduction of the eyes or the blind condition of the several sub-alpine or subterranean forms having, perhaps, arisen independently in those forms.

The vertical groove upon the head which, in my opinion, is to be regarded as the last evidence, in this family, of an originally free maxilliped segment, has already completely disappeared in *Amphisopus.* It is well developed in *E. kershawi,* in *P. capensis, P. australis, P. joyneri, P. assimilis* and, therefore, presumably in *P. kirkii* (vide Chilton, 1906, p. 274); very probably, too, in the several Tasmanian species, though Smith makes no reference to it in his descriptions, but then he does not figure it in *P. australis,* in which Chilton had previously described and figured it. Similarly has Sayce (1900) omitted all mention of this structure in *P. shephardi,* where it may perhaps be absent. If, however, it prove to be present in the Tasmanian forms and in *P. shephardi,* as I should expect, then *P. typicus,* alone in this genus, would be without it, but would share this peculiarity with *Phreatoicoides, Hypsimetopus* and *Hyperoedesipus.* All of these forms have a striking resemblance to *P. typicus,* a likeness most readily to be explained by the suggestion that they all have their descent from a common blind ancestor already adapted to life in subterranean waters, which in its turn had derived from a surface living form. That such surface-living forms existed at a time while yet there may have been land communications between Australia, Tasmania and New Zealand is practically established by the discovery of those well preserved Phreatoicid fossils from the Triasic beds of N.S.W.

In the possession of filiform and relatively long first antennae, *Eophreatoicus* is again in agreement with *Amphisopus* and in strong contrast with *Phreatoicus* and the group of subterranean genera; in this particular, *P. capensis* is in agreement with the Australian and Tasmanian forms (with the possible exception of *P. spinosus*).

A nearer approach to uniformity in the length of the segments (except the first free peraeon segment) and, as a consequence, the possession of a relatively long pleon-telson region, must be accounted as a primitive character in *Eophreatoicus*.* In *P. spinosus*, the development of this region is said to be even greater, being, according to Barnard (1914, p. 239), no less than 90 per cent. of the length of combined cephalon and peraeon. In this latter species, however, there is a remarkable development of the terminal telsonic projection, which adds the equivalent of the length of a segment to this region. Generally in the Phreatoicidae the tend ncy is towards a reduction of the pleon region, a tendency which has become very pronounced in the Isopoda as a whole. In the members of this family, the pleon-telson region, expressed in terms of the percentage length of combined cephalon and peraeon, offers a series displaying increasing reduction. *E. kershawi*, 80% ; *P. tasmaniae* and *P. capensis*, 75%—70% ; *P. joyneri*, *P. shephardi*, *P. kirkii*, *P. australis*, *P. assimilis*, *P. typicus*, in a bunch varying from 66%—58%, and *P. kirkii* var. *dunedinensis* to 45%. In the related subterranean genera an even greater reduction is attained. In *Hyperoedesipus* the figure is 53%, in *Hypsimetopus*, 45%, and in *Phreatoicoides*, 36%. While agreeing with Chilton's remarks (1906, p. 275) that measurements of this kind are not easily made with the same accuracy in all cases, and may vary to some extent in different individuals, I am of opinion, nevertheless, that such a series of stages in the reduction of the terminal body region as is found in the family is not without a distinct significance. In a form living in surface waters, *A. palustris*, as I have stated above, while the anterior peraeon appendages are largely functional in walking, aided (among debris), by the upturned, backwardly directed and more elongate legs of the hinder series—for swimming the animal relies upon the pleopods with or without the uropods, the deep pleura having a definite importance in this method of locomotion. In subterranean Isopods, if one may judge from *Hyperoedesipus* and *Crurегens*, the animal creeps but does

*In that generalised from *Anaspides*, the pleon-telson practically equals the cephalon-peraeon in length; in *Koonunga* the pleon-telson would appear to be a trifle the longer, the maxilliped segment here completely merged in the head.

not swim, the importance of the pleon region thus being largely diminished. Perhaps, too, a rounded sub-cylindrical body is better adapted for negotiating the interstices through which the water percolates, for I imagine that the animals' habitat is rather in such crevices than in actual subterranean lakes, and their entrance into wells might readily be through imperfections in the walls. There can be little doubt that *Phreatoicoides* may be taken at the surface for precisely the same reason as that which brings up *Hyperoedesipus* occasionally. Similarly a significance attaches to Chilton's statement (1906, p. 273) regarding the first finding of *P. kirkii* in "places that have been well searched, for Mr. Thomson and myself, and probably many others, have made collections in this locality without coming across the specimens in question." It would seem likely that this subterranean form comes only accidentally and rarely to the surface. *Hypsimetopus* is definitely recognised, as is *Phreatoicopsis*, as a dweller in damp earth rather than in subterranean water,* the latter quite possibly coming to the surface occasionally, perhaps, nocturnally. It has, it may be noted, the more usual proportions of surface-living forms (pleon-telson 60%), and its retention of eyes would suggest that its burrowing habit has been acquired comparatively recently.

The mandibles in *Eophreatoicus* seem more complete than in either *Amphisopus* or *Phreatoicus*, but the former, in the retention of the secondary dentate edge of the right mandible (even though in a more reduced condition) seems to approach more nearly to the condition of *Eophreatoicus*. In this particular, *Phreatoicopsis* and *P. capensis* are in agreement with *Amphisopus*.

In the condition of the first maxilla, with numerous (*seven*) plumose setae on the inner lobe, we are met again with what is, in all probability, a primitive condition,† retained in *Amphisopus*, but undergoing reduction in *Phreatoicus*. *P. typicus*, however, is stated to have nine or ten of such setae, while *P. australis* has four or five (Chilton, 1894, p. 198, and 1891, p. 158); all other Australasian species of *Phreatoicus* have but four plumose setae, but in every one of these (excepting *P. typicus*) there are said to be one or two setae which are not plumose. In *Hyperoedesipus* there are four

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*It has recently been noted of another group of Isopods, that *Haloniscus* (a saltwater form) has a damp-earth representative (*H. stepheni*), whose burrows may, perhaps, give it access to water percolating beneath the dry surface of the creek (Nicholls and Barnes, 1926).

†In *Anaspides* (vide Geoffrey Smith, 1909, pp. 507-511) this lobe bears numerous plumose setae, in *Paranaspides* eleven are figured (l.c. fig. 13), in *Koonunga* they are reduced to three.

with a number of simple setae, in *Phreatocoides* three and two simple spines. *Hypsimetopus* has a single spine, followed by a plumose seta and five others, pectinate and ciliate. *Phreatoicopsis* apparently has a large number (Spencer and Hall, 1897, p. 17). *Amphisopus* retains six or seven of these setae and again, in this, links up with *P. capensis*, which has four plumose, and two "plumose only at the tip."

Upon the outer plate of the appendage there are usually 8 or 9 setae in most Phreatoicids, but in *P. typicus* they are described as numerous (about 14 are figured); in *E. kershawi* I find eleven. A large number is similarly present in the Syncarida, *Koonunga* once more showing but a few. In the retention, then, of a large number of setae upon the lobes of the first maxilla, both *Eophreatoicus* and *Phreatoicus typicus* may be regarded as preserving the more generalised condition.

In the coupling hooks of the maxillipeds there is again a suggestion of a loss of parts, there being 4 or 5 in *Eophreatoicus,* 3 in *Amphisopus* and *P. australis,* 2 or 3 in *P. capensis, P. typicus* and *P. joyneri,* with but 2 in *P. assimilis.* In *Phreatoicopsis* the pectinate setae at the apex are said to continue down the outer border of the inner plate (as in *Eophreatoicus*), and basally are three strong setae which are not hooked.

The condition of the gnathopod "hand," with its straight, ill-defined palm and scarcely modified dactyl, may be regarded as displaying a primitive simplicity. Further, the largely expanded state of the meros is, as pointed out above, an unusual feature in living Phreatoicids, but strikingly seen in the extinct *P. wianamattensis.* Something approaching it is seen in *Amphisopus* and in *P. capensis.* Chilton's figures suggest that, in the fossil form, the basos of the anterior as well as of the posterior series of legs was expanded.

The apparent small size of the coxae, also seen in *Amphisopus,* should probably be regarded as due to reduction. The much more apparent condition of these structures in *Phreatoicus* may, however, be due to the lesser degree of development of the protective (epimeral) margin in burrowing and Cryptozoic forms, and a consequent greater exposure of these joints, but I am inclined to consider it as the more primitive condition.

A well developed sub-chelate condition of the fourth peraeopod in the male it shares with *Phreatoicus* and *Hyperoedesipus,* this condition being but slightly indicated in *A. lintoni,* and the modification of this appendage is not much greater in *P. capensis.* In *Amphisopus, Phreatoicopsis, Hypsimetopus* and *Phreatocoides* the appendage is apparently unmodified.

The persistence of epipodites upon *four* of the five pleopods furnishes still further evidence of the primitive condition of this form. The practical equality of the two pleopod rami would perhaps bear the same interpretation; a condition most nearly approaching this being found in *A. latipes*. *P. capensis* and *Hypsimetopus.* In other forms the endopodite shows varying degrees of development. A feature to which little attention has been called, but which, nevertheless, seems to be unique in this family, is the development of plumose setae upon the endopodite in *P. capensis* (Barnard, 1914, Pl. XXIV).

In the condition of the penial filament of *Eophreatoicus* there is furnished yet another linking character. Moderately curved, as long as its endopodite, and set with a conspicuous tuft of terminal setae, it exhibits a condition intermediate between that of *Amphisopus* (strongly curved, longer than the endopodite and without terminal setae) and that of *Phreatoicus*—little curved, shorter than the endopodite, and with a smaller tuft of terminal setae.

The absence of coupling hooks upon the basal joints of first and second pleopoda in *Eophreatoicus* is possibly primitive, and constitutes one distinction between this genus and *Amphisopus,* which alone, in this family, possesses such structures. What are perhaps comparable structures are seen on the basal joint of the second pleopod in *Koonunga*, and coupling hooks are somewhat widely and variably distributed throughout the Isopoda.

The expanded condition of the uropoda, both in peduncle and rami, of *Eophreatoicus,* is not met with elsewhere in the *Phreatoicidea,* and finds, perhaps, its nearest comparison with the condition in the Syncarida, where, however, the expansion is notable. In *Eophreatoicus* it is obviously only an expanded condition of a styliform structure.

The practical absence of a terminal projection to the telson is, on the other hand, a new point of agreement with *Amphisopus,* as also, with *Phreatoicopsis*, and indeed, the profile of this region in *Eophreatoicus* is strikingly like that of *P. wianamattensis*, but is, perhaps, not primitive, if the terminal projection is the vestige of the elongate telson of a Syncaridan-like ancestor.

A consideration of these several points justifies, I believe, the separation of the more typical Phreatoicids into at least three genera—of which *Eophreatoicus* may be regarded as occupying the central position* and from which may be derived, on the one hand, *Amphisopus,* and, upon the other, *Phreatoicus,* as exemplified by *P. australis*.

*Though possibly itself derived from some form nearer to *P. typicus* in general appearance.

The more robust habit of *Eophreatoicus* links it with the larger Tasmanian forms, with *Amphisopus*, and, also, with the still larger *P. wianamattensis*. *Phreatoicopsis* could readily derive directly from the extinct form.

Amphisopus differs from *Eophreatoicus* principally in the loss of certain structures, notably the scales, and the epipodite upon the second pleopod; in the development (or retention ?) of coupling hooks upon first and second pleopods, the structure of the penial filament, in the more complete degradation of the coxae of the peraeopods, in the absence of the sub-chelate condition of fourth peraeopod in the male, and the greater degree of expansion attained by the basos of the hinder legs.

Phreatoicus, climbing from the plains to sub-alpine regions, has diminished in size, has retained into adult life the larval or juvenile condition of the first antennae. A less compressed peraeon and smaller tergites permit of a greater exposure of the coxae, the palm has become restricted to the more distal portion of the propod, the eyes have dwindled and disappeared, the expansion of the several joints of the peraeopods has undergone more or less retrogression, while the prehensile character of the fourth peraeopod of the male has, perhaps, become more evident. A synchronous, or perhaps an earlier, change of habit may be supposed to have led to the modification of the burrowing forms, and thence to the occupation of subterranean waters, a change which may reasonably be presumed to have come about independently at different times and places.

In favour of the alternative view, that a form somewhat closely akin to *P. typicus*, but still possessed of eyes, would more nearly resemble the ancestral condition, the following features in that species might be cited as primitive:—the large head, a first peraeon segment scarcely smaller* than the succeeding (well seen, too, in *Hypsimetopus* and *Phreatoicoides*, and less evident in *Phreatoicopsis*), well developed coxae, basos rounded and without expansion, first maxilla with numerous plumose setae on inner lobe and still more numerous spines on outer lobe (equally well seen in *Phreatoicopsis*), pleon little compressed and without marked pleura, and terminal telsonic projection. Further, a shortened condition of the pleon appears to be of very general occurrence in the Isopoda and might reasonably be presumed to characterise the primitive Phreatoicid. Sub-alpine forms surviving in widely scattered localities might well be extremely ancient (as the admittedly generalised *Anaspides*) and have given rise to newer forms in lowland country, stray specimens washing down from high levels, the survivors undergoing modifications in adaptation to their new conditions. The mountain forms

*In *P. capensis* actually *longer* than the succeeding segment.

upon the Australian mainland all live, apparently, creeping beneath moss in highly sheltered situations. In open waters, with more active life and probably a more abundant food supply, adaptation might bring about the larger body, the expanded joints as aids to swimming, larger swimming and respiratory pleopods, the consequent increased importance of the pleon and a greater fecundity. In this view the short, almost clubbed first antennae of the larval stage of Amphisopus would appear merely as recapitulatory, the scaly clothing as a flattening and shortening of the fine fur-like covering of setae of the highland forms. The setae of the basal joints of the pleopods could be transmuted to coupling hooks, as those upon the maxilliped (in *Eophreatoicus*) appear to have been.

Many of the more important differences to be observed between *Eophreatoicus* and the sub-alpine species of *Phreatoicus* appear, however, to be more reasonably interpretable as due to loss and retrogression in the latter genus. So far as it is possible to judge, the very ancient *P. wianamattensis* would seem to find its nearest living counterpart in *Eophreatoicus.*

In the consideration of this question the structure of the South African species (which must have been isolated from its Australian congeners for an immense period of time) has a distinct importance.

P. capensis Barnard is described as having the posterior vertical groove upon the head, the first antenna very short, and its flagellum with but five joints, coxae of peraeopoda quite distinct, fourth peraeopod of male sub-chelate, the basal joint of the first peraeopod is figured as setose but without coupling hooks, the second pleopod with penial filament curved only at the apex, short and with terminal setae, the telson with prominent terminal projection—i.e., it has the general facies of the Eastern Australian forms. The inner lobe of the first maxilla, too, has four plumose setae and two others retaining cilia only at their apices.

In the retention of a secondary cutting edge to the right mandible it differs from these species and resembles *Amphisopus*, *Eophreatoicus* and *Phreatoicopsis.* The pleon, too, is longer relatively than it is in *P. australis*, but not longer than in one or two of the Tasmanian forms and near to that of *Amphisopus.* In the extremely elongated condition of the first free peraeon segment it is nearest to one or two of the subterranean species.

It is possessed, however, of two features in which it is apparently unique, in this family:—(1) the retention of a vestige of the innermost lobe on the second maxilla, which is plainly figured by Barnard, but not referred to in the text, in which condition it most nearly approaches that of the Syncarida; and (2), the existence of plumose setae upon the endopodites of the pleopods—no other

Phreatoicid, so far as I can discover, having setae of any kind upon this ramus.

In view of all these facts, it seems probable that it will become necessary to create a new genus to receive the South African species, but upon the whole, *P. capensis* may be regarded as approaching most nearly to the Australasian sub-alpine forms, while retaining certain characters undoubtedly primitive, many of these linking up with *Amphisopus*, *Eophreatoicus* and *Phreatoicopsis.*

Apart from *P. wianamattensis,* no undoubted fossil Phreatoicid seems to have been recognised. I have had, unfortunately, no access to the work of Packhard, quoted by Geoffrey Smith, but that author's reconstruction of *Acanthotelson stimpsoni* would serve, almost without modification, for the ancestral Phreatoicid. The elongated head, body with thirteen visible segments practically of uniform size, the telson marked off from the last pleon segment, pleon-telson practically equalling cephalon-peraeon (the elongate telson but an exaggeration of that of *P. spinosus*), pleon probably not strongly compressed and without downwardly developed pleura, the first antenna filiform and moderately long, without accessory flagellum, the second antenna without scale, with no trace of stalked eyes, the first peraeopod by way of becoming a gnathopod, peraeopods without exopodite not yet divided into two series, with distinct coxae and little differentiation of more distal joints, pleopods with stout basal joint and equal lamelliform rami, the elongate, equal and highly setose rami of the uropods, a walking form, but probably capable of feebly swimming, such a form might much more justly be classed with the Phreatoicidea than with the Syncarida.

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EXPLANATION OF PLATES XXV—XXIX.

PLATE XXV.

All figures of *Phreatoicus joyneri*, sp. nov.

Fig. 1 Entire animal (male), in side view.
2 First antenna, male.
2a First antenna, female.
3 Propod and dactyl of second peracopod of male.
4 Propod and dactyl of third peraeopod of male.
5 Propod and dactyl of fourth peracopod of male.
6 Propod and dactyl of first peracopod (gnathopod) of male.
6a Palm of gnathopod, more highly magnified, with a single spine of the same, much enlarged.
7 Seventh peraeopod of male.
7a Part of dactyl of seventh peracopod, highly magnified.

PLATE XXVI.

All figures of *Phreatoicus joyneri*, sp. nov.

Fig 8 First maxilla.
8a Inner plate of first maxilla, more highly magnified.
9 Lower lip.
10 Second maxilla.
11 Maxilliped.
12 Left mandible.
12a Dentate edge and spinous plate of right mandible.
13 Male appendage.
14 Second pleopod of male.
15 Third pleopod of male.
16 First pleopod of male.

PLATE XXVII.

All figures drawn from male of *Eophreatoicus kershawi*, gen. nov. et sp. nov.

Fig. 17 Side view of entire animal.
18 First antenna.
19 Second antenna.
20 Gnathopod, with palm more highly magnified.
21 Fourth peraeopod.
22 Seventh peraeopod.
23 First pleopod.
24 Basal portion of first pleopod more highly magnified.
25 Second pleopod, with epipodite, exopodite, endopodite, and

penial filament.

26 Penial filament, with apex more highly magnified.

PLATE XXVIII.

All figures from male of *Eophreatoicus kershawi*, gen. nov. et sp. nov.

Fig. 27 Maxilliped.

28 Inner plate of maxilliped, more highly magnified, with coupling hook still more enlarged.

29 First maxilla.

30 Part of second peraeopod, showing expanded lobes on ischios and meros.

31 Third pleopod.

32 Fourth pleopod.

33 Fifth pleopod.

PLATE XXIX.

Fig. 34 Left mandible of *E. kershawi.*

35 Right mandible of the same.

36 Second maxilla of the same.

37 Uropod of the same, in lateral view.

38 Male appendage of the same.

39 Dorsal view of telson of the same.

40 Dorsal view of telson of *P. joyneri.*

41 Terminal projection of telson of *P. joyneri,* more highly magnified, in postero-dorsal view.

42 Sixth pleon segment with uropod and part of telson of *P. joyneri,* seen from within.

42a Ventral spines from end of peduncle, in same view, more highly enlarged.

43 Uropod of *P. joyneri,* in lateral view.

43a Ventral spines from end of peduncle of the same, more highly enlarged.

44 Proximal portion of second Antenna of *P. joyneri.*

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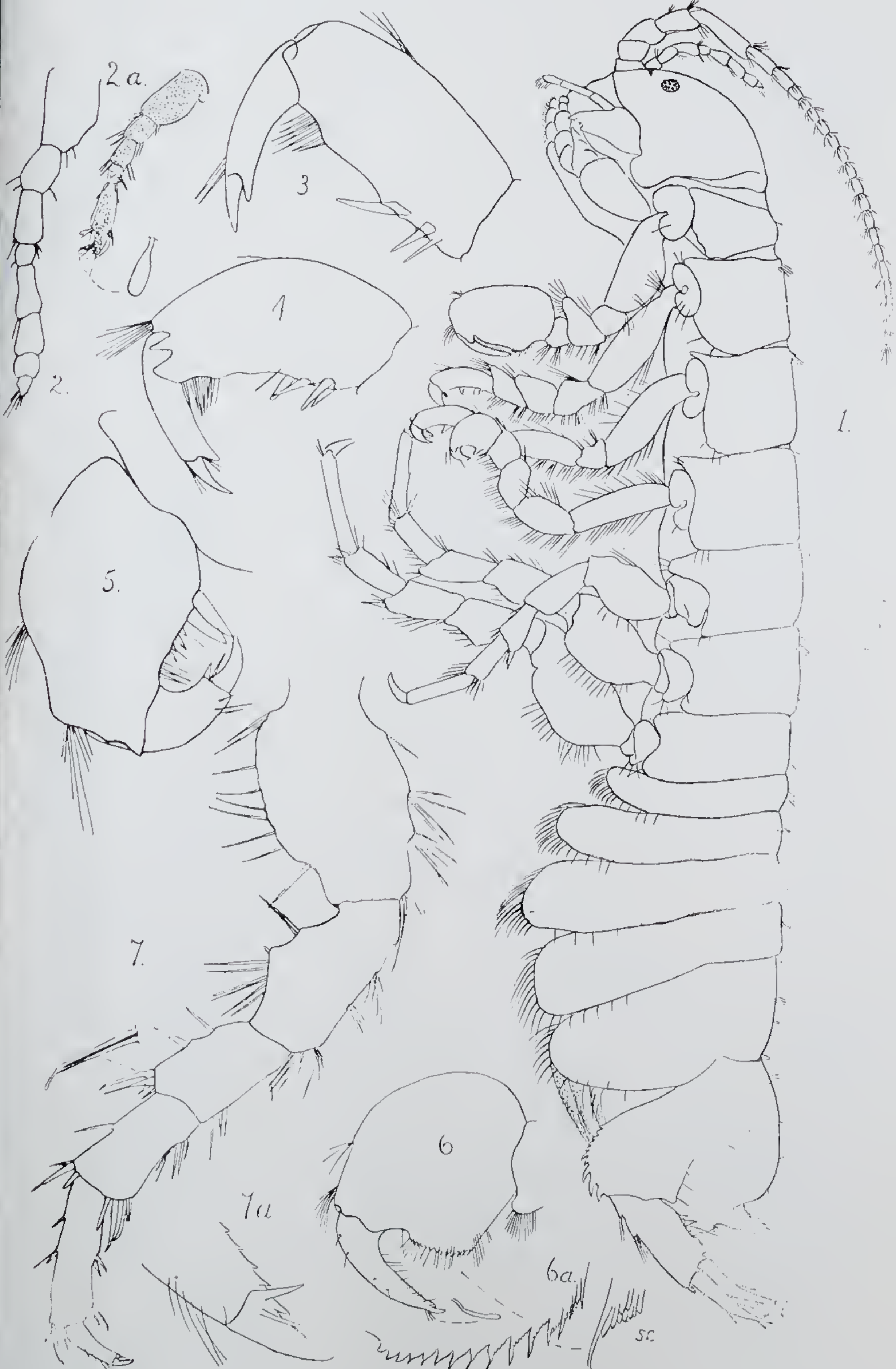
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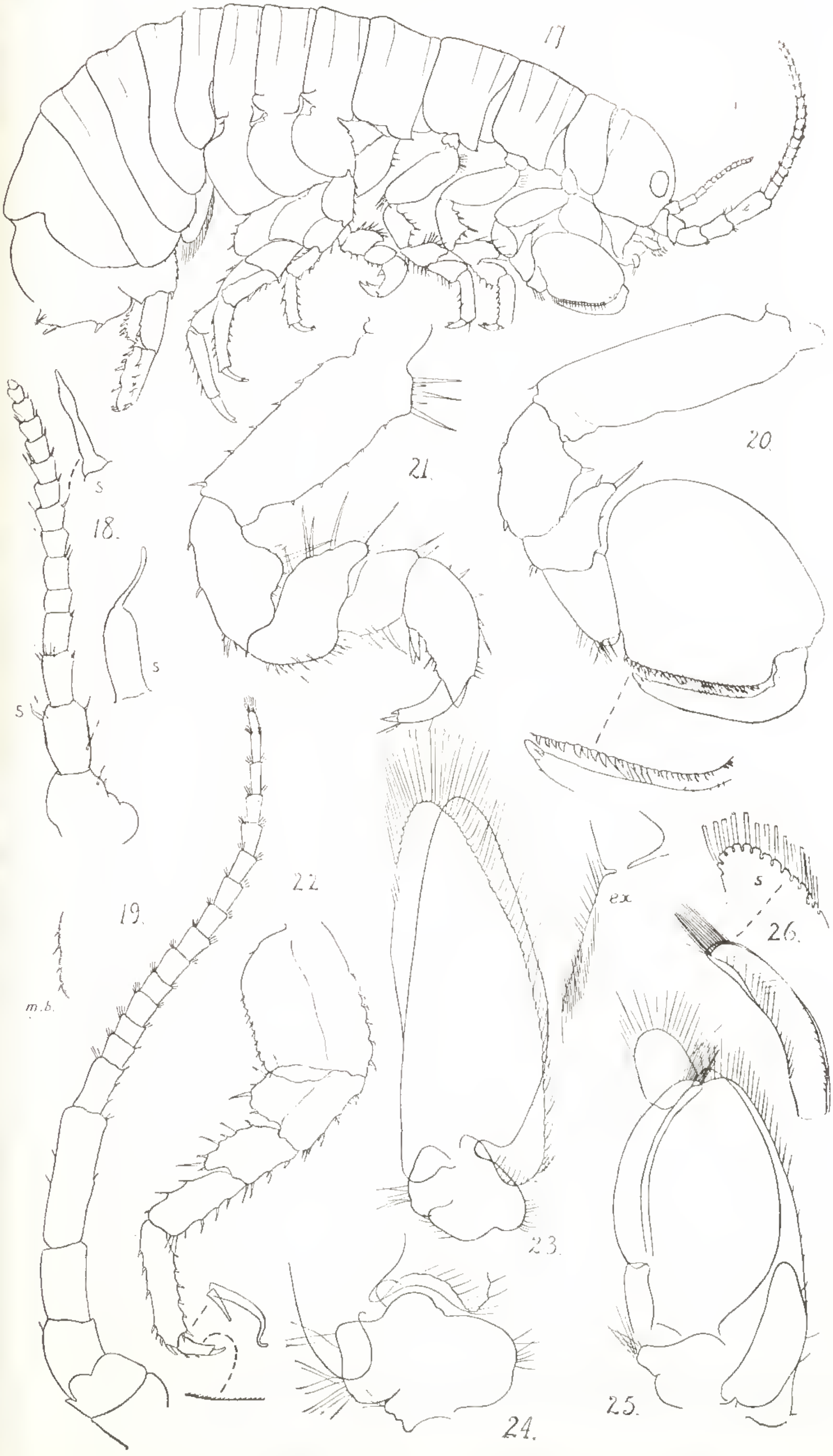
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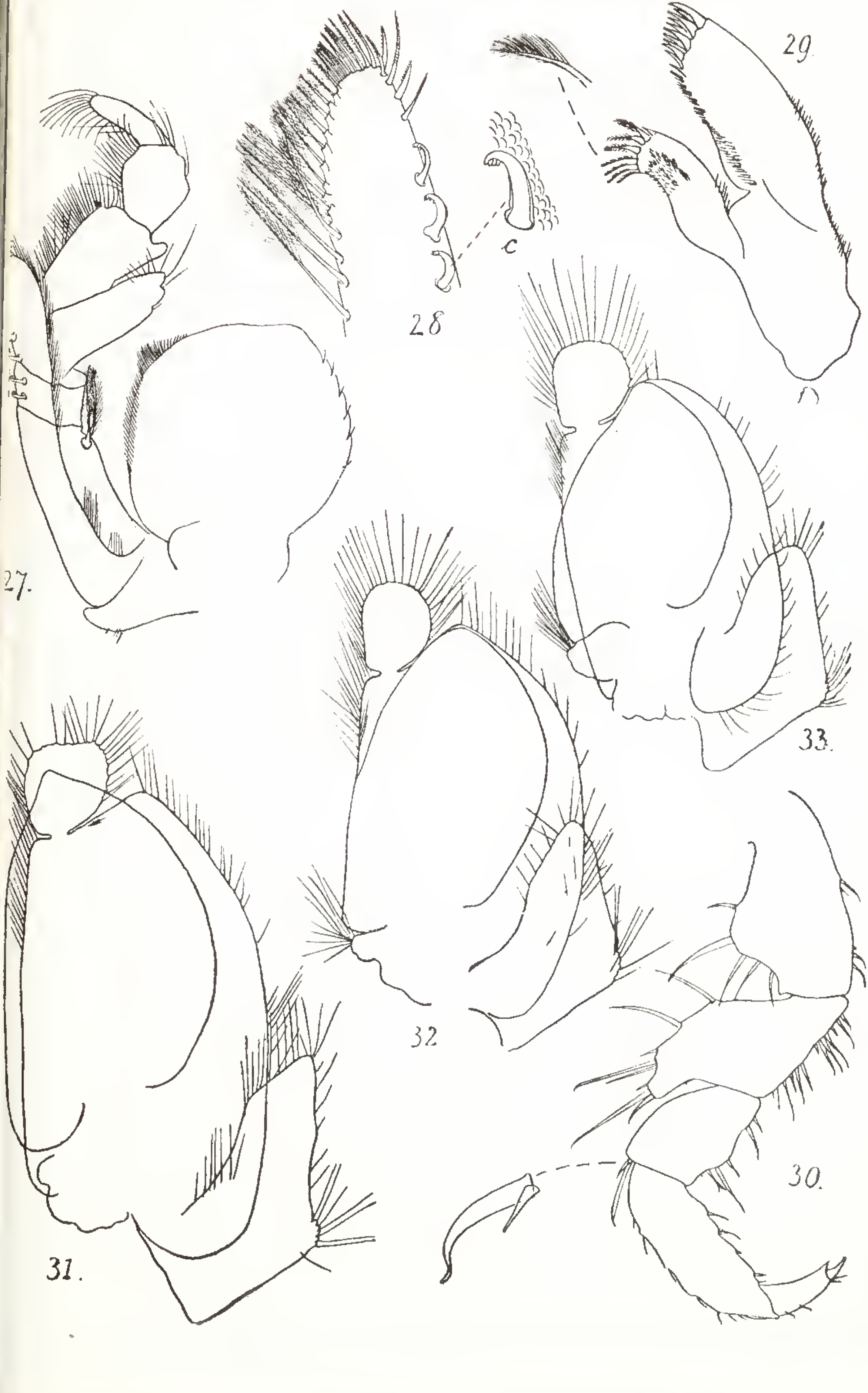

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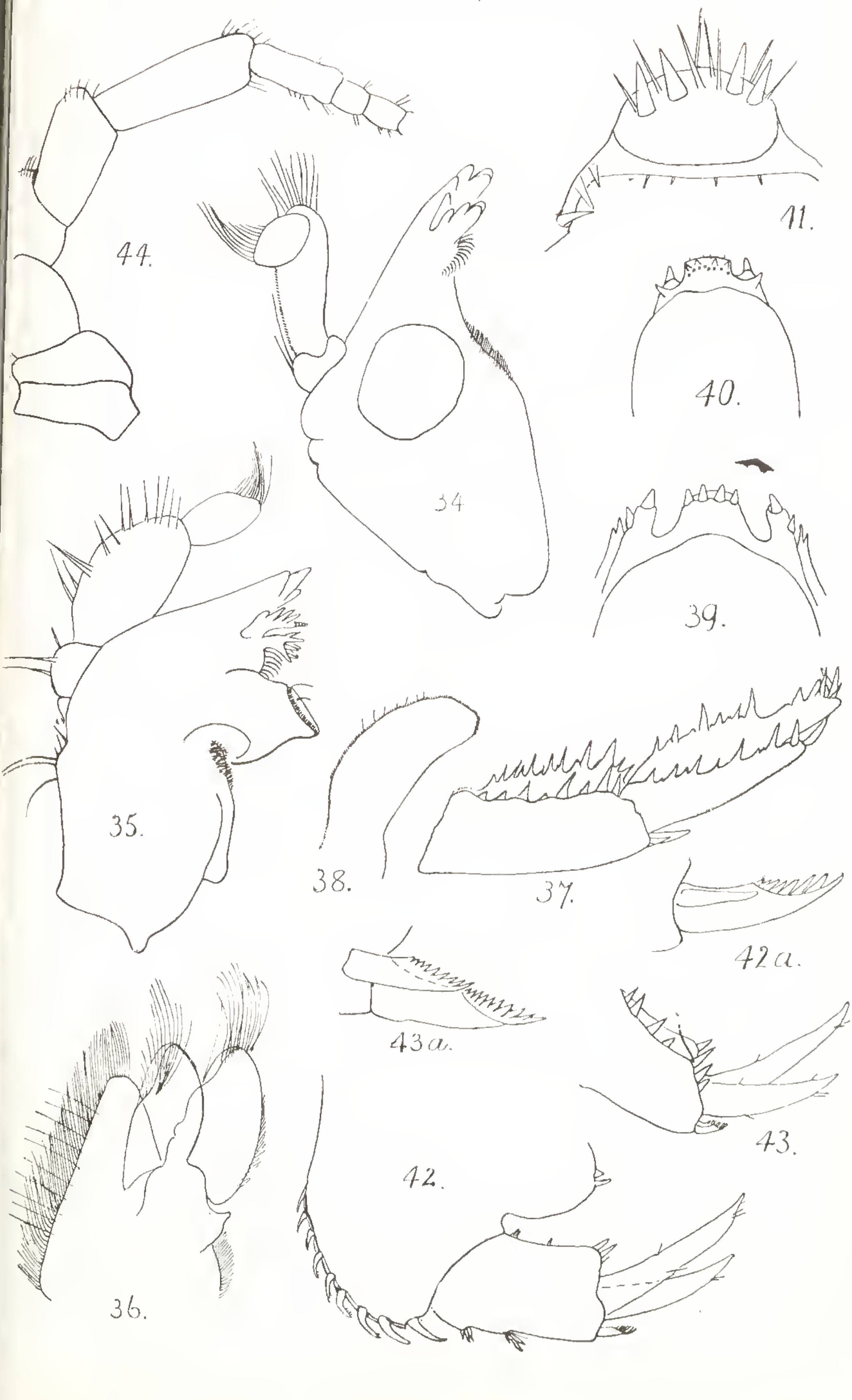
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WESTERN AUSTRALIA'S CONTRIBUTION TO EARTH HISTORY.

Presidential Address

to

The Royal Society of Western Australia

By

A. Gibb Maitland.

(Delivered on the 13th of July, 1926.)

"Grant we have mastered learning's crabbed text,
Still there's the comment."

On addressing you this evening, my foremost duty and one of pleasure is to thank you for the honour conferred by electing me for the second time after an interval of ten years as President of the Royal Society for the official year which terminates to-day. The election is not only a compliment to myself; it is also an expression of your conviction that the alliance between pure and applied science, for the prosecution of economic enquiries can only be efficiently and effectively carried out in a strictly scientific manner and is an *entente* which brings lasting benefit to both.

The obligations and responsibilities which the office with which you entrusted me twelve months ago to carry are not to be lightly undertaken, in view of the growing tradition of the work of my predecessors who have occupied the Presidential Chair.

I count myself fortunate in acting as your presiding officer at a time when the affairs of the Society are in such a very satisfactory position, not only as regards finance and membership, but also in its slow and steady growth of usefulness.

There seems every reason to hope that the work of the Royal Society will continue during the incoming year equally well as it has done during the relatively short period of its existence. Nevertheless it should not be forgotten that the President and Council cannot do everything to make and keep the Society as successful as it has been and ought to continue to be without the very active support of the members themselves. It is hoped, therefore, that members will continue to evince that interest in all that makes for the well-being and progress of the Society, and that the younger members (most of whom have been trained in our local educational institutions), in whose hands the future ultimately rests, will come forward and contribute some of the results of their investigations, adding in this way their quota to the sum total of human knowledge and thus assisting in the solution of those numerous problems which have long aroused the keenest interest amongst the scientific workers of all nations.

This brief reference to what might be called the material aspect of the affairs of the Society brings the somewhat disturbing reflection that custom prescribes that the President on the termination of his year of office shall carry out the law of precedence by delivering an address on some department of science to which his attention has been more especially devoted.

There is an old proverb that "Custom must be indulged by Custom or Custom will die," and while I have no desire to depart from traditional usage, the circumstance that Western Australia hopes next month to have the honour of welcoming, for the first time in the State's history, the members of the Australasian Association for the Advancement of Science, suggests that I should depart somewhat from the usual custom and devote an academic hour to bringing under notice the main contributions which Western Australia has made to the general principles of Geological Science, the full bearings of which, owing to the relative isolation of this portion of our island continent, have not been, perhaps, sufficiently recognised.

In bending myself to this task an endeavour will be made to follow out Pindar's advice:

"With vivid words your just conceptions grace,
Much truth compressing in a narrow space."

It was found necessary in the year 1896 to establish a permanent branch of the Public Service charged with a more or less comprehensive and systematic survey of the geological structure of the State and all that is connected therewith. Such geological investigations involved, *inter alia*, the application of the principles of the science to the exploration and exploitation of the State's mineral deposits, which have played a very important part in its economic and industrial development, for modern industry is more dependent upon mineral products than upon the commodities of any other natural group.

In the broad area of the State pretty nearly all geological systems have their representatives in the rocks which build up the territory.

One of the most fundamental features in the geology of Western Australia is the similarity in structure of its rocks to those of the countries bordering the Indian Ocean, viz., South Africa, Madagascar, India and the Netherlands Indies. This noteworthy resemblance is paralleled in the whole of the geological formations developed in the State; a close association which being reflected in the similarity of types of Western Australian mineral deposits is of considerable economic as well as scientific interest.

The Pre-Cambrian Rocks occupy nearly 400,000 square miles out of the 975,920 which constitutes the area of the State, and contain within the boundaries practically the whole of the metallic wealth of the State, of which about £160,000,000 have been raised. These Pre-Cambrian rocks, from the standpoint of their character, the complexity of their structural relationships, their development, their origin and the changes they have undergone, contain the materials for probably one-half of the geological history of the earth. There are probably few parts of the Australian Continent which can boast of a finer development of these Pre-Cambrian rocks than Western Australia, and the variety of lithological types bids fair to make the State a classic field for petrological research. It is to these Pre-Cambrian Formations that geological attention has naturally been principally devoted on account of the economic possibilities which such rock associations offer. Investigations have shown that especially noteworthy amongst them is the presence of huge composite batholiths of granite and gneiss with some crystalline schists resulting from the transmutation and partial assimilation of the granite, together with a group of schists, mostly altered sediments, and rocks of an allied nature, as well as their more or less contemporaneous igneous associates. These igneous rocks, principally of basic composition and of somewhat different geological types, have undergone extensive and widespread metamorphism, producing rocks of the epidiorite type on the one hand and the carbonated greenstone on the other. Ultra-basic rocks, represented by serpentine, peridotite, pyroxenite, and their transmuted derivatives, are also of frequent occurrence.

The distribution of the Pre-Cambrian Rocks resembles somewhat, as may be seen by an inspection of the geological map of the State, a sea of granite, studded with great islands of greenstone and their associated sedimentaries—an arrangement stated to have resulted from crustal foundering.

A typical and noteworthy member of the Pre-Cambrian group of rocks is the brilliantly coloured compact jaspilites and cherts, grading gradually into valuable haematite deposits, many of which are several hundreds of feet wide and some thousands of feet in length. There iron-bearing jaspers occur in more or less parallel bands which at times stand out in bold relief above the ground surface and constitute important stratigraphical horizons, traceable across country for considerable distances.

The presence of such thick and extensive deposits of jaspilite and iron ore in the Pre-Cambrian formations, not only in Western Australia, but also in South Africa, India, and the North American Continent, suggests, as has recently been pointed out by a leading geologist, that conditions at the period of their formation must have been fundamentally different from those obtaining in Post-Cambrian times and that "uniformitarianism as a working principle for the geologist cannot be pushed back indefinitely into the past."

The jaspilites may have been originally highly ferruginous fine-grained grits of sedimentary origin, and the source from which the iron-bearing minerals originated was basic igneous rocks. The ferruginous bands generally follow very closely the bedding planes of the enclosing metamorphic sediments, indicating that the solutions responsible for the deposition of the iron ore were to a very large extent controlled by the stratification. In many localities bands of siliceous dolomitic limestone are associated with and gradually pass into the ribboned jaspilites; an association which suggests that some of the jaspilites and their allies originated from the alteration of limestones.

One of the outstanding features in connection with these Pre-Cambrian rocks is their distribution along what geological investigation has shown to be one of the principal lines of weakness or mobility in the crust as developed in Western Australia.

The sedimentary beds were deposited in a broad geo-synclinel and since their formation have been more or less irregularly folded and compressed, concertina-fashion, along highly inclined axial planes. The folding is meridional with a tendency to an alignment in a north-west and south-east direction. The cleavage or schistosity commonly follows a like direction. In this geo-synclinal basin, which extends from the Recherche Archipelago on the South Coast to that portion of the North West coastline into which the De Grey, Yule, Fortescue, and Ashburton Rivers discharge their drainage, were deposited vast amounts of sediments carried by swift-running rivers issuing from the series of broad mountain ranges, which have since been worn down to base level by a cycle of erosion.

These rocks form part of that bow-shaped great circle which in Pre-Cambrian times extended from Western Australia across the north-eastern portion of the Indian Ocean, through Peninsular India, the Hindoo Koosh Mountains, down what is now the valley of the Oxus, and thence along that narrow belt between Eastern Europe and Western Asia—the Ural Mountains—and disappearing beneath the waters of the Arctic Ocean in the vicinity of Nova Zembla and the Kara Sea.

The beds in Peninsula India have the same general trend, lithological character, tectonic structure and community of origin as their Western Australian representatives. They disappear beneath that enormous development of horizontal basaltic lava flows, the Deccan Traps of Central India, reappearing in Udaipur and emerging from beneath the recent beds of the Indo-Gangetic Plain in the frontier ranges which separate the Indian Empire from Afghanistan and Turkestan. In the Hindoo Koosh Mountains fragments of these Pre-Cambrian rocks still exist, though much broken and shattered by those later earth movements which raised the Alpine-Himalayan and Dutch East Indies mountains during the Tertiary period, and which crossed the former almost at right angles, thus dividing the hemisphere into two halves.

Crossing the Himalayas and the frontier ranges, the beds reappear in the Ural Mountains. Here is a long belt of crystalline and metamorphic sedimentary rocks associated as in India and Western Australia with those characteristic red and other coloured ribbon jaspers, in addition to being invaded by gold-bearing acid dykes and quartz reefs.

Over the vast area of this Great Circle, there is a surprising uniformity in the character of the mineral deposits, as regards alike their geological relations and their structural and mineralogical features.

These long lines of weakness and mobility are also the zones of greatest vulcanism and concomitant earthquake activity. Volcanic eruptions, together with their cognate activities are the consequences of the major movements affecting the earth's crust, and produce, *inter alia*, a general heating and local increments of the temperature gradient. It is for this reason that the central portion of Western Australia in the regions of the geo-syncline to which previous reference has been made, has revelled in a long period of igneous activity, with its great crushing and folding movements, in the Pre-Cambrian period of its geological history.

The volcanic and allied igneous rocks, several of which are lavas, some sills, and others differentiation products, are in many areas much more abundant than the sedimentary members, though representatives of each occur in nearly every belt. The basic rocks—"greenstones"—probably originally dolerites—are of variable lithological types and in common with the other members of the Pre-Cambrian formations have undergone extensive and widespread metamorphism, producing on the one hand rocks of the epidiorite type, and on the other the carbonated greenstone type. Ultra-basic rocks are represented by serpentine, talc-schist, etc. An extensive development of the rare type of hypersthene-bearing rocks, with a marked persistent mineral banding similar in character and mode of occurrence to those of the Charnockite Series of West Africa, India, Norway and parts of the North American Continent, has been recognised in the Fraser's Range, to the north of Israelite Bay.

The Pre-Cambrian rocks have been invaded by huge composite batholiths and veins of granite which extend over some hundreds of square miles. They frequently have a schistosity developed along their lines of contact with the rocks into which they intrude. The acid batholiths and their satellitic intrusions are largely biotite-granites, usually made up of microcline, oligoclase and quartz, with a marked mineral banding or gneissic structure well developed. These extensive granite masses are traversed by many great dyke-like masses of white quartz which represent the end ultra-acid product of the differentiation of the granitic magmas. The intrusion of the granite and its allies is perhaps the most important event in the geological history of the State at this early period, inasmuch as with them are associated, areally and genetically, the most important gold and other metal-bearing deposits which place Western Australia in the front rank of mining countries in the British Empire.

Viewed in the light of its structural geology, coupled with the nature, variety, and wide distribution of its mineral deposits, Western Australia appears to be one of the most remarkable mineral regions on the Australian continent. According to researches which have been carried out, it appears that 235 mineral species have been already met with in the State. Of the rarer minerals, which occur as accessory constituents in the apophyses of the granites, and have a wide distribution in the State, thirty-six are confined to Western Australia and have so far not been recorded from other parts of the Commonwealth. Whilst Dr. Simpson, by whose researches our knowledge of the mineralogy of the State has been so much advanced, notes that the three minerals hitherto unknown to science, discovered by him, viz: Pilbarite (one of the uranium minerals), Goongarite (an argentiferous sulphide of lead and bismuth), and Tantalofergusonite (a rare mineral of the yttrium group) have not yet been met with anywhere else. The tantalate and niobate of antimony, Stibiotantalite, the first discovery of tantalum ore in Australia, was made in Greenbushes in 1893 and has so far been found only in California.

To these may be added the group of telluride minerals which occur in but few localities throughout the world and which have been so extensively mined at Kalgoorlie and Boulder, the chief gold-producing centre of the State.

The tellurium-carrying minerals constitute one of the most distinguishing characteristics of the ores of Boulder and Kalgoorlie, being the main source of over 16 million ounces of gold from this mining centre.

With such an *embarras des richesses* in the broad domain of mineralogy it is not at all surprising that Western Australia's contributions to what may be termed mineralogenesis have been so extensive and of such a high order.

The igneous rocks occurring in and associated with Pre-Cambrian formations have also thrown a great deal of light upon many of the more important problems of petrogenesis.

An outstanding feature in connection with the investigations is the important part which the upwelling of the molten granite and its complementary dykes, with the concomitant sagging of the overlying rocks into intervening troughs, has been found to play with regard to the gold-bearing and other mineral deposits.

A result of this granitic invasion has been the formation of fracture planes and other lines of weakness, having a general north-westerly alignment, along which the mineral-bearing solutions in circulation have found an easy passage, with the introduction of the metalliferous minerals; this being the latest expression of the subterranean forces in operation.

It is therefore the rocks along and adjacent to the margins of the granites which have proved to be the hosts for ore and which constitute the chief hope for an expanding mineral industry.

The existing land surface bears no relation whatsoever to that which existed when the ore bodies were formed. The limits of ore deposition, i.e., cooling and consolidation, are not confined to a few hundred feet from the surface, but are to be measured in miles rather than in fathoms. The inferior limits of mining, when viewed from the broad standpoint, are determined rather by the cost of production than by the exhaustion of ore.

Ore formation processes are at present in active operation at enormous depths beneath our feet, for such appear to be due to underlying causes that have been more or less continuously in operation from the earliest of geological times.

Modern writers on the natural history of ore deposits call attention to the connection between quartz veins and acid pegmatite dykes (the off-shoots from the granite) and their community of origin. In this connection it may be pointed out that my colleague, Mr. T. Blatchford, in his account of the geology of the Coolgardie Goldfield, published as far back as the year 1899, described the transition from the normal granite of the field, through auriferous acid dykes to pure quartz veins, distributed marginally with reference to the mass of intrusive granite, which in this part of the Central Division covers such an extensive area.

The mining centre of Westonia, on the Yilgarn field, also furnishes further important evidence of the intimate relationship which exists between the auriferous quartz veins and the normal granite of the district. The quartz, which contains rows of fluid inclusions, is intimately associated with felspar, both of which appear to have solidified at about the same time, and are merely varieties of a quartz-felspar pegmatite, an acid differentiate of the granite magma.

In this connection it is interesting to note that the origin of gold-bearing quartz veins as a result of differentiation from a granitic magma is not by any means new. As far back as the year 1861 that well-known naturalist and mining engineer, Thos. Belt, first pointed out in a paper entitled "Mineral Veins, an enquiry into their origin, founded on a study of the Auriferous Quartz Veins of Australia" that "quartz veins are as naturally produced by granitic eruptions as the acorn to the oak." In the year 1873 this author again approached this subject and in a work entitled "The Naturalist in Nicaragua," where he managed a gold mine, he wrote:

> "Mineral veins in granitic districts occur in regular sequences . . . There is also, sometimes, a complete gradation from veins of perfectly crystallised granite, through others abounding in quartz at the expense of the other constituents up to veins filled with pure quartz."

It may therefore be of interest to those engaged in the historical study of the researches into ore deposits to note that the conception sixty-five years ago, of the idea of the source of certain types of gold-bearing quartz veins as the end product of the differentiation of a granitic magma came about as a result of investigations into the goldfields of Australia, a fact which eminent geological writers on this subject have overlooked.

With regard to the Natural History of the Ore and Gem-bearing Pegmatites, the late Mr. H. P. Woodward made the important observation that the acid dykes of the Greenbushes Tinfield gave evidence of metasomatic action after solidification.

A complete series of rocks "illustrative of the gradual transition from a pegmatite composed mostly of albite, through greisen, into a pure quartz specimen, which when examined microscopically still exhibits the granitic structure, whilst tourmaline and cassiterite are the only associated minerals, which have so far been found to exist throughout the entire series" was obtained. Since the date of these observations in 1908, geologists have come to much the same conclusion from investigations carried out on the pegmatites of other mining districts in Africa, America and elsewhere.

The general geological structure of the State's principal gold producing mining centre, the East Coolgardie Goldfield, which has yielded about one half of the total gold output of the State, has now been definitely established. The gold deposits of the productive area, appropriately designated the "Golden Mile," are virtually confined to a group of genetically related rocks, originating by the transmutation of a quartz-dolerite (diabase) which is traversed by a number of acid dykes of variable width and of considerable length. The gold deposits are chiefly masses of crushed and fractured country rock of great horizontal extent and lenticular in shape, which have been metasomatically replaced and impregnated with quartz, pyrites, and other sulphides, so as to form exploitable ore bodies without any well defined walls. The gold occurs in the Boulder lodes both in the native state and, as has been previously pointed out, in combination with tellurium.

The most plentiful of all the tellurides of Boulder is the mineral Calaverite, the telluride of gold, occurring in large lenticular masses. One of the finest specimens, from the Golden Horseshoe Mine, consisted of a solid mass of Calaverite 6 inches long, 5 inches wide, and a quarter of an inch thick. The telluride of mercury, Coloradoite, is, with the exception of Calaverite, the most widely distributed of all the tellurides. Magnificent specimens have been met with during mining operations and masses several pounds in weight have been recovered. One of the finest specimens, from the celebrated "Oroya Shoot," which alone has produced nearly £8,000,000 worth of gold, consisted of a lens of Coloradoite about 5 inches long, 2 inches wide, and an inch thick, embedded in a green sericite schist, is now in the Geological Survey Collection.

It is a remarkable circumstance that though Boulder is as it were the home of the telluride minerals, few if any crystals with plane surfaces have yet been met with. It has pointed out by one of the leading living mineralogists of Great Britain that "with the occurrence of such large crystalline masses of telluride there can be but little doubt that one day crystals will be found, and these will in all probability surpass those hitherto met with from other parts of the world."

The ultimate derivation of the gold in the Boulder group of lodes would appear to have resulted from the action of a later series of igneous intrusions than that in which the ore bodies are contained. It may be that the introduction of the gold bears an intimate relationship to the after-effects of the intrusive granite which makes such a prominent feature in the country adjacent to Kalgoorlie on the north, but which has not reached the surface in the vicinity of Boulder, though it is probably represented by the acid dykes which traverse the field.

One remarkable and outstanding feature in the State is its iron ore resources, some of which are probably equal in size to other known deposits in the world. The most important class of ores in Western Australia are the large deposits of haematite associated with fine-grained sedimentary quartzites; these pass by all gradations through varieties of jaspilite to pure iron ore.

The ores themselves, in the light of such knowledge as is at present available, appear to owe their origin by hydrothermal processes, which collected and re-deposited the iron from adjacent basic igneous rocks. The highly ferruginous bands are generally found to follow the bedding and other structural planes of their hosts very closely, indicating that the solutions responsible for the deposition of the iron ore were to a very large extent controlled by the stratification. In some cases, however, there is distinct evidence of a complete replacement of the siliceous rocks by haematite, indicating that it has in part, at any rate, replaced the beds which have shared in the severe folding, faulting and compression to which they have been almost everywhere subjected.

The ultimate source of these enormous quantities of iron ore is as yet one of the many unsolved geological problems upon which much intensive research, both in the field and in the laboratory, is required.

An interesting occurrence of a chrome iron ore of some scientific importance has recently been discovered by Mr. Blatchford from the neighbourhood of Murrunda, a range of hills forming the headwaters of Skeleton Creek in the North-West Division. The deposit lies in a belt of serpentine about 80 chains in width, and the ore occurs in a series of massive lens-shaped or pod-like bodies from three to six feet wide, which average about 82 per cent of chromite. The serpentine appears to have been derived from either a pyroxenite or a peridotite in which the chromite is present as a primary constituent. Whether these lenses of chromite were segregations from the direct cooling of an igneous rock, or owe their presence to replacement since consolidation, yet remains to be investigated.

The occurrence of the mineral alunite (a sulphide of aluminium and potassium) at Kanowna, in the East Coolgardie Goldfield, in an aureola of alteration surrounding a mass of acid porphyry at Red Hill intruding the metamorphic sediments, is of considerable scientific importance. The alunite occurs in veins varying from a mere thread up to two feet in thickness, which may represent off-shoots from the porphyry. The mineral may owe its origin to percolating water charged with sulphuric acid, resulting from the decomposition of pyrites, or by sulphurous exhalations from an extinct volcano acting on felspathic rocks. The Red Hill porphyry and the satellitic dykes form the denuded relics of an ancient eruptive vent.

An unusual and unique type of an alunite deposit, and one not recorded from any other country, has been met with at Lake Brown, near Burracoppin. The deposit occurs in one of the clay pans which form part of an ancient watercourse draining into the Avon River. The material of which the deposit is made up is in the form of a fine powder consisting of quartz, kaolin, mica, felspar, salt and gypsum with some organic matter, and has been found to contain 30 per cent or more of alunite.

The mineral pyrites, reported by Mr. Bowley as occurring in some of the adjacent rocks, is probably the original source of the sulphuric acid required for the formation of the alunite.

It will have been apparent from the earlier portion of the address that Western Australia presents many geological problems of absorbing interest upon which research is required, but there is one connected with that great climatic revolution in the history of its Middle Ages (about 50 or 100 million years ago), resulting in a widespread refrigeration of a very large portion of the State, which provides almost as strong attractions as the pages of romance, viz., the Permo-Carboniferous Glaciation.

No period perhaps in the geological history of the State is of such importance and appeals so powerfully to our senses or comes into such close and intimate contact with our material wants and enjoyment as that of the Permo-Carboniferous, to which the Collie and Irwin River coalfields belong.

The Western Australian Permo-Carboniferous glaciation marks perhaps one of the most important episodes in the geological history of the State. The Permo-Carboniferous period combines many varied aspects; and being the greatest ice-age through which the world has passed, it renders the geological details of absorbing interest—upon which much still remains, and will always remain, to be done.

Investigation and study of this refrigeration is one of more than mere local significance, for it forms an important and integral part of the glaciation of the Southern Hemisphere during this geological period.

There is also its economic importance, for despite the fact that there is an extensive area of rocks belonging to the Permo-Carboniferous or Coal-forming Period in the North-West, Central, and Kimberley Divisions, they have almost everywhere proved to be destitute of coal. A large portion of these divisions having been covered by a great ice-sheet during this particular coal-forming period furnishes a possible explanation as to why there are no coal deposits, for there was neither sufficient vegetable growth to produce them nor were the geological conditions favourable for their accumulation and preservation. While the Western Australian Permo-Carboniferous glacial deposits owe their chief importance to purely scientific considerations, they do, however, mark very important stratigraphical horizons which not only tend to make possible geological correlation over the Australian Continent, but permit comparison between the Western Australian formations and those in other portions of the world.

Despite the interest which the discoveries of the evidences of this important great ice-age in the State arouse, it is only possible to deal this evening with the salient issues in an all too brief a manner.

Wherever the beds of the Permo-Carboniferous system of Western Australia have been examined they have been found to be divisible into (a) a lower, or mainly limestone series, and (b) an upper, or sandstone series, with, in the Irwin and Collie districts, some coal seams. The beds associated with the coal-bearing members of the system contain abundant representatives of a flora characterised by several species of the fern-like plant, *Glossopteris*, which has not only a wide distribution but is so abundant that some of the rocks are largely made up of its tongue-shaped and reticulately veined fronds.

The limestone series contains a rich assemblage of marine fossils, characterised by the frequent occurrence of a large number of species of the brachiopod, *Productus*.

There is a bed near the base of the formation crowded with boulders bearing the usual marks of glacier transported materials, such as rocks with smoothly planed and facetted surfaces and striations. Such deposits have been recognised at a great many localities in Western Australia, extending over 12 degrees of latitude, and to within 16 degrees of the equator. It having been found convenient to have a name for this important horizon, the term "Lyons Conglomerate" has been adopted, from the official designation of the Land District in which it was first discovered and where it is so well developed.

Where this conglomerate cannot be seen its presence is always indicated by the heterogeneous collection of boulders with which the flats are covered and which are derived from the weathering, *in situ*, of the boulder bed.

In a channel cut by the Wyndham River in the North-West Division, through the Arthur Range, there is an important exposure of the boulder bed, which is not more than three feet thick in this locality. It is crowded with boulders and pebbles of the crystalline rocks to the east, embedded in a calcareous fossiliferous matrix containing fragments of *Polyzoa*, the brachiopods *Spirifera* and *Productus*, in addition to the mollusc *Aviculopecten tenuicollis*.

The bed in which these boulders and pebbles occur is beyond all doubt of marine origin, as is proved by its fossil contents; it therefore can hardly be a glacial moraine and it is more than likely that the materials of which the bed is made up were transported by floating icebergs that drifted seaward after they had been broken off from some extensive ice sheet which came down to sea-level in a somewhat similar manner to the Great Barrier ice of the Antarctic Regions.

In the circumpolar regions of both hemispheres boulder bearing clays, muds and sands, which owe their origin to the distribution of continental debris carried seaward by floating ice, are at the present time being laid down over a very large area of the ocean floor, and these if consolidated would produce beds in every way identical to the Lyons Glacial Conglomerate.

There is in the Kimberley Division a large development of Permo-Carboniferous rocks which have yielded a remarkably rich assemblage of fossils.

It was pointed out in the year 1907 that although no glacial boulder beds had at that time been recognised in Kimberley within 16 degrees of the equator, their discovery in that region would cause little surprise. It is interesting in this connection to note that a conglomerate containing facetted and ice-scratched boulders has recently been discovered by Messrs. Blatchford and Talbot in the valley of the Fitzroy and its tributaries. This boulder bed is without doubt the equivalent of the Lyons Conglomerate. The Kimberley Permo-Carboniferous beds are believed to underlie nearly the whole of the so-called Great Sandy Desert, which nearly brought to grief Colonel Warburton's expedition in the year 1873. The southern margin of the formation lies in the valley of the Oakover River, which enters the sea between Condon and Port Hedland.

An important discovery of a somewhat sandy matrix crowded with glacially striated pebbles was made in 1924 by Mr. F. G. Clapp, an American geologist with considerable experience in glacial deposits, on the southern flank of the Great Sandy Desert, near Braeside Station on the Oakover River, which there are sound reasons for believing to be of Permo-Carboniferous Age.

Another very important discovery of these glacial deposits or more than local significance was made in 1916 by my colleagues, Messrs. Talbot and Clarke, in the Wilkinson Range near the South Australian Border in South Latitude 26° 30′. For over a distance of 200 miles between the Range and Axe Hill there were found numbers of pebbles and boulders of many different rock types, weighing several hundredweight, derived from the disintegration of a conglomerate about 15 feet thick. Attempts to correlate the Wilkinson Range beds with others containing evidence of ice action have not so far met with much success. There is, however, some little evidence indicating a possibility of these being on the same geological horizon as the glacial conglomerate of the Finke River in South Australia, to which the Gascoyne and other beds belong.

The ice which produced the Lyons Conglomerate did not owe its origin to what may be called the alpine type of glacier, but rather to a broad continuous ice-sheet with a thickness of hundreds or possibly thousands of feet which spread across 800 miles of country north and south and for an almost equal distance east and west.

The climatic conditions under which the Western Australian glacial beds were formed offer a peculiarly fascinating subject for enquiry and the first question which naturally suggests itself is what brought about that phenomenal refrigeration, the evidences of which are only manifest in Western Australia, India, South Africa and South America, but also in Eastern Australia.

The occurrence of glacial conglomerates near the base of the Glossopteris-bearing beds in these widely separated localities in the four continents, points conclusively to their resulting from a common cause.

It would take far too large a draft upon your time to attempt even a cursory examination of the various causes which have been sought to account for this Permo-Carboniferous glaciation, as these are somewhat outside the scope of this address. The exact explanation of this glaciation is not, however, quite clear and it would seem to remain as yet an unsolved problem, though it may be that as the question of past geological glaciations becomes more thoroughly investigated such may be found to result from a combination of factors both local and general.

It has been pointed out that "the discoveries of Australian glacial geology . . . are not only the most important that have hitherto been recorded (all the States of the Commonwealth have been more or less under the influence of glacial conditions), . . . but may fairly rank amongst the most important contributions ever made to our knowledge of the glacial geology of the world."

Prior to the time when the Permo-Carboniferous ice-floes drifted about loaded with boulders and silt, and which on melting scattered their debris along the shore line and over the sea-bottom, Western Australia formed an integral portion of that southern continent linking together South America, Africa, Madagascar, India and Antarctica. This continent, which has been named Gondwanaland, formed a barrier between a southern ocean and a great central Eurasian sea, extending across northern India where the Himalayas now stand, into Europe, and of which the Mediterranean is but a very small relic. There are also sound scientific reasons for thinking that Australia at this geological period had direct connection with Antarctica and thence to South America, and that Western Australia formed a somewhat remote corner of Gondwanaland. The great revolution in physical geography which resulted in the dismemberment of the old continent of Gondwanaland, produced, *inter alia*, the present continent of Australia by, as based upon what is nowadays known as the Wegner Drift Hypothesis, a disruption and drifting of parts under tidal influences, which gradually became widely separated by vast stretches of ocean having a depth in places of several miles. On the assumption that this continental wandering is a correct interpretation of the facts, it follows that ancient Gondwanaland must have had a very much smaller area than has been usually pictured.

If, as has been inferred, South Africa is the Mother Continent from which "South America on the one hand, and Madagascar, India and Australia, with their surrounding areas, on the other, have split off and drifted away," it is to the westward, across the wide expanse of the Indian Ocean where much of the evidence calculated to explain many of the problems of Western Australia's past and present geological history is to be looked for. According to the continental displacement hypothesis, the Indian Ocean has been formed gradually by Australia becoming detached from Africa and wandering slowly to the eastward. This implies a horizontal instability of continental land-masses which has an important bearing on the question of the permanency of ocean basins, about which much has been written in recent years.

Whatever may have been the causes which led up to the dismemberment of Gondawanaland, it gave to Western Australia many of its important features, and in a measure outlined the present configuration of the State. An inspection of a geological map of Australia shows that the continent is split right across by a broad belt of marine strata which separates it from an eastern and a western island. The larger of these islands comprises Western Australia, except the north, and the greater part of South Australia. Being the home of the characteristic Australian flora and fauna, it may be designated Australian Australia. The smaller is a long narrow island which extends from Cape York to Tasmania. As this island was connected with and received from Asia many plants and animals, it might be conveniently named Asiatic Australia. The Cretaceous sea which separated Australian from Asiatic Australia was shallow as is shown by the strata which were deposited all over its area, and in this respect resembled the Arafura Sea of to-day, though the climatic conditions were very different. The climate was comparatively cool and reef-building corals could not grow. It is significant that corals are rare in the Austialian Cretaceous strata. In Western Australia the group is represented by a new species of *Coelosmilia*, met with in the strata at Gingin, which is the third representative of the corals found anywhere in the Australian Cretaceous strata.

Australian Australia enjoyed bountiful rains, thus possessing insular as distinct from continental climates. The extent of the Cretaceous rocks points to these two having been well watered, for it is the water-borne waste of the land which formed the rocks in the bed of the sea. This ancient Cretaceous sea extended into the Great Australian Bight. The strata met with in the bore put down at 337 miles 61 chains from Kalgoorlie, penetrated at a depth of 667 feet a series of shaley beds which yielded two fossils, the molluscs *Aucella hughendensis* and *MacCoyella corbiensis*, forms which are characteristic of and abundant in the Cretaceous rocks of South Australia and the eastern portion of the continent. Remnants of this ancient Cretaceous sea are also to be found in the maritime districts of the western portion of the State, where they cover a very large surface area, and are in very many places concealed beneath a cover of later deposits; whilst their presence has been proved by boring operations.

There are two distinct faunal regions of this age in Western Australia, viz.: those occurring in the strata beneath the Nullarbor Plains, at the head of the Great Australian Bight, and those of Gingin and its surroundings, to the north of the metropolis. The Cretaceous rocks of Gingin consist of a thin bed of chalk—the only one in Australia—below which are "greensands" and clay shale. The chalk of Gingin is an ancient moderately deep sea foraminiferal deposit somewhat analogous to the Globigerina ooze now found on the floor of the Atlantic. The total amount of extraneous mineral matter in the rock being small, and the quantity of recognisable minerals still smaller, it may reasonably be concluded that the Gingin chalk was formed in clear water of some depth in a region where there were no volcanoes, and at some distance from land. The fauna of the Cretaceous system as developed in Western Australia is remarkably rich, especially in formainifera and ostracoda. The Cretaceous rocks of Western Australia are of far more than mere local importance, since the elements in their fauna connect them with those of South Africa, Portugese East Africa, Eastern Madagascar, Western Peninsular India, and Assam.

The Cretaceous sea was gradually becoming shallower owing to a steady elevation, as is evidenced by the preponderance of sandy rocks in the upper members of the Cretaceous formation. Elevation continued until the whole of the Trans-Australian Cretaceous sea became dry land, and for the first time Australian and Asiatic Australia became one great continent. It was the earliest federation of the States of the Commonwealth. The geological federation was complete and final and with it there came inevitable deterioration, for the drying-up of the Cretaceous sea caused the dessication of the central portions of the continent, and the climate became hotter and drier.

Following the period of elevation and erosion at the close of the Cretaceous, the Tertiary era was inaugurated, somewhere about 10 to 15 million years ago, by a subsidence below sea-level of a great part of the country at the head of the Great Australian Bight and portions of what are now the line to the westward. With the advent of the Tertiary era there were ushered in important changes in the topography and geography of the globe. First in order of importance was the formation of that great zone of elevated plications, the result of successive movements of elevation, which extended from the Atlas Mountains in Morocco to the Himalayas, and thence prolonged through the Malay Peninsula, the Dutch East Indies and New Guinea. This immense upheaval was accompanied by the gradual draining of the interior of Australia and by the sinking of other parts of the pre-existing land.

The general instability of the Western Australian area about this time is evidenced by the fracturing of some of the coastal areas by extensive faults, having apparently considerable downthrows westward towards the Indian Ocean. The Darling Range fault scarp, which extends from the south coast northward over 6 degrees of latitude, in all probability forms the eastern boundary of a series of sunken strips of the crust, of which the western wall is to be found in that narrow ridge of ancient crystalline rocks from Flinders to Geographe Bay. The fundamental rocks of the islands of Rottnest and Houtman's Abrolhos possibly mark its northward extension. The sharp trend northwards of the Murchison River close to its mouth and the remarkable coastal indents near Shark's Bay are suggestive of its prolongation in that direction.

Shortly after the deposition of the Tertiary strata there came a period of temporary elevation, erosion and igneous activity. Extensive basaltic eruptions, probably through long conduits rather than great volcanoes, together with eruptions belonging to the intrusive phase took place in the western portion of the South-West Division and probably reached its climax during the early stages of the late Tertiary period and became subdued if not surpressed at the end of this time prior to the Pleistocene epoch, together with the formation of the Coastal Cave Limestone.

The grim-black terraces of basaltic lava flows are to be seen on the sea coast at Bunbury and elsewhere on the south coast. They may also be seen in the Capel River, at several places in the valley of the Blackwood, and near Silver Mount between the Warren and the Donnelly Rivers; they were also cut in two of the bores put down in the search for petroleum in the Warren River. The basaltic lavas, covering an area of about 3000 square miles, remain as a fragment of the enormous flows which probably spread over the extreme south-western portion of Western Australia, and probably over a much larger portion now buried under the Indian Ocean and the sea along the south coast.

In the inland area of the Central Division there are many scattered veins and dykes of remarkably fresh dolerite, which, as at Norseman, can be followed across country for several miles. At times they may be seen intersecting the gold-bearing deposits. These may possibly belong to the same period of Tertiary igneous activity as the basaltic lavas.

The only direct evidence of the geological age of the olivine-dolerites at present known is met with in the neighbourhood of Albany, where a basic dyke is seen to intersect a member of the Plantaganet Beds, the organic remains in which prove them to be Miocene Tertiary. The dolerite dykes and basic lavas seem to belong to one series and reached their present position at about the same geological period. The dykes therefore are of late Tertiary age and belong to the same period as the volcanic rocks in South Australia and Victoria.

In the North-West Division a remarkable and very important feature is the abundance of dolerite intrusions in the form of sheets or steeply inclined dykes. These rocks have a remarkably uniform composition and exhibit little or no trace of recrystallisation or other signs of metamorphism, and are practically in the same condition in which they originally congealed. Some of them extend across country in more or less straight lines for many miles and give rise to fairly conspicuous features standing out boldly in the backs of the ridges, of which an excellent example, the Black Range, is to be seen in Pilbarra. At times these dykes and sheets invade the sedimentary rocks along the planes of bedding and occasionally arch up the overlying strata; whilst at others they form tapering sheets running out into the neighbouring sediments in form not unlike a cedar tree.

From the number and very large area over which these dolerite intrusions extend it appears that there must have been a huge reservoir of molten matter lying beneath the surface to the north of S. Lat. 26° which merely awaited the suitable opportunity of rising to the surface.

In the far north, in the Kimberley Division, basic lavas and volcanic ashes occur in great force. These lavas appear to have flooded the valleys of the Ord and Bow Rivers and levelled up the depressions, with the exception of certain knife-edged ridges of the older rocks which still protrude above the general level. On the Behn River, just above what is known as the Gorge, is a dome or "puy" of basalt which formed one of the foci from which these lavas issued. None of the volcanoes are still active, though the hot spring at Mount Wynne points to the fact that the igneous activity has not yet been entirely surpressed.

At the close of this geological period a great part of the southern coastal plain and the adjacent borders of the interior plateau were raised above the sea-level, but the full extent of this uplift is not as yet definitely known, but it is certain that the sea retreated considerably beyond its present shore line.

Part of the Western Australian coast line is occupied by a rock series designated the Coastal Limestone, the unequal weathering of which has resulted in the formation of an extensive system of caves and grottoes which yet await exploration. The coastal limestone contains abundant fossil mollusca, identifiable with those at present living in Australian waters, and furnishes unmistakable evidence of a distinctly warmer climate than at present obtains in these areas.

From the Mammoth Cave, on the Margaret River in the extreme south-west portion of the State, over 10,000 bones or fragments in an excellent state of preservation have been unearthed from beneath a layer of stalagmitic material which covered the floor.

The mammalian fauna of the Pleistocene caves of the Margaret River has been in part described in a series of publications issued under the aegis of the Trustees of the Western Australian Museum. A vast amount of material has still to be worked out and it is hoped that such will be put in hand at an early date as the investigations bid fair to open up important and fascinating phases in the ancient mammalian history of the State.

Careful and systematic exploration of these limestone caves and the numerous rock shelters and grottoes of the Central and other interior regions may possibly prove them to contain priceless fossil evidence capable of throwing light upon the origin of the Australian aborogines and incidentally that of the human race, and the location of the original home of mankind.

Many of the sedimentary and other residual deposits occurring in widely separated districts of the State weathered out into shallow caves which provided rock shelters frequented by the native races, whose former presence is indicated by stone and other implements, and fragments of bones of birds and animals, as well as realistic paintings of men and native animals done in colour on the surface of the rocks, many of them giving evidence of artistic skill of a relatively high order.

Palaeontological research on material from Western Australia virtually began with investigations made into the collections made during that early period devoted to official exploration and survey long prior to the commencement of more or less systematic geological work. The fossil collections made by Mr. F. T. Gregory between the years 1830 and 1861 gave the first evidence of the presence of Mesozoic rocks in the State in addition to furnishing an account of the scanty Carboniferous faunas occurring in rocks of the valley of the Lyons River, east of the Kennedy Range in the watershed of the Gascoyne, and on the Irwin River. This was followed in 1862 by the work of Mr. Charles Moore, F.G.S., on the collection of Mesozoic fossils made by Mr. Clifton, which was forwarded to England to Mr. A. Sanford, F.G.S., and displayed in the Museum of the Somersetshire Archaeological and Natural History Society in Wellington and it is claimed to have been "the earliest evidence obtained of the presence of Mesozoic beds on the Australian continent.''

The year 1869 is specially noteworthy on account of the publication by the Geological Society of the paper by Mr. Charles Moore on ''Australian Mesozoic Geology and Palaeontology,'' in which, *inter alia*, is given an account of the fossils collected by Mr. Shenton from the Greenough flats and other districts in Western Australia. This collection, which contained several species new to science, is stated to have been ''not only the most numerous but the best-preserved Australian secondary fossils that had yet been publicly exhibited in Great Britain.''

Mr. W. H. Huddleston, M.A., F.G.S., prepared an account of the collection of fossils and rocks collected by Mr. Forrest in the country north of the Gascoyne River, which was published in the year 1883 by the Geological Society. The paper contained a list of palaeozoic fossils, together with a description of a number of species new to science, all of which proved to be Carboniferous or closely allied forms.

Amongst the earliest more or less systematic official investigations into the palaeontology of the State were those carried out during the period when Mr. H. P. Woodward, F.G.S., occupied the position of Government Geologist, 1888 *et seq.*, on the collections made by him and his predecessor, Mr. E. T. Hardman, from the Cambrian, Devonian and Carboniferous formations of widely separated districts in Western Australia. The results of these investigations were published at intervals during the year 1890 under the general title of ''Notes on the Palaeontology of Western Australia.'' The description of the Brachiopoda, Mollusca, etc., was the result of the work of Mr. Arthur H. Foord, F.G.S. (at one time assistant Palaeontologist on the Geological Survey of Canada). The plant remains were briefly described by Mr. R. Kitson, F.R.S.E., F.G.S.; the Stromatoporoids by Prof. H. Alleyne Nicholson, M.D., F.G.S.; and the Corals and Polyzoa by Dr. Geo. J. Hinde, F.G.S. These proved to be a valuable contribution to the faunal study of Western Australia.

The inauguration of systematic geological survey work on modern lines furnished Western Australia with a series of palaeontological publications of which there have been issued seven volumes containing fifteen separate articles under the general title of ''Palaeontological Contributions to the Geology of Western Australia.'' The series contains many important studies of the fossil fauna and flora of Western Australia by some of the leading palaeontological specialists.

Palaeontological researches have also been carried out under the auspices of the Western Australian Museum, whilst the results of several important studies by Messrs. L. Glauert, J. L. Reath, T. Withers, and F. W. Whitehouse, M.Sc., have appeared in the pages of the Journal and Proceedings of the Royal Society of Western Australia. The results of the local palaeontological researches have furnished much valuable information relating to the faunal relationships of the strata from which the fossils were derived and of their stratigraphical equivalents not only in the countries bordering the Indian Ocean, but also in China and Great Britain, in addition to being of fundamental significance with relation to palaeogeography, climatic vicissitudes, and problems of biological history. Palaeontological research is still being carried on with increasing energy.

During the course of this address, a field of gathered fact and growing generalisation has been traversed, and an endeavour made to show that Western Australia, which forms but a fractional part of the globe, has added its quota to the general facts and principles of earth history. And as one reflects not so much upon what has already been accomplished but as to what may be possible in the future, for the necessity for further knowledge is insistent, the prophetic words of Seneca of 2000 years ago cannot but commend themselves to our admiration, besides furnishing a keynote for the future.

Seneca in Book VII of his "Quaestionum Naturalium," a Latin production constituting one of the few works of its time bearing upon the facts and phenomena of Natural History Science, reminds us that:

"Many discoveries are reserved for the ages still to be, when our memory shall have perished. The world is a poor affair if it do not contain matter for investigation for the whole world in every age. *Some of the sacred rites are not revealed to worshippers all at once. Eleusis contains some of his mysteries to show to votaries on their second visit.* Nature does not reveal all her secrets at once. We imagine we are initiated in her mysteries; we are as yet but hanging around her outer courts. These secrets are not open to all indiscriminately. They are withdrawn and shut up in the inner shrine. Of one of them this age will catch a glimpse; of another the age that will come after."

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NOTE.—A few off-prints of the papers contained in Vols. X., XI., and XII., are available at prices ranging from a few pence to about 5s.

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