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OF

QUEENSLAND

FOR 1918.

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—— Edited by ——
A. B. WALKOM, D.Sc.

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

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THE

Royal Society of Queensland.

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CONTENTS.

VOLUME XXX.

(PRESIDENTIAL ADDRESS).

SOIL FERTILITY.

BY E. H. GURNEY.

(Delivered before the Royal Society of Queensland, 25th March, 1918).

The activity of members of the Society during the past year has produced a number of additions to the scientific literature of the State. Eleven papers were accepted by the Society, ten of them being printed during the year and the eleventh held over till the coming year in order to prevent delay in the issue of Volume xxix.

The Queensland Government has again voted a sum of £50 to the Society, thus continuing its assistance towards the publication of original scientific research. When it is remembered that out of a total income of £130 for the year 1918, our printing bill was just over £119, it will be seen that we have very great reason to be grateful to the Government for its assistance. Without the Government's contribution we would only be able to print a little more than half our present volume, and much original scientific research would either be lost or would have to be printed in other States.

It is pleasing to observe that the membership of the Society remains about the same in spite of the strenuous time through which we are passing. Of our members on active service or doing war work, all are safe with the exception of Dene B. Fry, who was killed in action in France on 9th April, 1917. We have to offer our congratulations to a corresponding member, Major T. W. Edgeworth David, on the award of the D.S.O.

During the year the Society has suffered the loss by death of one corresponding member and two ordinary members.

The Rev. George Brown, C.M.Z.S., President of the Australian Methodist Conference, had been a corresponding member of the Society since 1910. He was born at Barnard Castle, Durham, on 7th December, 1835. He was educated in England, and went to sea in 1851. He sailed for New Zealand in 1855 and while in Auckland conceived the idea of church work. He became a missionary and lived in Samoa from 1860 to 1874, and at Port Hunter in the Bismarck Archipelago from 1875 to 1880. He travelled very extensively in the South Sea Islands, and was able to speak a number of the island languages. He died on the 9th April, 1917, at the age of 81.

Dr. T. P. Lucas joined the Royal Society of Queensland on 13th April, 1887. He was born at Dunbar, Scotland, in July, 1843, and died in Brisbane, 15th November, 1917. He studied and became a medical practitioner in London, being a member of the Royal College of Surgeons, England. In 1876 he came to Australia and for ten years practised his profession in Melbourne, afterwards coming to Queensland. He was an extensive collector of natural history specimens and was a member of the Linnean Society of New South Wales and the Entomological Society, London. He made a number of contributions to the British Medical Journal and also published a number of papers in the Proceedings of this Society.

The following is a list of his contributions to the Proceedings of this Society :—New Species of Queensland Butterflies, vi, (2 and 3), p. 117 : Six New Species of Rhopalocera, vi, (4), 155 ; On 34 New Species of Australian Lepidoptera, viii, (3), 68 ; The Colouration of Insects, xi, (2), 66 ; The Flying Fox : its habits and depredations, xii, 49 ; Descriptions of Queensland Lepidoptera, xiii, 59 ; Scrubs and the part they play in the mitigation of tropical floods, xiv, 2 (title only printed) ; New Species of Queensland Lepidoptera, xv, 137 ; Queensland Lepidoptera, xvi, 73 ; A few scientific notes taken during the present drought, xvii, (2), 97.

Dene Barrett Fry was born at Lewisham, near Sydney, in 1893. As a boy he went to live at Lindfield and in the rocky gullies of that district he developed the love of nature and interest in the living things of the bush, that later influenced his choice of profession. Consequent on a boyish review of Mr. A. J. North's book on Australian Birds, he entered the service of the Australian Museum as a cadet in 1908. He remained at the Museum over five years during which time he did good zoological work and published four original papers. At the end of 1913 he courageously resigned his position at the Museum, and studied with the object of taking a Science course at the Sydney University. He succeeded in matriculating in November, 1914, and entered the University in 1915, the same year being appointed demonstrator in Zoology.

He enlisted in 1915 and was placed in the A.M.C. He left Australia on 14th July, 1915, for England to join the first Australian Hospital Ship (the Karoola). His hope of doing pathological or some similar work was not realised, such work having been found to be impracticable on board, and on his return to Australia he transferred to the Infantry. He qualified for a Commission at Duntroon, but there was a surplus of candidates, and rather than wait indefinitely, he took the first opportunity to get away and left Australia for the second time on 22nd August, 1916. He left England for France on 16th November, and spent the next four months alternately in and out of the front line, passing safely through a number of engagements. On Easter Monday (9th April), 1917, his company rushed a German position, and Fry was killed. So the Royal Society lost its first member "Killed in Action" and Australian Zoology lost one of its most promising students.

The following is a list of the papers published by him :—

Description of *Austrochaperina*, a new genus of Engystomatidæ from North Australia. Rec. Austr. Mus., ix., 1, 1912, pp. 87-106, pls. viii-ix.

On a Varanus and a Frog from Burnett River, Queensland, and a Revision of the Variations in *Limnodynastes dorsalis*. Rec. Austr. Mus., x., 2, 1913, pp. 17-34, pls. i-iii.

On the Status of *Chelonia depressa*, Garman. Rec. Austr. Mus., x., 7, 1913, pp. 159-185, pls. xix-xxii.

A Re-Examination of Macleay's New Guinea and Queensland Frog Types. Memoirs Qld. Mus., ii, 1913, pp. 46-50.

On a Collection of Reptiles and Batrachians from Western Australia. Records W. Austr. Mus., 1., 1914, pp. 174-210, pls. xxvii-xxviii.

Herpetological Notes. Proc. Roy. Soc. Qld., xxvii (1), 1915, pp. 60-95, pls. i-iv.

Description of *Aphantophryne*, a new Batrachian Genus from New Guinea, with Comparative Notes on the Pectoral Musculature. Proc. Linn. Soc. N.S. Wales, xli., 1916, pp. 770-785, pls. liv-lv.

SOIL FERTILITY.

The greatest problem confronting any nation is that of food supply, and particular attention has been directed to this matter during the period of the present war. The cultivation of the soil for food is therefore the most important occupation of man, and for this reason there has been soil investigation from the earliest times. And the country with the most knowledge concerning the best methods of soil management, in connection with the various types of soil existing within its area, has the greatest power for the economical production of food.

The object of soil study is to gain knowledge in respect to the factors which are favourable or unfavourable to soil fertility.

That soil fertility depends upon a number of factors is now an accepted fact, and these factors are grouped under the headings—Chemical, Physical, and Biological. It is recognised that deficiency in any condition included under the above headings may have considerable influence upon soil fertility, also that climate, distribution of the annual rainfall, etc., have very marked influence upon crop production.

The above-mentioned soil conditions being interdependent, the study of soil fertility is a very complex one, and the mistake of placing undue importance upon one particular factor is easily made.

When Liebig made the discovery that plants required mineral matter for their growth great impetus was given to the study of the chemical condition of the soil, and for a time, it was thought the fertility or infertility of a soil could be foretold by judgment based only upon the chemical analysis of the soil. But since then the influence of the physical and biological factors has been more fully recognised, and now, in soil investigation work consideration of all these factors is included. But as mentioned before these conditions are interdependent, therefore the recognition and correction of deficiency in the chemical condition of the soil is of great importance.

From the soil, plants require, for successful growth, a certain amount of food material, and the general assumption is that most soils contain sufficient plant-food material with the possible exception of lime, potash, phosphoric acid, and nitrogen, one or all of which may be in some soils in insufficient amount. Although investigators have at various times suggested that a deficiency or an excess of other mineral substances in the soil may have an influence upon the growth of different crops, the chemical investigation of the soil has been to a large extent directed to the determination of the above-mentioned substances, and their availability to crops.

It should be stated here that a large amount of work has been done in connection with the chemistry of the organic matter of the soil.

In connection with the mineral food material mentioned above, when the analyses of soils from different parts of the world are examined, it is found that each substance exists in very varying amounts in the different soils of the same country. This is shown in the following table, which gives the extreme amounts of the different substances reported in some analyses of soils from different parts of the world.

Soil of	Potash (K_2O) %	Phosphoric Acid (P_2O_5) %	Lime (CaO) %
Queensland	Trace to 1.34	0.004 to 1.39	Trace to 10.76
Great Britain and Ireland	0.03 to 1.58	0.034 to 1.24	0.002 to ($CaCO_3$ 61.4)
United States	Trace to 11.37	Trace to 2.61	Trace to 36.0
France	0.02 to 1.30	0.01 to 7.14	($CaCO_3$ 0.003 to 94.7)
Germany	0.003 to 3.23	0.003 to 0.81	0.003 to 47.0

The figures in connection with Queensland soils are compiled from analyses published in the reports of the Agricultural Chemist appearing in the Annual Reports of the Department of Agriculture and Stock, Queensland, since the year 1907. Of the 857 analyses of surface soils presented in these reports a large number were made upon samples of soil forwarded by farmers, who desired information in connection with the particular type of soil of their farm. It is therefore possible that higher amounts of the substances will be found when all the different types of Queensland soils have been analysed.

The figures referring to the other countries mentioned are taken from a paper by Whitney* ; in this paper a list of 4,142 analyses of soils from the different countries is given.

It will be seen from this table that, with the exception of the maximum lime content, the extreme amounts of substances reported in the analyses of Queensland soils are somewhat similar to those reported in the analyses of soils from the other countries.

The great variation in the lime content of the soils of all the countries is particularly noticeable, and lime is one of the most important soil ingredients owing to the influence it has on so many of the factors which are necessary to good soil condition.

*A Study of Crop Yields and Soil Composition in Relation to Soil Productivity, Milton Whitney, U.S. Dept of Agriculture, Bur. of Soils. Bull No. 57, 1909.

Therefore the consideration of the lime content of the Queensland soils previously referred to will be of interest.

In the Agricultural Chemist's report appearing in the Annual Report of the Department of Agriculture and Stock, 1912, a standard to judge fertility in average soil is given, and the percentages of the soils coming within the different limits prescribed by this standard are as follows :—

Lime (CaO) Soluble in Hydrochloric Acid Sp. Gr. 1.115.	Under 0.10% Very Low.	0.10 to 0.24% Low	0.25 to 0.49% Fair	0.50 to 0.74% Very Fair	0.75 to 1.49% Good	1.50% and over Very Good
Percentage of Soils	3.0	22.5	30.5	14.3	18.8	10.9

From these figures it is seen that 25 per cent of the soils contain only very small amounts of lime, but from these figures it is not possible to judge how much of the lime present is in a form capable of neutralizing soil acidity.

The reaction of these soils with litmus paper has been determined, and the following table gives the percentage of soil arranged according to their reaction with litmus paper.

Strongly Acid	13.0 %
Acid	29.5 %
Slightly Acid	25.8 %
Neutral	17.0 %
Slightly Alkaline	6.4 %
Alkaline	6.0 %
Strongly Alkaline	2.2 %

Thus 68 per cent. of these soils give an acid reaction with litmus paper, and judging from this standpoint would benefit by the application of lime.

It is interesting to note here, that the above percentage of acid soils corrresponds very closely to that found in the soils of Wisconsin, U.S.A., as according to Whitson and Weir*, two thirds of these soils are acid. Again in connection with the soils of England, Murray† writes :—

*Soil Acidity and Liming. A. R. Whitson and W. W. Weir. The University of Wisconsin, Agri. Exp. Station Bull. No. 230, 1913.

†Soils and Manures.

"Except in the case of very open soils in which organic matter is so rapidly oxidised that very little humus is ever found, there is a general tendency for the soils in this country to become "sour" unless the acid substances, formed by the decay of organic matter, are neutralised by lime. If the soil does not naturally contain enough calcium carbonate to effect this, frequent liming becomes a paramount necessity."

In a paper entitled "Lime Requirements of Certain Soils," by H. B. Hutchinson and K. MacLennan*, a method is given for the determination, by means of $\frac{N}{50}$ calcium bicarbonate solution, of the lime requirements of soil, and the following extract from this paper is given, as it bears upon the litmus paper test:

"The simple and commonly adopted test for soil acidity is that with litmus paper, in which a strip of neutral paper is interposed for upwards of 15 minutes between two masses of the moist soil to be tested. For rough work in the field the method possesses a certain amount of value—the production of a red tint generally being an indication of acid soil conditions. On the other hand, however, the failure to give any colour change does not necessarily mean that the soil would not respond to an application of lime. The Craibstone soil largely used in our experiments failed to react to this test, but responded distinctly to treatment with carbonate both in laboratory and pot culture experiments. A refinement of the method has been introduced by Christensen and Larsen, who used neutral litmus solution and classified the soil according to the tint produced in the test, etc., etc.

"Of the soils tested by these investigators, 26 were found to be acid or weakly acid in reaction and of these only one failed to respond to treatment in the field; of 50 soils found to give a neutral reaction, 58 per cent. still responded to treatment and 14 per cent. were doubtful, thus supporting the view expressed above with regard to this test."

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*Journal of Agricultural Science, Vol. vii, Part I, 1915.

The lime requirements of the soils, analyses of which were published in 1916 and 1917 Reports, were determined by the method of Hutchinson and MacLennan, and soils with a neutral reaction to litmus paper, as well as those with acid reaction, were by this method found to require lime.

From this it will be apparent that some of the soils with neutral reaction must be included with soils requiring lime. The Agricultural chemist, J. C. Brünnich* has stated: "There can be no doubt that the great bulk of our agricultural lands would be greatly benefited by liming."

Of the many effects, favourable to increased soil fertility, derived from the application of lime to soils requiring it, the following may be mentioned—improvement of soil tilth; neutralisation of soil acidity; liberation of inert plant food; promotion of bacterial activity; encouragement of legume growth.

Full information concerning these effects has been published in text-books and pamphlets dealing with the soil, and in Agricultural Journals. Also officers of the Department of Agriculture have recommended liming to farmers cultivating land requiring lime.

Though lime in some of its different forms is used in the cultivation of the soil for some crops, there is no general attempt throughout the State to apply lime to meet the soil lime requirements. And though deposits of limestone occur in many parts of Queensland†, the present cost of ground limestone to farmers of different districts will prohibit its extensive use. In connection with this matter, it may be stated, that the Department of Agriculture is importing limestone pulverisers for trial.

In connection with the phosphoric acid and potash contents of these Queensland soils, the percentage of soils

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*Agricultural Lime and Limestone in Queensland. J. C. Brünnich, Queensland Agricultural Journal, May, 1914.

†Queensland Mineral Index and Guide. B. Dunstan.

coming within the different limits of the standard previously referred to, are as follows :—

Phosphoric Acid (P_2O_5) Soluble in Hydrochloric Acid Sp. Gr. 1.115	Under 0.05% Very low	0.05 to 0.09% Low	0.1 to 0.14% Fair	0.15 to 0.24% Very Fair	0.25 to 0.49% Good	0.5% and over Very Good
Percentage of Soils	14.7	25.4	18.8	22.5	14.2	4.4

Potash (K_2O) Soluble in Hydrochloric Acid Sp. Gr. 1.115	Under 0.05% Very low	0.05 to 0.09% Low	0.1 to 0.19% Fair	0.20 to 0.39% Very fair	0.40 to 0.74% Good	0.75% and over Very Good
Percentage of Soils	15.4	17.7	25.4	25.4	14.4	1.7

These figures show the amount of phosphoric acid and potash in the soils examined which by weathering agencies may become available to crops.

The organic matter of the soil is a very important constituent owing to the very great influence it has upon the chemical, physical, and biological condition of the soil.

In connection with organic matter, in soil analysis determinations of the "loss-on-ignition" (volatile and organic matter), humus, and nitrogen, are generally made. The loss obtained by igniting a soil, includes chemically combined water and sometimes carbon dioxide from carbonates, and therefore does not represent organic matter only. If the humus (the organic matter most readily available for crop use) be determined, no information concerning the amount of total organic matter is obtained. The estimation of the total nitrogen in the soil includes that from nitrates and the nitrogen of all the organic matter, but from this determination the amount of nitrogen which is available, or which will soon become available, cannot be estimated. Some investigators report both the percentage of total soil nitrogen and of nitrogen in the humus. The following extract from Hilgard* is given as bearing upon this matter—

"It thus appears that on the average the humus of the arid soils contains about three and a half times as much nitrogen as that of the humid; that in the extreme cases, the differ-

*Soils. E. W. Hilgard.

ence goes as high as over six to one; and that in the latter cases, the nitrogen-percentage in arid humus considerably exceeds that of the albumenoid group, the flesh-forming substances.

"It thus becomes intelligible that in the arid region a humus percentage which under humid conditions would justly be considered entirely inadequate for the success of normal crops, may nevertheless suffice even for the more exacting ones."

In a very large number of the Queensland soils previously referred to, the humus has been determined, and the results, detailed in the same way as the lime content, are given below.

Humus	Under 0.8% Very low	0.8 to 1.19% Low	1.2 to 1.7% Fair	1.7 to 2.0% Very Fair	2.0 to 3.0% Good	3.0% and over Very good
Percentage of Soils	14.3	13.0	24.3	12.4	19.2	16.8

The lowest humus content reported was 0.11 per cent. in a sand soil and the highest content 10.62 per cent. in a red sandy loam—virgin scrub soil.

In connection with these soils it is convenient to record here the extreme range of figures obtained for "loss-on-ignition," viz., 0.71 per cent. (including 0.33 per cent. humus) in a red sand with neutral reaction to litmus paper, and 20.98 per cent. (including 0.88 per cent. humus) in a strongly alkaline, black sandy loam. Another high figure for "loss-on-ignition" 20.88 per cent. (including 2.58 per cent. humus) was obtained in an acid red volcanic loam.

Referring now to the total Nitrogen content of these soils and arranging the figures as above, the following results are obtained:—

Nitrogen	Under 0.05% Very low	0.05 to 0.09% Low	0.1 to 0.14% Fair	0.15 to 0.24% Very fair	0.25 to 0.49% Good	0.5% and over Very good
Percentage of Soils	7.9	22.2	24.4	29.6	15.2	0.7

The lowest nitrogen content reported was 0.001 per cent. in a neutral very sandy loam, and the highest nitrogen content 0.786 per cent. in a slightly acid clay loam.

The amounts of humus, nitrogen, and "loss-on-ignition" (volatile and organic matter), as reported in some analyses of soils of other countries are given below.

The following are the extreme figures taken from a number of analyses by Hall and Russell*.

Loss-on-ignition ..	1.36 per cent., and	17.16 per cent.
Nitrogen	0.033 per cent., and	0.633 per cent.

In connection with soils of the United States of America, Cameron† gives the average content of organic matter of 1,340 samples as 2.06 per cent. In a paper by Cameron and Breazeale‡ the percentages of humus and carbon in humus of typical soils of the United States are given, and the lowest humus content recorded is 0.23 per cent., and the highest 12.18 per cent. The following figures are taken from tables by Hilgard||, in which are stated the percentages of the humus, nitrogen in humus, and nitrogen in soils, of the arid and humid regions of California. In soils from the arid region the average content of humus is stated as 0.91 per cent., the lowest percentage of humus recorded being 0.2 and the highest 3.06 ; the average percentage of nitrogen in these soils being 0.135—the extreme percentages being 0.035 and 0.670. In humid soils from arid and humid regions, the average content of humus is 2.45 per cent., the lowest percentage recorded being 0.94 and the highest 7.83 ; the average percentage of nitrogen in these soils is given as 0.135, and the extreme percentages are 0.049 and 0.514.

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*Agriculture and Soils of Kent, Surrey and Sussex. A. D. Hall and E. J. Russell.

†A comparison of The Organic Matter in Different Soil Types. F. K. Cameron. Jour. Amer. Chem. Society, 1905.

‡The Organic Matter in Soils and Subsoils. F. K. Cameron and J. F. Breazeale. Jour. Amer., Chem. Society, 1904.

||Soils. E. W. Hilgard.

The following extreme figures referring to Victorian soils are taken from analyses given by Howell* :—

Humus	0.50 per cent. and 18.55 per cent.
Nitrogen	0.008 per cent. and 1.08 per cent.

It should be stated that the highest humus and nitrogen mentioned refer to the same soil, and which, though it is not stated as such, is thought may be a reclaimed swamp soil. The organic matter found in the Victorian wheat soils ranges from 2.32 per cent. to 8.68 per cent.

In connection with the soils of New South Wales the following figures are from analyses given by Jensen†.

Volatile Matter	from 0.84 per cent. to 18.99 per cent.
Nitrogen	from 0.007 per cent. to 0.651 per cent.

These figures do not include those given in connection with marsh soils.

For the purpose of easy comparison the extreme figures previously mentioned in connection with humus, volatile and organic matter, and nitrogen, are tabulated below.

Soils from	Humus %	Volatile and organic matter %	Nitrogen %
Queensland ..	0.11 to 10.62	0.71 to 20.98	0.001 to 0.786
England (Kent, Surrey, Sussex) ..	————	1.66 to 17.16	0.033 to 0.633
America ..	0.23 to 12.18	————	————
California arid soils	0.20 to 3.06	————	0.035 to 0.670
California humid soils	0.94 to 7.83	————	0.049 to 0.514
Victoria ..	0.50 to 18.55‡	2.32 to 8.28‖	0.008 to 1.08‡
New South Wales ..	————	0.84 to 18.99	0.007 to 0.651

It is seen from this table that the amounts of humus, volatile and organic matter, and nitrogen, in the soils of Queensland vary greatly, also that this variation is of a very similar nature to that occurring in the soils of other countries.

Thus though no comparison concerning the actual amounts of plant food material, or amounts of available plant food, occurring in the soils of the different countries

*Soil Problems in Wheat Growing. F. J. Howell.

†The Soils of New South Wales. H. I. Jensen.

‡May be reclaimed marsh soil.

‖Wheat soils.

has been made, the variation in the amounts of plant food material (with the exception of lime) as shown by the analyses of the soils that have been considered has very similar extremes. And with favourable physical and biological conditions, crops, suitable to the particular climate in which their cultivation is undertaken, under correct soil management should give yields comparable with those obtained in other countries.

That the obtaining and maintaining of correct soil moisture content in our soils is the factor that must claim first attention, is recognised. The utilisation of the rainfall to the greatest extent is therefore necessary, and it is desired to mention here that humus and tilth of soil have a very great influence upon soil moisture. Humus, by improving the tilth increases the water absorptive power of the soil by permitting of easier penetration of rain, and the presence of this material in the soil increases the retention of water absorbed.

The improvement of tilth by the application of lime has already been mentioned.

It has been shown that twenty-seven per cent of the Queensland soils now being considered, have been found to have a low humus content, and considering the value humus has in connection with soil moisture, it is apparent that the increase and maintenance of the organic matter in these soils is of the very greatest importance. And acknowledgment of the importance of this subject is evidenced by the fact that green manuring forms part of some cultural systems adopted in this country.

That this matter receives consideration in countries where it has been shown the soils contain somewhat similar amounts of organic matter, is illustrated by the following statements.

Thus Hilgard* writes in connection with the humus of the soils of California :—

"That excessive aeration results in serious loss of humus, as well as nitrogen, is very obvious in the arid

*Op. cit.

regions where it is the habit to maintain on the surface of orchards and vineyards during the dry, hot summers a thick mulch of well-tilled soil, thus preventing loss of water and evaporation. In the course of years this surface soil becomes so badly depleted of humus that tilth becomes impossible, the soil becoming light-coloured and compacted, while the loss of nitrogen is indicated by the small size of the fruit. Similar losses are of course sustained in the practice of bare summer-fallow, which at one time was almost universal in portions of the arid region. The complete extirpation of weed growth thus brought about, at first considered an unmixed benefit, has ultimately, had to be made up for by the practice of green manuring—since in the arid region the use of stable manure encounters many difficulties."

In analyses of Canadian prairie soils by Shutt*, the extreme figures, mentioned for this particular type of soil, were for organic and volatile matter 5.54 per cent. and 26.29 per cent., and for nitrogen 0.134 per cent. and 1.005 per cent., which indicate the very high content of organic matter in these soils. The following extract from this paper is given to point out that consideration of the organic matter even in these soils is deemed necessary :—" While expressing this very favourable opinion of the Canadian Western Prairie soils it must, at the same time, be pointed out that exclusive grain growing and fallowing, now so common, must give place to more rational farming methods if the soil is to be maintained at its present high standard of productiveness. For the continued supply of available plant food, for the conservation of the necessary soil moisture and for the preservation of good tilth, the store of humus with its concomitant nitrogen must not be allowed to become depleted, and to this end the means are the adoption of a rotation, more particularly one containing a legume, and the keeping of live stock."

And Howell† in connection with the Victorian wheat soils, writes :—

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*Western Prairie Soils. F. G. Shutt, Bull. No. 6, Dept. Agriculture, Canada, 1910.

‡Op. cit.

"The humus content of all soils, principally from considerations of a physical character, might be appreciably increased with advantage. There is reason to think, as will be shown later on when dealing with the mechanical characteristics of the soils under discussion, that the mechanical working and the water holding capacity of certain of the lands of the north would be improved by an increase in the organic supplies of these soils. In the Mallee, where, owing to a limited rainfall, especial benefits from the increased moisture point of view might be expected, the humus content, it will be noted, reaches its lowest figure."

In the foregoing pages particular attention has been devoted to lime and organic matter on account of their many functions in connection with soil fertility.

It is of course known that the total amount of phosphoric acid and potash in the soil is not increased by liming and green manuring, but that these operations increase the availability of the phosphoric acid and potash of the soil—deficiency of phosphoric acid or potash can only be rectified by application of fertilisers containing these substances.

Liming or marling was a practice of the ancients, as was also the ploughing in of legumes and farm yard manure, and from then up to the present time these operations have been conducted by agricultural communities to maintain and increase soil fertility. Therefore it is not claimed that anything new has been stated in connection with the subject, but it is thought that reiteration of the value and importance of the methods taken to assure soil fertility is still very necessary.

In modern times artificial fertilisers have been used, and their value when correctly applied has received wide recognition.

Soils in many parts of the world have been for various reasons abandoned, one reason being that of soil exhaustion, but now in many cases these soils, their fertility restored by correct treatment, are again being cultivated. Thus it may be stated that though there are many soil problems unsolved, the different means of maintaining the fertility of most soils are, in a general way, known.

But before any system of soil management can be adopted in connection with the maintenance of soil fertility the characteristics and particular requirements of the soil to be treated have to be considered. And this being the case, the value of the knowledge gained of the different soil types in a country by means of soil survey work cannot be over estimated.

In conclusion it is desired to state, that as time goes on measures for obtaining permanent fertility of the soil will be required, and soil study will always form an important subject of scientific investigation.

THE TROPICAL ACACIAS OF QUEENSLAND.

(With Descriptions of New Species).

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(With Seven Plates).

(*Read before the Royal Society of Queensland, 29th April,* 1918).

Introductory. My examination of Australian tropical Acacias* has gradually led to an investigation of those of tropical Queensland. I have found that their taxonomy was in a very unsatisfactory state, and one of the results of my work has been to indicate certain lines of investigation. As regards Queensland we can build on the foundations laid by Cunningham, Bentham, Mueller, Bailey and Cambage, but the following pages show some of the many hiatuses there are at present in our knowledge.

Tropical Queensland is not a botanical province, but I speak from experience when I say that the possession of a ist of the species in that area will be a public convenience.

*See Bibliography, p 21.

In Acacia we have the old trouble of non-matching, or doubtful matching, of flowers and fruits. This difficulty is often referred to in the *Flora Australiensis*, and with collectors at any time it is a real one because of the comparative scarcity of permanent residents in the tropics, and of the distinct interval that often occurs between flowering and fruiting time in this genus. The flowering specimens, being the more attractive and conspicuous, are by far the more abundant in herbaria. Correspondents are asked for fruiting specimens, but while the task may be difficult enough if the pods are *in situ*, it is sometimes immeasurably greater if they are detached.

Select Bibliography.

Bentham, George. "Notes on Mimosæ," with a synopsis of species (Tribe iii. Acaciæ), in Hooker's *London Journal of Botany*, i, 318-392, 494-523 (1842). In Latin. This is valuable in that it describes a number of Queensland species collected by Allan Cunningham, Charles Fraser, Ferdinand Bauer (Brown's colleague), Major Mitchell. The species that interest us most in the present enquiry are those collected by Allan Cunningham.

Mueller, F. "Contributiones ad Acaciarum Australiæ Cognitionem" by Ferd. Mueller. Communicated (and edited) by Bentham. *Journ. Linn. Soc.*, iii, 114 (1859).

This primarily takes cognisance of the Acacias of what is now the Northern Territory, collected by the author in the Expedition under A. C. Gregory in 1856 from the Lower Victoria River to the Gulf of Carpentaria. At the same time Mueller includes some species from Queensland and other parts of Australia.

Of the localities given, I only know three as stated to occur in tropical Queensland. It has since been proved that a number of species first recorded by Mueller from the Gulf of Carpentaria have since been found in Northern Queensland, but it must be borne in mind that Mueller collected on the Northern Territory side of the Gulf of Carpentaria, and it is unscientific to record for a State unless a specimen has been collected within the borders of that State.

Bentham, G. "Flora Australiensis" (B. Fl. ii). *Acacia* is dealt with at pp. 301-421 (1864). Referred to hereafter as Bentham.

It is not easy to pick out the North Queensland Acacias in this work unless specific localities are quoted, since some are to be found under "N. Australia."

Bentham, G. "Revision of the Suborder Mimosæ." *Trans. Linn. Soc.*, xxx, 335 (1875), with 4 plates of pods of *Acacia.* Acacias are dealt with at pp. 444-533, and in the beginning of the paper.

Mueller, F. Iconography of Australian species of *Acacia* and cognate genera. Decades i-xiii, 1887-8.

The value of this quarto work, great as it is, is depreciated because no information is given as to the sources of the specimens illustrated. We do not know whether they are the types, or where they were collected, or any history of them. The history has been elucidated in a few cases, and perhaps the tedious work (which can only be carried out at the Melbourne Herbarium) of matching these figures by actual specimens, can be undertaken. At present all that we can say (and the same remarks apply to Mueller's "Flora of Victoria," his "Eucalyptographia," and his companion illustrated works on the Myoporinæ, Salsolaceæ and Candolleaceæ) is that they depict plants attributed to the species whose name they bear. It is regrettable that this example of figuring plants of whose origin we know nothing, has been followed by some others, quite thoughtlessly, I am sure. If a plant is worth figuring at all, it is worthy of a statement as to whence it was obtained, and other necessary particulars concerning it.

Bailey, F. M. "Queensland Flora." Part ii (1900). Referred to hereafter as Bailey. This work makes a very free use of the Flora Australiensis. In a number of cases Bailey admits into the flora of Queensland species whose only claim is Bentham's statement, "Islands of the Gulf of Carpentaria" (R. Brown and others). Bailey admits some of Mueller's Carpentaria records (almost invariably Northern Territory) in a similar way. It is not proper to admit such records as Queensland without further evidence, however we may feel in our own minds that, as botanical exploration proceeds, they will eventually be found to occur in Queensland.

Cambage, R. H., in *Proc. Roy. Soc. N.S.W.*, xlix, 389 (1915). This is a valuable paper because it embodies the results of the travels of the author himself, who collected this genus carefully. It is hereafter referred to as Cambage.

Maiden, J. H. The chapter on Acacias in the following work: " The Flora of the Northern Territory by Alfred J. Ewart and Olive B. Davies, with the co-operation of J. H. Maiden, E. Cheel and A. A. Hamilton " (published December, 1917, by the Federal Government).

Maiden, J. H. " Notes on *Acacia*, No. ii. Tropical Western Australia (including descriptions of new species)." (*Proc. Roy. Soc. N.S.W.*, li, 71 (1917)).

Doubtful records.

I propose that the following species be removed from the flora of tropical Queensland, unless satisfactory evidence be forthcoming. I do not know of such evidence in regard to the species named.

1. *Bynoeana* Benth. in *Linnæa*, xxvi, 614. Bentham, p. 337, quotes " Gulf of Carpentaria, *Mueller*," which is probably Northern Territory. It is found in North Western Australia, and also in Western and South Australia. Bailey, p. 482 has no additional information.

2. *conspersa* F.v.M. in *Journ. Linn. Soc.*, iii, 140, from Roper and Limmen Bight Rivers, Gulf of Carpentaria, Northern Territory. Bentham, p. 403, cites a number of Northern Territory localities. Bailey, p. 507, cites one (or more) of them, " Islands of the Gulf of Carpentaria " (*R. Brown*), and on that, admits it into the flora of Queensland.

3. *delibrata* A. Cunn. Benth. in *Hook. Lond. Journ. Bot.*, i, 374, not of Mueller's " Iconography." This is a North West Australian plant so far as we know. It should be looked for in Northern Queensland; it is not known to occur there at present.

The *A. delibrata* referred to by Bailey, p. 507, from " Gulf Country " (Bancroft) is *A. Hemsleyi* Maiden (see

Proc. Roy. Soc. N.S.W., li, 87, 1917, with a figure. *A. delibrata* is described at p. 80 of the same paper, also with a figure).

4. *dimidiata* Benth. in *Hook. Lond. Journ. Bot.*, i, 381. The type comes from " North Coast in various places." Bentham, p. 412, quotes Northern Territory localities. This is a common Northern Territory species, admitted into the Queensland flora by Bailey, p. 513, with only the reference " Islands of the Gulf of Carpentaria, *R. Brown.*"

5. *dineura* F.v.M. in *Journ. Linn. Soc.*, iii, 130. Recorded by Bailey as a Queensland plant in *Queens. Agric. Journ.*, p. 28 (Jan. 1909) on a Stannary Hills (Dr. T. L. Bancroft) plant which is *A. hemignosta* F.v.M., according to specimens kindly furnished by Mr. C. T. White. *A. dineura* has not been found out of the Northern Territory, so far as I am aware, and what its differences from *A. latescens* Benth. are, I am not clear at present.

The figure of *A. dineura* in the Iconography, is *A. latescens* Benth.

6. *gonocarpa* F.v.M. in *Journ. Linn. Soc.*, iii, 136. Bailey, p. 506, repeats " Rocky shores of the Gulf of Carpentaria (*Mueller*) from Bentham, p. 401, but there is no evidence, so far as I am aware, that the species extends into Queensland. It is not uncommon in the Northern Territory.

7. *impressa* F.v.M. in *Journ. Linn. Soc.*, iii, 133. Type from the Northern Territory. Bentham, p. 380, has no additions other than Northern Territory. It is common in North West Australia. Bailey, p. 494, has " Northern Interior." This, however, is not a definite locality. I have seen a specimen from James River, Upper Georgina River (Lieut. Dittrich from Herb. Melb.), which, however, is in the Northern Territory.

8. *juncifolia* Benth. in *Hook Lond. Journ. Bot.*, i, 341. The type came from the " Interior of New South Wales." A co-type was Mitchell (Mt. Pluto, near 25° S. Lat.).

In my paper on the Acacias of the Northern Territory (in Ewart and Davies' work already referred to), I have shown that this species does not extend to the Territory, some, at least, of the Territory references in B. Fl. ii, 339, being *A. Alleniana* Maiden described in my paper.

Bailey, p. 483, follows Bentham, and I recommend that the typical Queensland localities be eliminated until such time as a specimen of *A. juncifolia* from tropical Queensland can be produced.

9. *latifolia* Benth, in *Hook. Lond. Journ. Bot.*, i, 382. The type comes from "North Coast (?) Bauer." Bailey, p. 512, quotes "Islands of the Gulf of Carpentaria. *R. Brown.*" Roth records it, as regards the fibre of its inner bark, from the hinterland and coast of Princess Charlotte Bay, Cooktown, Cape Bedford, etc., in his North Queensland Ethnography, Bull. No. 1. This is based on a wrong determination. It should be *A. sericata* A. Cunn. Bailey records it from Princess Charlotte Sound on Dr. W. E. Roth's specimens.

10. *linarioides* Benth. in *Hook. Lond. Journ. Bot.*, i, 371. The type comes from "Australia, Bauer," and therefore probably from the Gulf of Carpentaria. Bentham, p. 393, has "Cavern Island, Gulf of Carpentaria" (*R. Brown*, who was with Bauer), and Bailey, p. 502, has no additional information.

It is found in North West Australia as well as the Northern Territory.

11. *spondylophylla* F.v.M. *Fragm.*, viii, 243. Quoted by F. Bennett in this *Journ.* xix, 70, from Irvinebank, is *A. hippuroides* Heward.

12. *stipuligera* F.v.M. in *Journ. Linn. Soc.*, iii, 144. Mueller gives only Northern Territory localities. Bentham, p. 393, adds nothing to these. Bailey, p. 503, says "Gulf Country," which must be backed by a specimen.

I have seen a specimen from James River, Upper Georgina (Lieut. Dittrich, from Herb. Melb.). The Surveyor General of Queensland informs me that "James River" is in the Northern Territory.

13. *subternata* F.v.M. in *Journ. Linn. Soc.*, iii, 124. Type from Table-land, Upper Victoria River, Northern Territory. F. M. Bailey in *Queens. Agric. Journ.*, Sept. 1906, p. 162, records this species from Newcastle Range on the authority of a specimen from A. H. Blackman. I have seen it through the courtesy of Mr. C. T. White, and it is *A. galioides* Benth.

14. *translucens* A. Cunn. in *Hooker's Icones Pl.*, t. 160. The type comes from North Western Australia. Bentham, p. 379, gives "Islands of the Gulf of Carpentaria, *R. Brown*; *Henne.*" Bailey, p. 494, has "Islands of the Gulf of Carpentaria" (R. Brown). It is common in the Northern Territory.

15. *trineura* F.v.M. *Pl. Vict.*, ii, 25, and *Fragm.*, iv, 5. Quoted by F. Bennett in this *Journ.*, xix, 68, from Irvinebank. The type comes from Victoria; it has since been found in southern New South Wales (Temora, etc.). It is a most improbable record, but what it is I cannot say, in absence of the specimen.

16. *xylocarpa* A. Cunn. Benth. in *Hook. Lond. Journ. Bot.*, i, 370. The type comes from Dampier's Archipelago, North West Australia. Bentham, p. 401, gives additional North-West localities, and adds some Northern Territory ones. Bailey, p. 506, says "Gulf of Carpentaria. Mueller," but Mueller's specimen comes from the Northern Territory, and I have never seen a Queensland one.

Tentative list of tropical Queensland species.

For the most part, the sequence of the Flora Australiensis has been followed. I have been at pains to ascertain the origin of the type.

PUNGENTES (Plurinerves).

1. *phlebocarpa* F.v.M. in *Journ. Linn. Soc.*, iii (not ii), 119. Type from Seven Emu River, Gulf of Carpentaria, Northern Territory. Bailey, p. 481, has "Gulf of Carpentaria," but although he admits it into the flora of Queensland, I do not think he ever saw a Queensland specimen. I have since the publication of his work, seen a specimen from the Gilbert River (*Armit.* ex herb. Melb.), which proves that it is a Queensland species.

BRUNONIOIDEÆ.

2. *hippuroides* Heward. Benth. in *Hook. Lond. Journ. Bot.*, i, 344.

Type from Usborne's Harbour, North West Australia. Recorded in B. Fl., ii, 342, also from Northern Territory. It was recorded from Queensland by Bailey in his "Comprehensive Catalogue."

I have now received it from Stannary Hills (Dr. T. L. Bancroft), Irvinebank (F. Bennett), Herberton (R. C. Ringrose), all through C. T. White.

3. *galioides* Benth., in *Hook. Lond. Journ. Bot.*, i, 344. The type comes from "Australia," *Bauer*, which means Gulf of Carpentaria. Bentham, p. 342, records "a variety with rather stouter phyllodia," Sweers Island, *Henne.* This is in the Queensland portion of the Gulf of Carpentaria, near Bentinck Island. Cambage, p. 416, records it from Forsayth to Normanton, p. 420, two miles north of Croydon.

Other localities are near Herberton (S. Dixon), Stannary Hills, *via* Irvinebank, (Dr. T. L. Bancroft), Cape River (Herb. Melb.), Rockhampton (no collector).

4. *conferta* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 345. The type comes from the tributaries of the Macquarie River, N.S.W.; "also in Bauer's collection." Bentham, p. 343, quotes Shoalwater Bay, *R. Brown*, which is just inside the tropics.

I have seen a specimen "Shoalwater Bay, *R. Brown*, 1802-5." It may be that this is the specimen referred to as "in Bauer's collection," for Ferdinand Bauer was the artist who accompanied and who worked under Brown's direction. See my "Sir Joseph Banks: the Father of Australia," p. 69.

This is the only specimen of *A. conferta* from Queensland I have seen, and I would invite the attention of collectors to it. It is fairly common in the drier (not the driest) parts of New South Wales, both north and west.

UNINERVES (Brevifoliæ).

4*a*. *purpureapetala* Bailey, in *Queensland Agric. Journ.* xv. 780, (1905).

Type from Herberton (J. Stirling). Mr. C. T. White also sends it to me from Stannary Hills (Dr. T. L. Bancroft).

UNINERVES (Angustifoliæ).

5. *sentis* F.v.M. in *Journ. Linn. Soc.*, iii, 128. "In Australia orientali tropica."

In the rare *Pl. Indig. Col. Vict.*, ii, 18, Mueller gives a useful description in English of his species, stating that the dromedaries (camels) of Howitt's Expedition in search of Burke and Wills were extremely fond of browsing upon it, and adds that "the generally paired, much longer peduncles, distinguish *A. sentis* at once, even in its exstipular state from Reichenbach's figure of *A. decora*, to which species it was referred, though not without doubt, by Bentham in *Journ. Linn. Soc.*, iii, 128." He further discusses the dissimilarities. For a figure of *A. decora* Reichenb. see my *Forest Flora of N.S.W.*, Part 45.

Bentham, p. 360, records it from the Bargoo (Barcoo) River, and figures the pod in *Trans. Linn. Soc.*, xxx, t. 67. Bailey, p. 487, quotes "Gulf of Carpentaria." Cambage, p. 428, specifically quotes Normanton to Cloncurry; p. 436, Cloncurry to Hughenden; p. 437, Hughenden to Prairie. These are the first precise tropical Queensland localities known to me.

6. *fasciculifera* F.v.M. in B. Fl., ii, 361. The pod of *A. macradenia* as described in B. Fl., ii, 362, is that of *A. fasciculifera* as pointed out by Mueller in *Wing's Southern Science Record* for July, 1882. Both species are recorded from Rockhampton. Its range requires further investigation.

UNINERVES (Racemosæ).

7. *macradenia* Benth. in *Mitch. Trop. Aust.*, 360. The type came from beds of rivers near Mt. Pluto. The pod from Rockhampton (Thozet) as quoted in B. Fl., ii, 362, is that of *A. fasciculifera* F.v.M. It may be admitted into a list of tropical species on the authority of a species from the Leichhardt district sent by Bailey to Mueller. Its range requires further investigation.

7(*a*) *A. Bancrofti*, n. sp.

Frutex glaucus ca. 6′, ramulis teretibus, apicibus angulatis. Phyllodiis obovatis ad lanceolatis, obtuse acuminatis, plerumque 12-18cm longis, latitudine valde mutantibus (2-9 cm), basin versus valde attenuatis, in petiolum fere 2 cm terminantibus, falcatis, asymmetricis, parte dorsale margine undulata, in modo ilicifolii, lobos triangulares saepe formantibus in glandulam terminantibus, 1-nervis, prominenter et tenuiter penniveniis. Racemis 8 cm longis, laxis, minus 20 capitulis globosis, 5-meris. Rhache laeve. Calyce sinuato-lobato, margine ciliata, sparse piloso, dimidio corollam aequante. Petalis glabris, infra lobis cohaerentibus. Pistilli parte superiore pilosa. Legumine recto, symmetrico, 17 cm longo, 1.5 cm lato, valvis nitentibus, nigris, reticulatis, marginibus planis, seminibus longitudinalibus, funiculo duplo plicato, semen bis circumcingente.

A glaucous shrub of about 6 feet, forming stools of several feet in diameter, branchlets round, though with the tips angular.

Phyllodia obovate to lanceolate, bluntly acuminate, usually 12 to 18 cm (say 5 to 7 inches) long, and varying greatly in width, say from 2 to 9 cm; much narrowed towards he base, terminating in a distinct petiole of nearly 2 cm. Falcate, asymmetrical, the main nerve nearer the dorsal portion which has often a holly-leaved undulate margin, the lobes often forming triangular processes terminating in a gland, 1-nerved and prominently and finely penniveined, the margins nerve-like.

Racemes of bright yellow flowers, about 8 cm long, loose, with under 20 globular heads of flowers, sometimes two in each axilla, 5-merous. The rhachis smooth, with a small bract.

Calyx sinuate-lobed, with ciliate edge, and scattered hairs running up from the base, about half the length of the corolla. Petals glabrous, united below the lobes. Pistil smooth when young, but the upper half hairy when more mature.

Pod straight, symmetrical, 17 cm long and 1.5 cm broad, the valves shining, black, reticulate, the margins flattish and grooved, the seeds longitudinally arranged, elliptical, dull, with a funicle bent double and twice encircling the seed and terminating in a clavate arillus.

This interesting species commemorates the Bancrofts, father and son, the former the late Dr. Joseph Bancroft, and the latter Dr. Thomas Lane Bancroft, who have done splendid work in the elucidation of the flora of Queensland (to mention only one phase of their scientific activities).

Type from dry stony ridges at Beta. In flower 1st July, 1913 (J. L. Boorman). Description of pod and seed drawn up from a specimen "between Haly's and York's, on the newly cut road, the Dawson, October, 1877 (Dr. Joseph Bancroft).

Other specimens have phyllodia with lobes more pronounced than the type, for example (*a*) Nanango (C. H. Grove, No. 54). In this specimen the rhachis and peduncles are covered with a short golden, silky pubescence, the calyx is comparatively shorter than in the case of the type, and the petals are sprinkled with hairs.

(*b*) Eidsvold (Dr. T. L. Bancroft).

(*c*) Copperfield (John Shirley).

The following specimens have the leaves non-lobed, or scarcely lobed, like the type.

(*d*) A specimen mixed with a specimen of *A. macradenia* Benth. collected by Mitchell at Mt. Pluto in 1846.

(*e*) Clermont (H. Salmon, No. 28).

(*f*) Rockhampton (Rev. J. E. Tenison Woods, as *A. macradenia* (?)).

It is confined to Queensland, so far as is known at present, but it may be expected to be found in northern New South Wales.

Affinities.

1. With *A. penninervis* Sieb.

[*A. Bancrofti* was looked upon by Bailey as a form of *A. penninervis*, and perhaps by Bentham also].

A. Bancrofti has not the secondary nerve which is a character in *A. penninervis*, and the lobing of the phyllodes is absent in the latter species. The raceme in *A. penninervis* is shorter and the flowers are 48 in the head. The flowers in *A. penninervis* are narrower, the petals more separate and the calyx less continuous with the corolla. The pods of *A. penninervis* are not shining black; the sculpture of the margins is different in the two species. At the same time the affinity of the two species is evident.

2. With *A. macradenia* Benth.

This has obvious affinity as already indicated as having been noted by Bailey. *A. macradenia* has a smaller raceme with the calyx-lobes separate to the base, and the curved pods much smaller, with orbicular seeds, with the funicle not folded and about half as long as the seed. It is figured in the Iconography, with some points scarcely agreeing with Bentham's description, but I agree that the species depicted is as stated.

3. With *A. falcata* Willd.

The affinity has been suggested by competent botanists. *A. falcata* is a single-stemmed species with more angular branchlets, the flowers are pale-coloured, not bright yellow, and the racemes shorter, the sepals are free and the petals soon separate. The pods are much shorter and narrower. Some phyllodes present a good deal of resemblance to the non-lobed forms of *A. Bancrofti.*

4. With *A. latescens* Benth.

This species may be mentioned also having a tendency to angled-lobing, terminating in a gland, but the phyllodes are lanceolate-falcate, usually 2-nerved, the calyx is different, nor is there an encircling funicle.

8. *salicina* F.v.M. var. *varians* Benth., B. Fl., ii, 367. Bentham, at p. 367 quotes Curtis Island (*Henne*), which is a Queensland locality, almost in the tropics. Bentham says "to this belong all the tropical and sub-tropical specimens." I have seen specimens from the Northern Territory. It is figured and described in Part 39 of my Forest Flora of New South Wales.

9. *Dietrichiana* F.v.M. in "*Wing's Southern Science Record,*" ii, 149 (July, 1882). The type comes from Lake Elphinstone (Lat. 21.30, Long. 148.20). It is figured in the "Iconography." I have it also from Beta (J. L. Boorman).

10. *decora* Reichb. *Icon. Exot.*, t. 199. I have not personally seen this species farther north than Rockhampton (see my Forest Flora of N.S.W., Part 45, Plate 169). In view of the confusion which has arisen between this species and *A. sentis*, it would perhaps be desirable to re-examine all tropical specimens referred to *A. decora.*

Bailey, p. 491, says "Gum eaten, Cloncurry," evidently on the authority of Edward Palmer in *Proc. Roy. Soc. N.S.W.*, xvii, 94 (1883), a plant I believe to be referable to *A. sentis.*

PLURINERVES (Oligoneuræ).

11. *Simsii* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 368. The type comes from Cleveland Bay, Queensland. Bentham, p. 382, quotes a number of other North Queensland localities. Specific localities are, East of Inlet, Cairns (R. H. Cambage, No. 3,840); about 15 feet high, granite, 1,600 feet, Almaden (R. H. Cambage, No. 3,890), 8 feet high, on granite, Townsville (R. H. Cambage, No. 3,802), and I could quote others. It is confined to North Queensland so far as I am aware.

PLURINERVES (Microneura).

12. *homalophylla* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 365. Type from Lachlan River, N.S.W.

Cambage, p. 439, provisionally records this species ("Boree," No. 3,971) from "a little more than half way from Winton to Longreach." Peak Vale, Clermont (correspondent of Dr. J. Shirley). Bailey, p. 495, simply says "inland localities.' The following locality is sufficiently close to warrant its inclusion in the present list. It is a specimen labelled "Neercool" Creek in Mueller's handwriting. The Surveyor General of Queensland informs me that Neerkool Creek has its source about 4 miles south of Stanwell on the Central Railway, and under the names of Neerkool, Scrub and Gavial Creeks flows into the Fitzroy River a short distance below Rockhampton. The specimen was perhaps collected by E. Bowman, who collected *A. julifera* there, see p. 41.

13. *Cambagei* R. T. Baker in *Proc. Linn. Soc. N.S.W.*, xxv, 661 (1900). The "Gidgee." See my *Forest Flora of N.S.W.*, Part xl, p. 24. Cambage, pp. 428, 431, gives Normanton to Cloncurry, p. 436, Cloncurry to Hughenden, p. 437, Hughenden to Prairie; p. 438, Hughenden to Winton; p. 439, Winton to Longreach.

14. *Oswaldi* F.v.M., Bentham, B. Fl., ii, 384, quotes *Pl. Vict.*, ii, 27, but that work quotes *Linnæa* xxvi, 609, for the description of the species. It was originally described from specimens in the dry country of New South Wales (perhaps Victoria) and South Australia. In Bentham,

p. 384, we have "Towards Broad Sound, without collector's name," and I admit it into a list of tropical species on that specimen. Dr. J. Shirley's "near Mount Morgan," is approaching the tropics. Bailey admits it in his Queensland Flora simply as "common inland." I have several other specimens from sub-tropical Queensland.

15. *coriacea* DC. in *Mem. Leg.*, 446. The type comes from "Eastern New Holland." Mueller has a note as to whether it is a form of *stenophylla*. Besides Northern and Central Queensland, it occurs in the Northern Territory, and also in North West Australia, and sub-tropical Western Australia.

Cambage, pp. 437, 438, Hughenden to Prairie, describes it under 3,961, Wirewood, as *A. cibaria*, which is a *lapsus plumæ* for *A. coriacea*. I have it also from Beta (J. L. Boorman).

It is not mentioned either by Bentham or Bailey as a Queensland plant.

16. *stenophylla* DC., Benth, in *Hook. Lond. Journ. Bot.*, i, 366. The type comes from the Lachlan River, N.S W. Bentham, p. 385, quotes it from the Northern Territory, and, as regards Queensland localities, Maranoa and Narran Rivers, *Mitchell*. (He also gives localities in Victoria and South Australia). Bailey, p. 497, repeats these Queensland localities. Cambage, pp. 428, 432, gives Normanton to Cloncurry ; p. 436, Cloncurry to Hughenden ; p. 438, Hughenden to Winton ; p. 439, Winton to Longreach.

Other Queensland localities could be given that connect with the sub-tropical localities of the other States.

Plurinerves (Nervosæ).

17. *hemignosta* F.v.M. in *Journ. Linn. Soc.*, iii, 134. From the Gilbert River (together with Northern Territory localities). It is common in North Western Australia. Bentham, p. 385, has additional information. Bailey omits it. Cambage, pp. 401 and 404 has Almaden; p. 416, Forsayth to Normanton ; p. 428, Normanton to Cloncurry. I have it also from Mt. Albion (S. Dixon) and Saxby River (Miss F. Sulman).

18. *harpophylla* F.v.M. in B. Fl., ii, 389. Bentham has Rockhampton, *Thozet.* Various localities, Emerald to Rockhampton (J. L. Boorman). See my "Forest Flora of N.S.W.," Part 34, p. 51.

19. *excelsa* Benth., in Mitchell *Trop. Austral.*, 225. This may be admitted into the flora of tropical Queensland on the authority B. Fl., ii, 390. Of the localities, Clarke River, *Daintree,* is tropical.

I have seen specimens, Flinders River, named by Mueller but no collector is quoted, also Rosewood, near Rockhampton (P. O'Shanesy). See also my *Forest Flora of N.S.W.*, Part 33, p. 39.

20. *complanata* A. Cunn., Benth., in *Hook. Lond. Journ. Bot.*, i, 369. The type comes from "Dumaresque and Brisbane Rivers." Bentham, p. 390, gives Endeavour River, *Banks and Solander.*

It extends as far south as the Macleay River district in New South Wales.

21. *homoclada* F.v.M. in *Fragm.*, xi, 34. Type from Hinchinbrook Island. I have not seen any other specimen, and the attention of collectors is invited to it.

PLURINERVES (Dimidiatæ).

22. *Rothii* Bailey in *Queens. Agric. Journ.*, vi, 39. Type from "mouth of the Batavia River." (Flows into the east coast of the Gulf of Carpentaria). See also Bailey, p. 500.

23. *sericata* A. Cunn., Benth., in *Hook. Lond. Journ. Bot.*, i, 380. The type comes from Montagu and York Sounds, North West Australia. Bentham figures the pod, *Trans. Linn. Soc.*, xxx, t. 67. He (B. Fl., ii, 391) adds Northern Territory localities. Bailey, p. 501, has "Gulf of Carpentaria, *Mueller*," but this is Northern Territory. He adds Etheridge River, which is of course Queensland. I have it from Princess Charlotte Bay (Dr. W. E. Roth, through C. T. White); Cape York (E. Ramsay; E. Daemel); Jericho (J. L. Boorman). Cambage, pp. 416 and 420, quotes it from Gilbert River to Croydon.

24. *flavescens* A. Cunn., Benth,. in *Hook. Lond. Journ. Bot.*, i, 381. The type comes from "North-east Coast." In Bentham, p. 391, North Queensland localities are given. In Bailey, p. 501, the only additional locality given is Mt. Wheeler, *Thozet.*

Roth (*Bull. N. Q. Ethnography* No. 1) explains how the aborigines prepare twine from the bark, about Cape Bedford and Cooktown.

Cambage, p. 396, quotes Kuranda to Almaden.

It comes as far south as Moreton Bay.

25. *oraria* F.v.M. in *Fragm.*, xi, 66. Co-types from Port Denison, Rockingham Bay and Trinity Bay. Mueller figures it in the Iconography.

JULIFLORÆ (Rigidulæ).

26. *Wickhami* Benth. in *Hook. Lond. Journ. Bot.*, i, 377 not 379. The type comes from Swan Bay, North West Australia. In B. Fl., ii, 392, Bentham adds a Northern Territory locality.

Stannary Hills (Dr. T. L. Bancroft, through C. T. White) is the only Queensland locality known to me.

27. *lysiphlœa* F.v.M. in *Journ. Linn. Soc.*, iii, 137, as *lysiphloia*. Type from the Northern Territory. It extends to North Western Australia.

The inner bark is used by the aborigines of the Middle Palmer River (Roth in *Bull. N. Q. Ethnography*, No. 1), which appears to be the first specific Queensland locality.

I have seen it from Normanton (T. Hann).

28. *Chisholmi* Bailey in *Queens. Agric. Journ.*, iv, p. 47. The type comes from Prairie, Torrens Creek. Northern Railway Line. See also Bailey, p. 502.

Cambage, p. 432, quotes it Normanton to Cloncurry; (?) p. 436, Cloncurry to Hughenden; p. 437, Hughenden to Prairie.

29. *umbellata* A. Cunn., Benth. in *Lond. Journ. Bot.*, i, 378. (*acradenia* A. Cunn.). The co-types come from Cleveland Bay and Cape Flinders. Bentham adds some Northern Territory localities. It extends to North Western

Australia. Cambage, pp. 428, 432, has Normanton to Cloncurry. I have seen it from Stannary Hills (Dr. T. L. Bancroft).

30. *brevifolia* Benth. B. Fl., ii, 395 = *A. aulacocarpa* A. Cunn. var. *brevifolia* in *Journ. Linn. Soc.*, iii, 143 (not 144) = *A. leptophleba* F.v.M. var. *brevifolia* (as corrected in B. Fl., ii, 395).

Type from "Suttor Desert," or "Desert of the Suttor" (Mueller). I do not know the precise locality of the "Desert." (Under *A. salicina* Mueller in *Journ. Linn. Soc.*, iii, 126, speaks of "In eremo ad flumen Suttor"). *A. brevifolia* does not appear to have been found since, which is unsatisfactory. Pods are unknown, and as it has never been figured, I illustrate the type at Plate i.

31. *A. curvinervia*, n. sp.

Frutex erectus 6-10′, non ramosus. Ramulorum apicibus angulatis, ramulis inferioribus teretibus et cum aliquis phyllodiarum pubescente albo tectis. Phyllodiis obliquo-crescentibus mucrone deciduo, basin versus angustatis in petiolum brevem rugosum terminantibus, crescentis diametro 4 cm. maxima latitudine 2 cm., coriaciis venis numerosis curvatis, 3 v. pluribus prominentioribus. Floribus in spicis, plerumque geminis, 5-meris. Calyce irregulariter lobato, pilosissimo. Petalis laevibus, calycem duplo superantibus, dimidio longitudinis cohaerentibus. Legumine non viso.

An erect growing shrub of 6-10 feet, with marked absence of the usual branching habit. The ends of the branchlets angular and brown scurfy, with a sprinkling of short white hairs, the lower branchlets terete and covered with a soft white pubescence, which extends to the lower part or whole of the phyllodes, the majority of the branchlets and phyllodes glabrous. Phyllodia oblique-crescentic, with a brown, deciduous point, narrowed at the base, terminating in a short, wrinkled petiole ; diameter of the crescent about 4 cm, greatest width up to 2 cm., very coriaceous with numerous curved veins three or more prominent than the others.

Flowers in spikes, usually in pairs, 5-merous. Calyx sinuate-toothed or irregularly lobed, very hairy, about half the length of the corolla. Petals smooth, slightly united about half-way up.

Pistil covered in such a thick coat of hair as to conceal its outline. Rhachis hairy. Pod not seen.

Collected in flower by J. L. Boorman at Beta, a railway station on the Central Railway, Queensland, 291 miles west of Rockhampton. Elevation about 1,300 feet, 3rd July, 1913. The type.

Also obtained in flower by the same collector at The Virgin, Springsure. Springsure is 40 miles from the railway junction at Emerald, which is itself 166 miles west of Rockhampton. June, 1913. These localities are a little south of the tropic.

Affinities.

1. With *A. brevifolia* Benth. It differs in the shape and indument of the phyllodia. The calyx of *A. brevifolia* is of a different shape, is glabrous, and is much smaller proportionately to the petals, while its pistil is smooth and that of *A. curvinervia* is hairy. At the same time, it would appear that, in the present state of our knowledge, *A. brevifolia* is closest to the new species.

2. With *A. difficilis* Maiden in Ewart's "Flora of the Northern Territory." The relations are more distant. Some of the shorter, more crescentic-phyllode forms of this species have a somewhat distant affinity to *A. curvinervia*, but the indument is different, the spikes of the former are more slender, while the calyx of *A. difficilis* is divided into sepals.

32. *gonoclada* F.v.M. in *Journ. Linn. Soc.*, iii, 140. A Northern Territory species. Cambage has it, p. 437, from Hughenden to Prairie. This is the first record for Queensland.

JULIFLORÆ (Tetrameræ).

33. *A. Whitei*, n. sp.

Frutex parvus glaber, ramulis angulatis. Phyllodiis rectis vel paullo falcatis, plerumque lineari-lanceolatis apice basique angustatis, 5-12 cm longis, 4-5 mm latis, rigidis mediocriter crassis, 7 nervis prominentibus parallelibus longitudinalibus, uniformibus cum marginalibus, costa media prominentiuscula. Spicis solitariis vel geminis in axillis, brevibus, ca. 1.5 cm longis, sessilibus vel breviter pedunculatis, non gracilibus, densiusculis, rhache laeve. Floribus 4 v. 5-meris. Calyce truncato vel paullo lobato, petalis calycem ca. triplo superantibus. Petalis laevibus vel paullo pruinosis, costatis, dimidio longitudinis cohaerentibus. Pistillo breviter piloso. Legumine (maturo non viso) lineari-lanceolato, paullo falcato, plerumque ca. 5 mm lato, ca. 4·5 cm. longo, marginibus valde incrassatis. Seminibus elongatis, longitudinaliter dispositis, valvis inter semina leniter constrictis, funiculo in arillum leniter expansum terminante.

A small woody shrub (of two to six feet at Stannary Hills; a low straggling shrub at Herberton), glabrous, with angular branchlets. Phyllodia straight or slightly falcate, usually linear-lanceolate, gradually tapering into both ends, the apex a blunt point, at the base an indefinite nectary (gland), 5 to 12 cm. (2 to 5 inches) long, 4 to 5 mm. broad, rigid and moderately thick, with 7 well-defined parallel nerves, running the whole length of the phyllode and uniform with the marginal ones, the mid-vein somewhat more prominent.

Spikes single or two in the axils, short, about 1.5 cm. long, sessile or shortly stalked, not slender, rather dense, rhachis smooth. Flowers 4- or 5-merous, the bracts concave. Calyx truncate or somewhat lobed, somewhat thickened at the base, about a third the length of the petals. Petals smooth or slightly hoary, ribbed, united about half way up. Pistil covered with short hairs.

Pod (not seen quite ripe), linear-lanceolate, slightly falcate, usually about 5 mm. broad; short, about 4 or 5 cm. long, with strongly thickened, raised paler-coloured margins. The seeds elongate, longitudinally arranged, the valves slightly constricted between the seeds, the funicle (not seen fully developed) forming a flattish ribbon; terminating in a slightly expanded arillus.

Type. Stannary Hills, *via* Irvinebank, North Queensland (Dr. T. L. Bancroft, 1910, communicated by Mr. C. T. White).

Mr. White also communicated to me a flowering specimen collected by the late Rev. J. E. Tenison-Woods, at Herberton, with phyllodes rather shorter and broader than the type. Also a flowering specimen collected by Dr. Hamilton Kenny, December, 1911, at Herberton, and described by him as "common" there.

Named in honour of Cyril Tenison White, Government Botanist of Queensland, who has worthily succeeded his grandfather, the late F. M. Bailey, in that office.

Affinities.

The affinity of this species appears to be with the Western Australian *A. cochliocarpa* Meissner and *A. neurophylla* W. V. Fitzgerald. The phyllodes of all three are a good deal alike ; those of Western Australia are of a yellower green and the veins are more marked.

The flowers and fruits are, however, very different, the pods of *A. cochliocarpa* being as indicated by the specific name, while the sepals are narrow-spathulate. In regard to *A. neurophylla* the same remarks apply : the pods are narrower, straighter and longer, without a pronounced margin, while the flowers have narrow-spathulate calyces, not so narrow as those of *A. cochliocarpa.*

JULIFLORÆ (Stenophyllæ).

34. *cyperophylla* F.v.M. in B. Fl., ii, 400. A form attributed to this species is from the Flinders River. See my *Forest Flora of N.S.W.*, Vol. vi (Part 60), p. 273. It is figured at figure 1, Plate 227, and I invite the attention of Queensland botanists to it. Bailey, p. 505, gives no Queensland locality for the species.

35. *pityoides* F.v.M. in *Journ. Linn. Soc.*, iii, 135. A Northern Territory and North Queensland species. The original description includes the Gilbert to the Suttor. Bentham, p. 400, has Gilbert River (under North Australia), and adds "Ridges of the Suttor." Bailey, p. 505, has only the latter reference. Cambage, pp. 437, 438, has Hughenden to Prairie. I have also seen it from Jericho (J. L. Boorman).

36. *drepanocarpa* F.v.M. in *Journ. Linn. Soc.*, iii, 137. Described from Northern Territory. "Whitsunday and Palm Islands," *Henne*, in B. Fl. ii, p. 402, under "N. Australia." Ben ham igures the pod at *Trans. Linn. Soc.*, xxx, t. 68.

JULIFLORÆ (Falcatæ).

37. *doratoxylon* A. Cunn. This was originally described from New South Wales, and an a count of it is given in my *Forest Flora of N.S.W.*, Vol. iv, p. 109, with Plate 141. Bentham quotes it from the Upper Maranoa, *Mitchell*, and Moreton Bay, *C. Moore.*

Cambage, at pp. 412, 413, who knows *A. doratoxylon* in New South Wales well, quotes it from Almaden to Forsayth and from Forsayth to Normanton with a query. His remarks at p. 413 should be read. After careful consideration later I cannot see any difference which cannot be explained by a change in environment, for North Queensland is far from the home of the type. The pods of the northern form are undoubtedly more fleshy. I have since received the following from Mr. C. T. White:

(*a*) "Lancewood," Gilbert River (E. W. Bick).

(*b*) "Lancewood," Rockhampton (Chief Engineer for Queensland Railways).

(*c*) Eidsvold and Dalby (both from Dr. T. L. Bancroft).

38. *torulosa* Benth. in *Journ. Linn. Soc.*, iii, 139. The type comes from the Nicholson and Northern Territory. I have received it from Groote Eylandt, Gulf of Carpentaria (A. E. Martin).

Bentham, p. 405, quotes "Dayman's Island, Endeavour Straits. *W. Hill.*" I have seen it from the Endeavour River (W. Persieh, through Mueller). Bentham figures the pod at *Trans. Linn. Soc.*, xxx, t. 68. Cambage, pp. 416, 420, has Gilbert River to Croydon; (?) pp. 428, 432, Normanton to Cloncurry.

The four species which follow, viz., *julifera*, *Solandri*, *leptocarpa* and *polystachya* are often confused in collections, but I will try and make their limitations clearer. The notes which follow from B. Fl., ii, 317, supplemented by the specific descriptions in pages 405-7, are given in brackets.

[Phyllodia narrow-lanceolate. . . . usually with about 3 nerves more prominent than the rest.]

* * * * * *

[Phyllodia glabrous. Pod spirally twisted into numerous coils
Spikes dense, 1-1½in. long]
Sepals spathulate .. .. *julifera*

[Phyllodia glabrous. Spikes interrupted, 2-3 in. long, slender. Calyx truncate].
"the fruit curled flexuous" (F. v. M.) .. *Solandri*

[Phyllodia more falcate than in the preceding species, often broader or longer, with more nerves.
Pod narrow or flat, straight or twisted.

Branches terete or nearly so. Flowers glabrous.
Calyx sinuate toothed (or truncate).
Pod very narrow and straight].
(often curled and flexuous. J. H. M.) ..*leptocarpa*
Calyx sinuate toothed (or truncate)
[Pod broad, very flexuose or twisted, not spiral (netted veined, J. H. M.)
Seeds along the centre]. .. .. .. *polystachya*

The phyllodes of all four species may be very much alike, and it would be well if further enquiries could be locally made in regard to the amount of variation in each species. Subject to reservations, the phyllodes of *A. julifera* are falcate, comparatively narrow and short. Those of *A. Solandri* may be long, narrow, and hardly falcate. Those of *A. leptocarpa* and *A. polystachya* may be large and broad, but I am speaking only very generally.

The sepals of *A. julifera* are spathulate and divided, and are sharply different to those of the other three species.

The spike of *A. julifera* is dense, while that of *A. Solandri* is thin and markedly interrupted ; this seems to me a character. Those of *A. leptocarpa* are moderately dense, but by no means so thin and interrupted as those of *A. Solandri*. The spike of *A. polystachya* is interrupted, but not to the same extent as *A. Solandri* ; their similarity in this respect is, however, sufficiently close to necessitate great care, especially as the calyces of the last three species strongly resemble each other.

Coming to the pods, the figure of that of *A. julifera*, as figured by Bentham in *Trans. Linn. Soc.*, xxx, t. 68, shows a cincinnal or cochliate fruit, but (see Plate ii) the pod may sometimes take on a looser form, and thus come nearer to that of *A. Solandri*. The pod of *A. Solandri* is described by Mueller in *Macleay Mem. Vol.*, p. 225, as "curled-flexuose, compressed, about $\frac{1}{6}$ inch broad." Bentham's description (p. 317) of the pod of *A. leptocarpa* as very narrow and straight, is not always true, but it may be curved and flexuose (as originally observed by Mueller in *Macleay Mem. Vol*), so that in this respect it may approach *A. Solandri*. The pod of *A. polystachya* is different to that of the other three, being comparatively broad and netted-veined.

Here follow some notes on individual species.

39. *julifera* Benth. in *Hook. Lond. Journ. Bot.*, i, 374. Type from Rodd's Bay, Port Curtis. Bentham, B. Fl., ii, 406, also quotes Cumberland Islands, *R. Brown*; Rockingham Bay, *W. Hill*; Edgecombe (Edgecumbe) Bay, *Dallachy.* He figures the pod in *Trans. Linn. Soc.*, iii, t. 68.

Through the kindness of Kew I have a specimen of the type, which is figured at Plate ii. As it has not been figured in the Iconography, a figure of a spike, Edgecumbe Bay, *Dallachy*, has been added.

It has often been confused with *A. Solandri* in collections; see that species for some notes.

40. *Solandri* Benth. in B. Fl., ii, 406. The type is from Bay of Inlets, *Banks and Solander* (Herb. R. Br.), and I have received from the British Museum a fragment of the type with the reference="*Mimosa salicifolia* Sol., Bay of Inlets, Banks and Solander. 1770." It is not figured in *Botany, Cook's Voyage*, nor in Iconography. The pod although described in 1893 by Mueller (see below), has not been previously figured, and I figure it. Note the very great length of the rhachis.

Besides the type, I have it from Port Denison (collector of Mueller, probably Frau Dietrich), *Macleay Mem. Vol.*, p. 225; (Port Denison and Edgecumbe Bay are identical localities), and also from Percy Islands (Henry Tryon through C. T. White). Yeppoon, near Rockhampton (J. L. Boorman), where it is a small tree with stem 6-12 inches in diameter, with hard, flaky bark, timber dark-coloured in centre.

The *A. julifera* (?) or *A. Solandri* (?) of R. H. Cambage at p. 420, near Normanton (No. 4,109), young pods only available, is probably *A. leptocarpa* A. Cunn., but that species is very near *A. Solandri*, as has already been indicated.

Dallachy collected both species at Edgecumbe Bay. The spike of *A. Solandri* is thin and much interrupted, while that of *A. julifera* is not (the structure of the individual flowers is very different). I have already compared the pods of the two species.

There are some notes on *A. julifera* and *A. Solandri* (together with other species) in *Macleay Mem. Vol.*, p. 225.

"*A. julifera*. . . . from which it differs . . . . and *A. leptocarpa*, by smaller spikes and different cleft calyces; but the fruit specimens from Edgecombe Bay, alluded to by Bentham, may not perhaps belong to the same species, as they are nearer to *A. Cunninghamii* also as regards foliage.

"Mr. Bowman gives the height of *A. julifera* as only up to 10 feet at Nercool Creek (near Rockhampton, J.H.M.) and the Upper Flinders River, and says it is early flowering in the season. It is contained in Madame (Frau) Dietrich's collection from Port Denison under 2,812, mixed with *A. Solandri*. That species agrees in venulation of the phyllodes certainly with *A. julifera*, but the phyllodes are narrower and straighter, the spikes longer, with remarkably dissite flowers like *A. aulacocarpa* and *A. cincinnata*; the calyces are short-lobed and glabrous, the fruit (of *A. Solandri*, J.H.M.) curled-flexuous, compressed, about $\frac{1}{6}$ inch broad, the seeds ellipsoid, the funicle forms folds, but reaches the lowest part of the seeds only."

This is the first time the pods and seeds have been described.

41. *leptostachya* Benth. in B. Fl., ii, 406, with a mark of interrogation. He quotes it from Newcastle Range, *Mueller*; Port Denison, *Dallachy* and *Fitzalan*: Broad Sound *Herb. Mueller*.

The pod was unknown to Bentham, but Mueller subsequently figured it in the Iconography.

I have it from Normanton (E. Macdonell, through C. T. White) and Yeppoon, near Rockhampton (J. L. Boorman), wood dark brown, hard and heavy.

Cambage, p. 401, quotes it from Almaden, 10 feet, (No. 3,893), with doubt, but this turns out to be a new species, *A. argentea*.

42. *A. argentea*, n. sp.

Frutex 10′ altus, argyro-pubescens, ramulis angulatis deinde fere teretibus. Phyllodiis lanceolatis vix falcatis, basi apiceque angustatis, obtusis, 5-6.5 cm longis, 1-1.5 cm latis, rectis vel basin versus paullo obliquis, coriaceis, tenuiter striatis, venis numerosis tenuibus parallelibus 2 vel 3 prominentioribus, basi glandula. Spica breviter pedunculata, gracile, circiter 1″ longa, rhache glabra, floribus 5-meris. Calyce poculo simile formato, margine sinuato piloso. Petalis calycem plus duplo superantibus, glabris minus dimidio longitudinis cohaerentibus. Pistillo piloso. Legumine (maturo non viso) recto, lineari, 6 cm longo, 2-3 mm lato. Seminibus elliptico-oblongis, legumine longitudinaliter dispositis, funiculo planato.

A shrub of 10 feet, hoary or silvery white with a very minute pubescence: branchlets slender, angular at the tips, soon becoming nearly terete. Phyllodia lanceolate, hardly falcate, narrowed at each end, but obtuse, 5-6.5 cm. (say 2-2½ inches) long, 1-1.5 cm. (about ½ inch) broad, straight or slightly oblique at the base, coriaceous and finely striate, with numerous fine parallel nerves all equal or 2 or 3 rather more prominent; gland at base.

Spikes mostly in pairs, shortly pedunculate, slender, up to about an inch long, rhachis glabrous, flowers 5-merous. Calyx cup-shaped with a sinuous ragged edge, hairy, but not quite to the edge, less than half the length of the petals. Petals glabrous, united not quite half the way up. Pistil hairy. Pod not seen perfectly ripe, straight, linear, 6 cm. long and 2-3 mm. broad. Seed, not seen ripe, elliptical-oblong, longitudinally arranged in the pod, with a ribbon-like funicle hardly forming an arillus.

Collected at Almaden, North Queensland, 20th August, 1913. (R. H. Cambage, No. 3,893).

Affinities.

1. With *A. leptostachya* Benth. It is sharply separated by the moniliform pod of the latter, and apparently also by the funicle, but I have not seen seed of that species. The phyllodes of *A. leptostachya* are narrower, and the calyx less hairy.

While both species are imperfectly known, they are sufficiently distinct, although closely allied.

2. With *A. glaucescens* Willd. This is a large species confined to New South Wales, so far as we know at present. I have described it in Part 38 of my "*Forest Flora of N.S.W.*" with Plate 145. There is a good deal of similarity between *A. glaucescens* and the new species in regard to the floral structure, but the calyx is comparatively shallower and the petals hairy and not recurved in *A. glaucescens.*

In that species the pods are linear, as in *A. argentea*, but the pods are densely tomentose, while they are glabrous in the new species.

43. *leptocarpa* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 376. The type comes from "Endeavour River and Cape Flinders." Bentham, p. 407, quotes some North Queensland localities.

"*A. leptocarpa* is distinguished from *A. Maidenii* in the phyllodes showing hardly any anastomosing venulation, the interstices between the venules being also wider, in flowers less crowded along the rhachis, in glabrous calyces, in generally 5-parted corollas, and in numerous almost consolidated folds of the funicle, these forming downward, an appendicular mass of a length as great as the seed itself, or even greater, though basal only; I find, however, the fruit-valves to a considerable extent flexuous. The phyllodes are without lustre." (Mueller in *Macleay Memorial Volume*, p. 224).

Fibre is made by the aborigines of the Palmer River from the inner bark (Roth in *North Qld. Ethnography*, Bull. No. 1).

Cambage, p. 437, records it from Hughenden to Prairie. It is a shrub of 10 feet at Normanton. (R. H. Cambage, No. 4,109).

44. *polystachya* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 376. The type comes from "Port Bowen, Port Essington, Haggerstone's Island, East Coast."

Haggerstone's Island is near Cape Grenville, 12° S. Lat. I figure a specimen of the type. The broad, netted-veined pod is an important character in this species.

Bentham, p. 407, gives North Queensland localities.

45. *Hemsleyi* Maiden in *Proc. Roy. Soc. N.S.W.*, li, 87, 1917, with a plate. This is the species formerly recorded for Queensland under the name of *A. delibrata* A. Cunn., see p. 21.

It extends from North Western Australia to Northern Queensland, the Queensland localities recorded being Gregory Downs, Gregory River, near Burketown (Dr. T. L.

Bancroft); Dugald River, Granada (R. H. Cambage, No. 4,165).

I have since found additional North Queensland specimens, which increase its range. The first is

"On the banks of the Etheridge River at Georgetown" (R. H. Cambage, No. 3,898). Provisionally identified as *A. delibrata* A. Cunn. in *Proc. Roy. Soc. N.S.W.*, xlix, 420. Scantily in flower; in young fruit.

The second is a specimen received from the Melbourne Herbarium (the late J. G. Luehmann, then Government Botanist), collected by the late J. Dallachy at the Herbert River, 1st August, 1863, and noted by him, "grows 12 feet high, flowers yellow and sweet scented." It is evidently a riparian species.

Judging from the specimens, it is a slender, graceful plant; the two specimens just referred to have the phyllodes somewhat shorter and narrower than those of the type. They are 6 to 8 cm. (say 2½ to 3 inches) long, 4 to 5 mm. broad, thin and somewhat resinous, with a few distant, scattered hairs.

46. *plectocarpa* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 376. The co-types come from Cambridge Gulf (North West Australia), and Sims' Island, Northern Territory. Bailey, p. 511, follows Bentham in "Islands of the Gulf of Carpentaria" (*R. Brown*), but he is wrong in interpreting this as Queensland. The Queensland plants referred to this species which have been seen by me are the *A. plectocarpa* of the *Iconography*, which is *A. Hammondi* Maiden. *A. plectocarpa* is critically examined by me in *Proc. Roy. Soc. N.S.W.*, li, 90, (1917), with a plate.

Hitherto known only from North West Australia and the Northern Territory. I have received a specimen in flower belonging to this species from Dr. Eric Mjöberg, Coleman River, Cape York Peninsula, and thus we have an additional species for the Queensland flora.

47. *Armitii* (F.v.M.) Maiden (Syn. *A. delibrata* F.v.M., "Iconography of Acacias," non A. Cunn.).

Einasleigh River (Armit). See *Proc. Roy. Soc. N.S.W.*, li, 84 (1917).

48. *Hammondi* Maiden in *Proc. Roy. Soc. N.S.W.* li, 95 (1917) with a plate, = *A. plectocarpa* F.v.M. of *Iconography,* non A. Cunn.

Type from Northern Territory. Also found in Queensland. Etheridge River (Armit); Normanton, Cloncurry Road, a shrub of 8-10 feet (R. H. Cambage, No. 3,935). Cambage, p. 401, has Almaden; p. 416, Forsayth to Normanton; p. 428, Normanton to Cloncurry (all as *A. plectocarpa*).

Also Sweers Island (J. F. Bailey), as *A. lysiphlœa.*

49. *difficilis* Maiden in Ewart's *Flora of the Northern Territory,* with Plate.

In my contribution it is stated the following specimens from North Queensland have narrower phyllodes:

(*a*) Little River, 30 miles east of Croydon, North Queensland, 28th August, 1913. Flowers and fruits (R. H. Cambage, No. 3,918).

(*b*) Also from a correspondent of Mr. Cambage at Croydon. Phyllodes comparatively narrow. In flower and mixed with *A. torulosa* Benth., August, 1914 (R. H. Cambage, No. 4,107, in part).

(*c*) About 15 feet high. On granite at 1,600 feet, Almaden, North Queensland, 18th and 20th August, 1913. Fruit only (R. H. Cambage, Nos. 3,855 and 3,891).

50. *aulacocarpa* A. Cunn., Benth. in *Hook. Lond Journ. Bot.*, i, 378. The type of *A. aulacocarpa* comes from Port Bowen. (Syn. *A. crassicarpa* A. Cunn., *op. cit.*, p. 379). Type of *A. crassicarpa* from "North Coast" and Lizard Island. See Bentham, *Trans. Linn. Soc.*, xxx, tab. 68, for a figure of a fruit of *A. crassicarpa.*

Mueller (*Fragm.* xi, 69) gives a number of localities for *A. crassicarpa* (incorrectly spelt by him *crassocarpa*). He goes on to say that the distinctions between it and *A. aulacocarpa* do not appear to be clear; the species ought to be united, and the name *A. crassicarpa* should be preferred to the other unfortunate one of *A. aulacocarpa.* The name does not seem to be unfortunate (*infausto*), *aulax, aulacis*, in reference to the grooving of the sutures of the pods. In his *Second Census*, p. 80, Mueller, however, adopts *aulacocarpa*, and omits *crassicarpa*, which is technically correct, because, although they were described at the same time, *aulacocarpa* was described in an earlier page of the work to *crassicarpa*.

I have independently examined the evidence, and agree that *A. crassicarpa* A. Cunn. is a synonym.

As regards *A. aulacocarpa*, Mueller in *Macleay Memorial Vol.*, p. 224, suggests that a specimen from Fitzroy Island attributed to that species may = *A. holcocarpa*.

For an account of *A. aulacocarpa* see my *Forest Flora of N.S.W.*, Vol. 3, p. 123, with plate 103.

Under *A. crassicarpa*, Roth (*Bull. N. Qld. Ethnography*, No. 3) says the roots are roasted, hinterland and coast of Princess Charlotte Bay, Butcher's Hill, Cooktown. It is not figured in the *Iconography*, but *A. aulacocarpa* is.

Herewith is a figure of the type of *A. crassicarpa* (Plate vii). The pod " under 2 inches long and 7-8 lines broad " is an accident.

51. *calyculata* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 379. The type of *A. calyculata* comes from Fitzroy Island. (Syn. *A. holcocarpa* Benth., B. Fl., ii. 408). Type of *A. holcocarpa* from " Port Bowen and Thirsty Sound, *R. Brown*."

After careful examination of available material, I am of opinion that *A. holcocarpa* should be suppressed, confirming a surmise of Mueller in 1893, which seems to have been forgotten. The description of *A. holcocarpa* would apply to *A. calyculata* with the exception of the reference to the branches as terete ; they are, however, almost flat in the young stage in our specimens, as in *A. calyculata*.

The original description of *A. calyculata* states that it is allied to *A. aulacocarpa*, but Bentham (who edited the description) had not then seen the pod. In B. Fl., ii, 410, he contrasts the two species, for he had in the meantime got authentically matched pods. The type of *A. calyculata* came from Fitzroy Island. It was collected by Allan

Cunningham (in Capt. P. P. King's Voyage) in June, 1819, and its number is 323.

It is figured (without pod) in "Botany of Cook's Voyage" (ed. Britten), t. 88. A portion of the type is figured at Plate vii. It is not figured in the *Iconography*.

Coming to *A. holcocarpa*, the pods and seeds described in B. Fl. ii, 408, are those later on figured by Mueller in the *Iconography*. The pods that I have seen are loose. An aboriginal equivalent for *A. holcocarpa* is given in *Bull. N. Qld. Ethnography*, No. 2 (Roth).

Following are Mueller's observations (abbreviated) on an imperfectly known species :—

"*A. holcocarpa*, which has the venulation of *A. glaucescens*, is easily distinguished from *A. Maidenii* in various respects. . . . Mr. Dallachy noted this species (*holcocarpa*) as dwarf, the fresh flowers as fragrant, and—strange to say—as white; so they must at all events be very pale; but Solander likewise indicated the flowers of *A. calyculata* as white, and thus the question arises whether perhaps the two species are identical." (Mueller, in *Macleay Memorial Volume*, Sydney, 1893, p. 224).

"Specimens, but in flower only, from Fitzroy Island (Walter), seem referable to *A. holcocarpa*, but they accord so far also fully with the description of Cunningham's plant from there; the fruit, sent with his flowering specimens, may really belong to the rather widely distributed *A. aulacocarpa*. Visitors to Fitzroy Island could easily solve this enigma. *A. holcocarpa* has become further known from Cape Sidmouth (C. Moon), Trinity Bay (W. Hill), Rockingham Bay and Hinchinbrook Island, where it is common (J. Dallachy). It seems to be essentially a plant of coastal regions." (Mueller, *loc. cit.*).

If collectors have solved the enigma to which Mueller refers, I have not heard of it.

Cambage, p. 401, recorded the species from Almaden, and p. 416, Forsayth to Normanton.

52. *auriculæformis* A. Cunn., Benth, in *Hook. Lond. Journ. Bot.*, i, 377. The type comes from "Goulburn and Sims' Islands, North Coast," which are Northern Territory, It is not uncommon in the Northern Territory.

Bentham (B. Fl., ii, 411, the spelling is *auriculiformis*) quotes Albany Island (Hill and Mueller). He figures the pod at *Trans. Linn. Soc.*, xxx, t. 68.

Cambage, p. 396, records it from Kuranda to Almaden.

JULIFLORÆ (Dimidiatæ).

53. *holosericea* A. Cunn. in G. Don, *Gen. Syst.*, ii, 407. "Native of New Holland within the tropic."

It is figured at t. 89 of the plants of Cook's Voyage (British Museum, Britten). Bentham, p. 412, quotes North West Australia, Northern Territory, and North Queensland localities. He figures the pod at *Trans. Linn. Soc.*, xxx, t. 68. Roth, *N. Qld. Ethnography*, Bull. No. 3, says that the "fruit" is eaten by the natives of Cooktown and Cape Bedford.

I have it from Stannary Hills (Dr. T. L. Bancroft and R. G. Shearer). Cambage, pp. 401, 404, Almaden; p. 412, Almaden to Forsayth; p. 416, Forsayth to Normanton. I have it as far south as Rockhampton (A. Dietrich and R. H. Cambage).

A strictly glabrous form in fruit only, Gilbert River (E. W. Bick), communicated by Mr. C. T. White; may be called var. *glabrata* var. nov.

54. *Mangium* Willd. *Sp. Pl.*, iv, 1,053.

Quoted in *Fragm.*, xi, 35, 36. He suggests transit to a glabrous form of *A. holosericea*. He quotes his *Papuan Plants*, i, 103. Bailey records it at p. 513, without the references.

55. *cincinnata* F.v.M. in *Fragm.*, xi, 35. The type comes from Rockingham Bay and Gould Island. There is an important note on this species in *Macleay Memorial Vol.*, p. 225.

Cambage, p. 396, quotes Kuranda to Almaden. It comes as far south as Bribie Island (Dr. J. Shirley, C. T. White).

56. *humifusa* A. Cunn., Benth. in *Hook. Lond. Journ. Bot.*, i, 382. The type comes from "North Coast," *Bauer*; Cleveland Bay, *Cunningham*.

Bentham, p. 412, quotes Northern Territory and North Queensland localities. I have it from Stannary Hills (Dr. T. L. Bancroft).

BIPINNATÆ (Gummiferæ).

57. *Farnesiana* Willd. *Sp. Pl.*, iv, 1,083. A well known species, common in tropical and sub-tropical

Australia and in the tropics of the Old and New World (Benth.). It is an anomalous species.

Mueller, p. 147, gives "Intratropical Eastern Australia." Bentham, p. 419, gives a Northern Queensland locality (Port Denison). E. Palmer (*Proc. Roy. Soc. N.S.W.*, xvii, 94, 1883, gives the native name on Cloncurry, and says it occurs on all the Flinders plains. Cambage, pp. 428, 433, Normanton to Cloncurry; p. 436, Cloncurry to Hughenden; p. 437, Hughenden to Prairie; p. 438, Hughenden to Winton; p. 439, Winton to Longreach.

58. *Bidwilli* Benth. in *Linnæa*, xxvi, 629. I have a note on this species in the Northern Territory in a paper (see Bibliography, p. 21).

It extends in Queensland as far south as Eidsvold (Dr. T. L. Bancroft).

Bentham, p. 420, gives some Queensland localities. E. Palmer (*Proc. Roy. Soc. N.S.W.*, xvii, 93, 1883) gives the native name on the Cloncurry, says that it grows on the plains on the Flinders and Mitchell, and that "there are two varieties very much alike." Cambage, pp. 401, 404, has it from Almaden, and, p. 439, Winton to Longreach, doubtful.

59. *Sutherlandi* F.v.M. in *Fragm.*, vi, 22. The type comes from the Flinders River.

Bailey, p. 517, quotes southern slope of Newcastle Range, between Georgetown and Junction Creek, *R. C. Burton*. Cambage, p. 412, has Almaden to Forsayth; pp. 428, 433, Normanton to Cloncurry, (?) p. 437, Hughenden to Prairie. I have also seen it from Bowen Downs (correspondent of Mueller), and vicinity of Nicholson River, (?) in Queensland territory. (Lieut. Dittrich, through Mueller); also Woolgar (E. W. Bick).

60. *pallida* F.v.M. in *Journ. Linn. Soc.*, iii, 147 (partly). Recorded originally by Mueller from the Northern Territory. Bentham modified the description in B. Fl., ii, 421. E. Palmer (*Proc. Roy. Soc. N.S.W.*, xvii, 94, 1883) recorded it from the Cloncurry River. Not in Bailey. I have not seen a specimen from Queensland.

Tentative list of tropical Queensland species.

argentea
Armitii
aulacocarpa
auriculæformis
Bancrofti
Bidwilli
brevifolia
calyculata
Cambagei
Chisholmi
cincinnata
complanata
conferta
coriacea
curvinervia
cyperophylla
decora
Dietrichiana
difficilis
doratoxylon
drepanocarpa
excelsa
Farnesiana
fasciculifera
flavescens
galioides
gonoclada
Hammondi
harpophylla
hemignosta
Hemsleyi
hippuroides
holosericea
homalophylla (?)
homoclada
humifusa
julifera
leptocarpa
leptostachya
lysiphlœa
macradenia
Mangium
oraria
Oswaldi
pallida
phlebocarpa
pityoides
plectocarpa
polystachya
purpureapetala
Rothii
salicina
sentis
sericata
Simsii
Solandri
stenophylla
Sutherlandi
torulosa
umbellata
Whitei
Wickhami

making 62 species at present.

Species proved, for the first time, to belong to Queensland.

phlebocarpa
plectocarpa
Wickhami

New Species.

argentea
Bancrofti
curvinervia
holosericea var. *glabrata* (new variety)
Whitei

Species proposed to be removed from the flora of Queensland, unless satisfactory evidence is forthcoming.

Bynoeana
conspersa
delibrata
dimidiata
dineura
gonocarpa
impressa
juncifolia
latifolia
linarioides
spondylophylla
stipuligera
subternata
translucens
trineura
xylocarpa

Tropical Queensland Species, systematically arranged.

PUNGENTES (Plurinerves)—
phlebocarpa

BRUNIOIDEÆ—
galioides
hippuroides
conferta

UNINERVES (Brevifoliæ)—
purpureapetala

UNINERVES (Angustifoliæ)—
sentis
fasciculifera

UNINERVES (Racemosæ)—
macradenia
Bancrofti
salicina
Dietrichiana
decora

PLURINERVES (Oligoneuræ)—
Simsii
PLURINERVES (Microneura)—
homalophylla
Cambagei
Oswaldi
coriacea
stenophylla
PLURINERVES (Nervosæ)—
hemignosta
harpophylla
excelsa
complanata
homoclada
PLURINERVES (Dimidiatæ)—
Rothii
sericata
flavescens
oraria
JULIFLORÆ (Rigidulæ)—
Wickhami
lysiphlœa
Chisholmi
umbellata
brevifolia
curvinervia
gonoclada
JULIFLORÆ (Tetrameræ)
Whitei
JULIFLORÆ (Stenophyllæ)—
cyperophylla
pityoides
drepanocarpa
JULIFLORÆ (Falcatæ)—
doratoxylon
torulosa
julifera
Solandri
leptostachya
argentea
leptocarpa
polystachya
Hemsleyi
plectocarpa
Armitii
Hammondi
aulacocarpa
calyculata
auriculæformis
JULIFLORÆ (Dimidiatæ)—
holosericea
Mangium
cincinnata
humifusa
BIPINNATÆ (Gummiferæ)—
Farnesiana
Bidwilli
Sutherlandi
pallida

Illustrations.—The drawings I submit include a number of old types, never before figured, which I have received through the kindness of Kew (Sir David Prain, F.R.S.), and British Museum, Natural History (Dr. A. B. Rendle, F.R.S.).

An important reason why figures of some of our types should be published is because some are so fragmentary, and have been so frequently sub-divided, and the history has, in some cases, become so obscure, that it is desirable to fix our facts in regard to them before they disappear altogether, as some species appear to have done already.

I am indebted to Mr. W. F. Blakely and Miss Flockton, National Herbarium, Sydney, for much valuable assistance, and to Mr. C. T. White for a number of Queensland specimens, and some references.

PLATE 1.

Acacia brevifolia Benth.

1. Twig, showing spike.
2. 3. Individual flower (two views).
4. Pistil.

[All from the type, "Desert of the Suttor, Queensland, Mueller.]

Acacia curvinervia, n. sp.

5. Twig, showing spike.
6. Upper portion of phyllode, showing deciduous tip.
7. Flower and floral bract.
8. Pistil.

[All from the type, Beta, Queensland, J. L. Boorman].

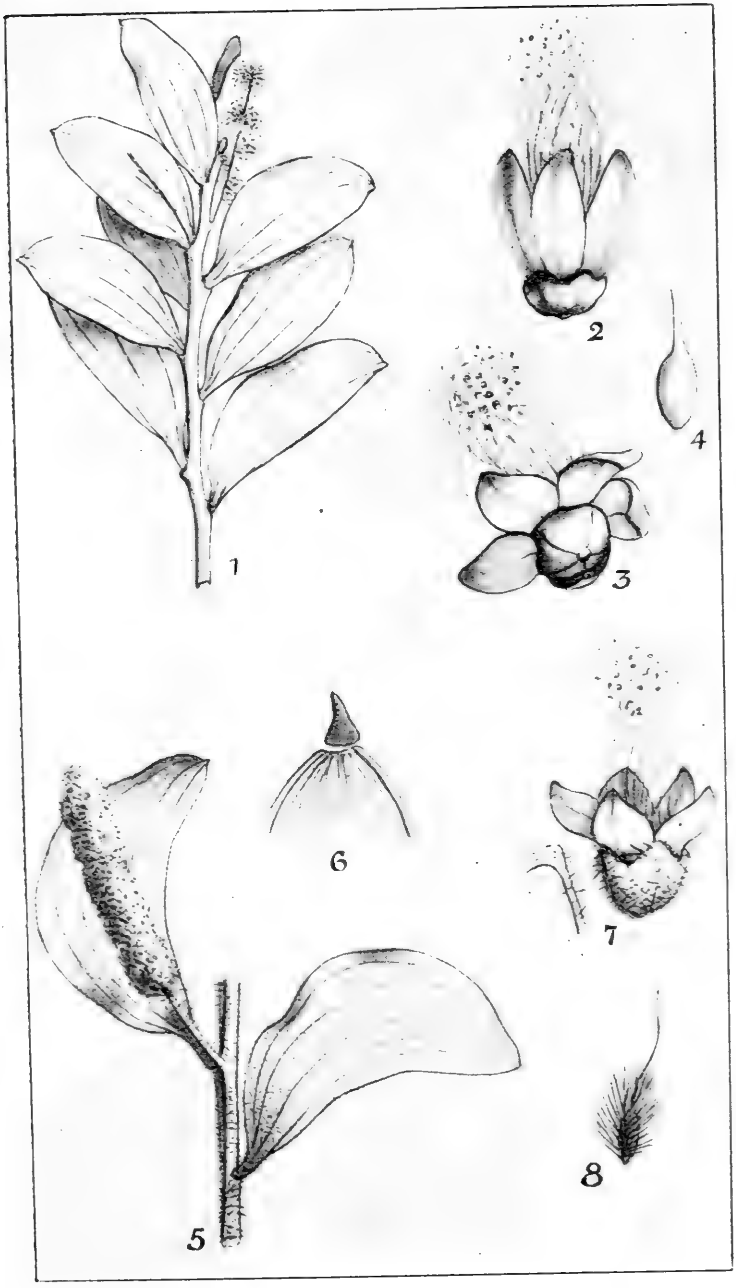
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PLATE II.

Acacia Whitei, n. sp.

1. Phyllode.
2. Pair of spikes.
3. Flower and floral bract.
4. Flower showing pistil.
5. Pistil.
6. Pods.
7. Seed, with funicle and arillus (immature).

[All from the type, Stannary Hills, North Queensland, Dr. T. L. Bancroft].

Acacia julifera Benth.

8a. Phyllodes with immature spikes.
8b. Spike, a little more advanced.
9. Flower and floral bract.

[All from the type, "Rodd's Bay, N.E. Australia," A. Cunningham, No. 325, May, 1819].

10. Flower and floral bract.
11. Pistil.
12. 13. Pods.
14. Seed with expanded funicle.
15. Seed.

[All from Edgecumbe Bay, J. Dallachy, a specimen quoted in B. Fl. ii, 406].

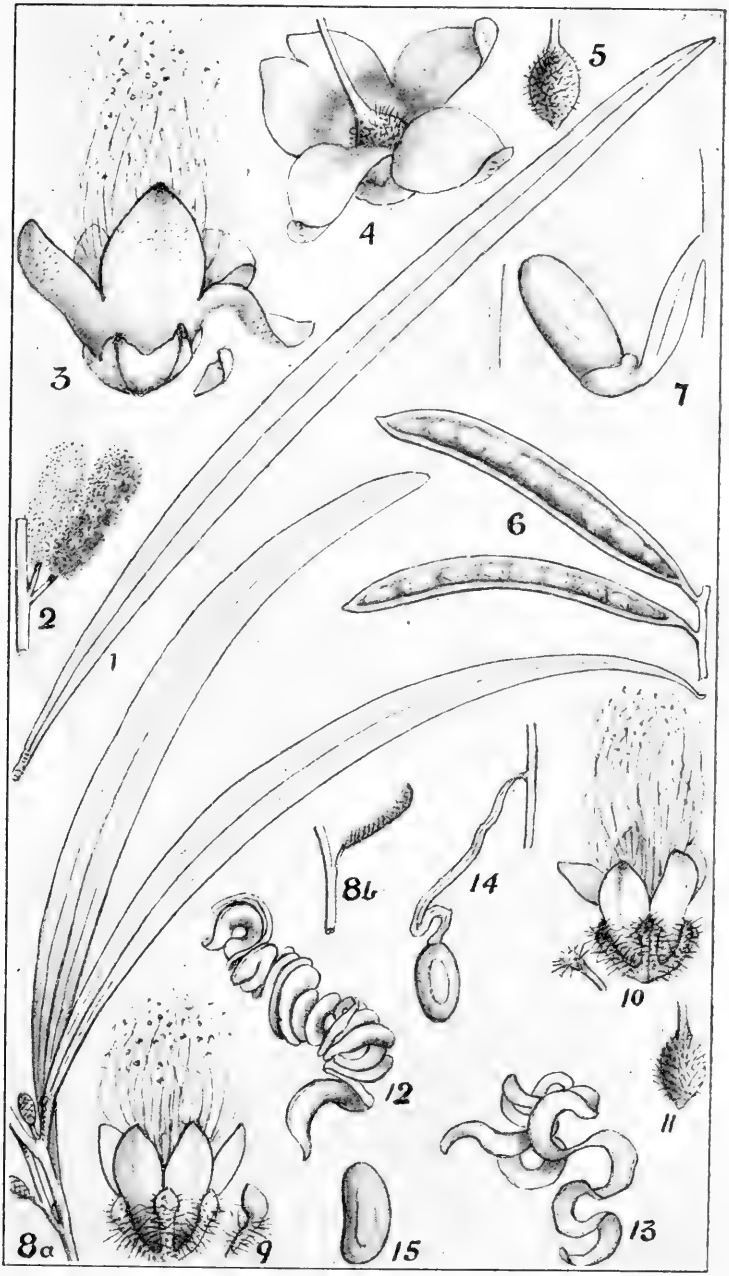
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PLATE III.

Acacia Solandri Benth.

1. Phyllode.
3. Flower.
4. Pistil.

[All from the type, Bay of Inlets (Banks and Solander)].

2. Interrupted spike.
5. Phyllode.
6. 7. 8. Flowers.
9. Pistil.
10. Seed with expanded funicle.
11. Fruit on a very long rhachis.

[All from Port Denison].

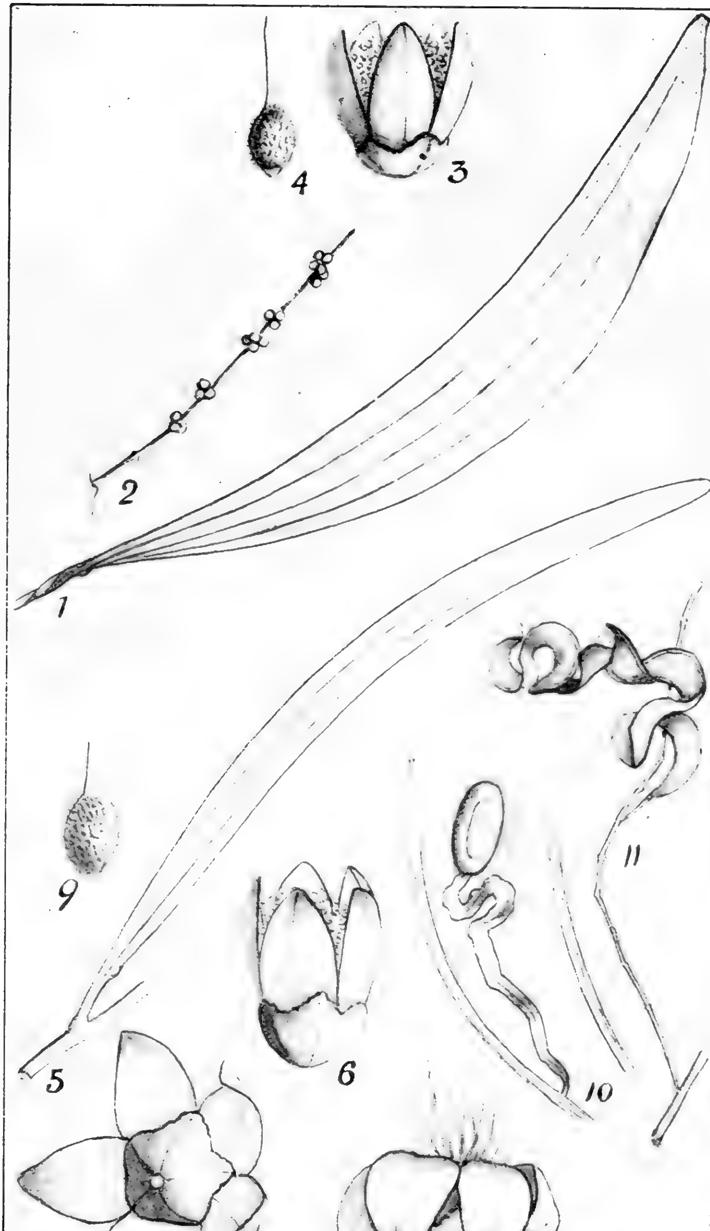
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PLATE IV.

Acacia leptostachya Benth.

1. Phyllode.
2. 3. Flowers.
4. Calyx.
5. Pistil.
6. Portion of pod.

[All from co-type, Port Denison, Fitzalan].

Acacia argentea, n. sp.

8a. 8b. Phyllodes.
9. Spike.
10. Flower.
11. Calyx.
12. Pistil.
13. Pods.
14. Seed and funicle.

[All from type, Almaden, R. H. Cambage, No. 3893].

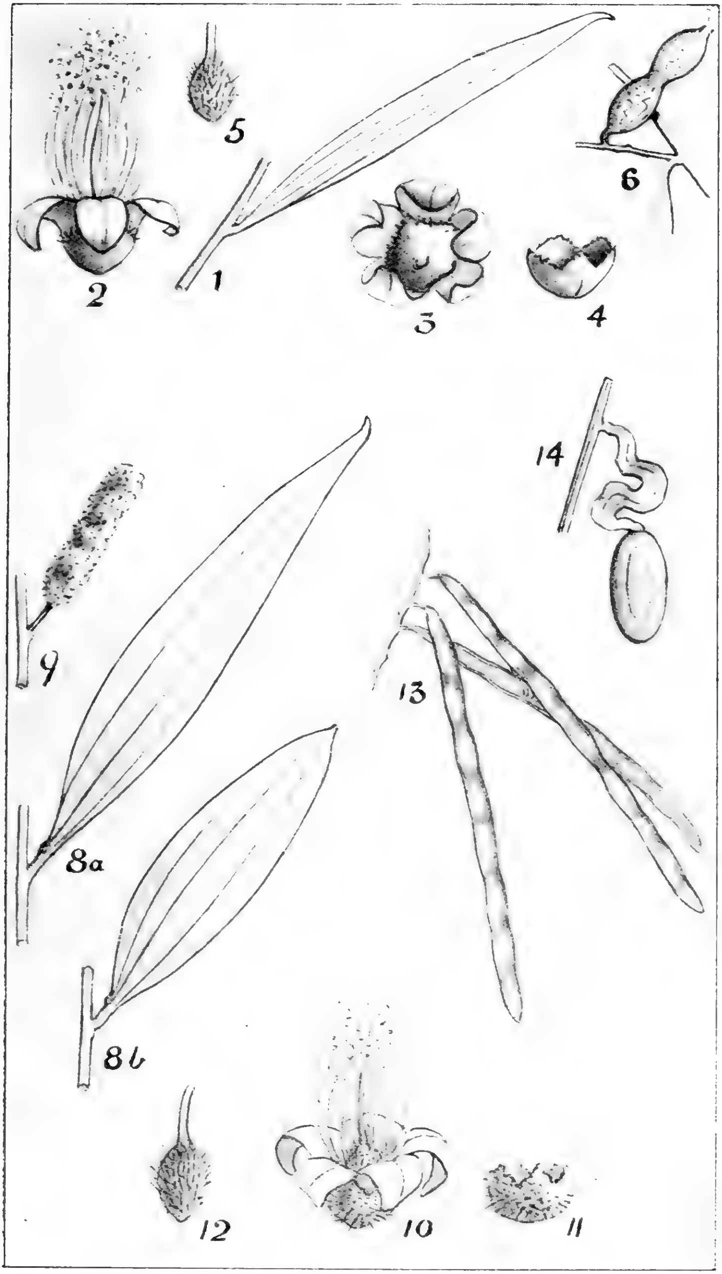
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PLATE V.

Acacia leptocarpa A. Cunn.

1. Phyllode.
2. Flower.
3. Calyx.
4. Pistil.

[All from type, Endeavour River, Queensland, Allan Cunningham, No. 319, July, 1819].

5. Fruit.
6. Seed with funicle and arillus.

[Both from co-type, Cape Flinders, Allan Cunningham, No. 118 1820].

7. Immature fruits, on very long rhachis.
8. 9. Seeds with funicles and arilli, both from the same specimen.

[From Endeavour River, W. Persieh. N.B. This is the type locality].


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PLATE VI.

Acacia polystachya A. Cunn.

1. Phyllode.
2. Interrupted spike (? broken at tip).
3. 4. 5. Flowers.
6. Pistil.

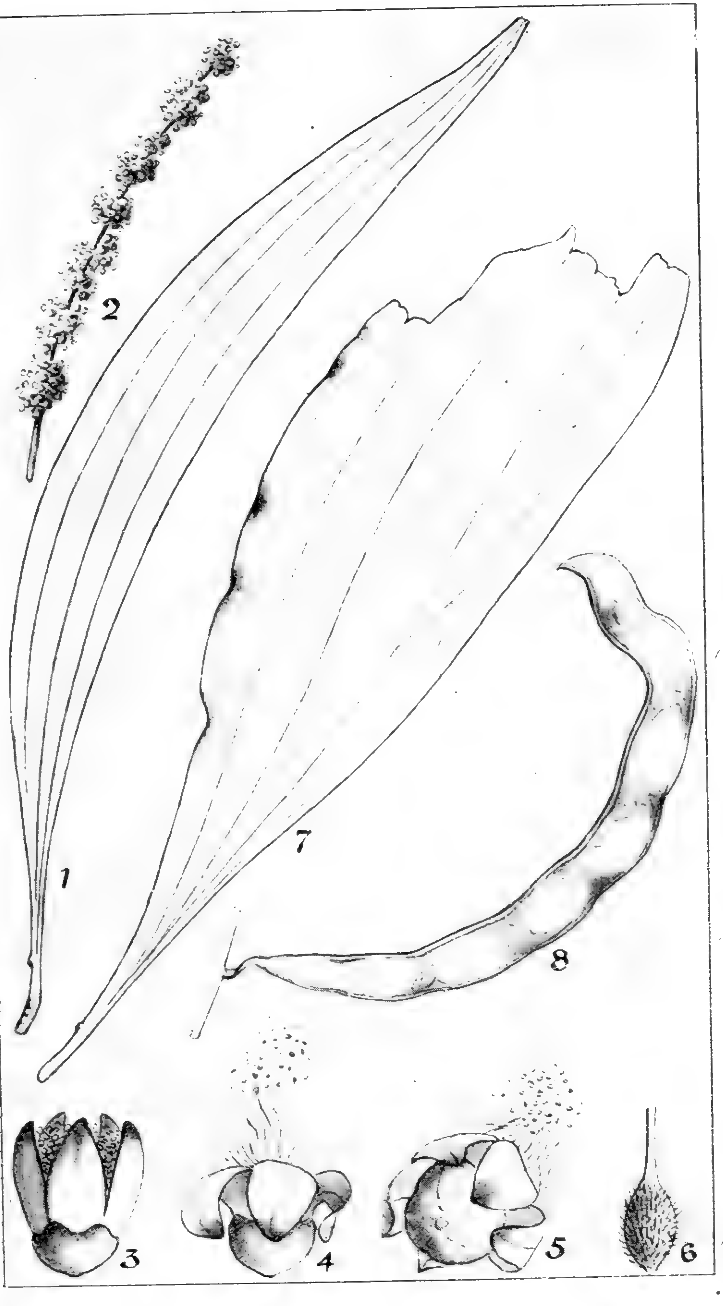
[All from co-type, Port Essington. Northern Territory, Armstrong].

7. Portion of phyllode.

[Co-type, Port Bowen, Queensland, Allan Cunningham, No. 123, 1820. Flowers identical with 3-5].

8. Pod.

[Communicated by F. M. Bailey, 1904, Locality unknown].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Between September 1909 and February 1910, an almost daily examination of rats and mice for the presence of entozoa was made and careful records kept, Mr. W. Thompson greatly assisting me in this work. Besides, there were plenty of other casual searches made prior to, and after, the period mentioned. During the stated time 28 out of 119 specimens of the house rat, *Epimys rattus*, were found to contain some intestinal or stomach helminths (23.5%); 21 out of 100 red rats, *Ep. alexandrinus* (21%); 51 out of 121 brown rats, *Ep. norvegicus* (42.1%); and 34 out of 73 mice, *Mus musculus* (46.6%).

Tænia tæniæformis Bl.

The cystic stage of this parasite, generally known in its larval forms as *Cysticercus fasciolaris* R. and in its adult stage as *Tænia crassicollis*, occurs in Australian rats and mice. It was found rarely in *Epimys alexandrinus* in Sydney, (only 3% infected), but more commonly in *E. norvegicus* and *Mus musculus*, though even in these the percentage infection was not high. Leidy (1879) examined 500 brown rats (*E. norvegicus*) in Philadelphia and found only six to be free from this cyst.

The greatest number that I have found in one animal was 189, most of them small, from a brown rat (February, 1909), very little liver substance being visible. In the liver of a mouse, no less than six full-grown cysts and a small one were detected (Feb. 1909), some of them being pendulous and some of them more or less imbedded, very little liver tissue being seen.

The largest measured by me was found on opening the membrane of the cyst to be nine and a-half inches long with a tiny bladder. It was removed (Feb. 1909) from a pendulous cyst from *Ep. norvegicus*.

McCoy (1910*b*, pp. 65, 66) in writing on the tumours of rats, mentioned the frequency of sarcoma in the liver, the majority of such sarcomata being associated with this *Cysticercus*. Blanchard (1909, p. 158) also referred to the association, mentioning that Regaud had found the larva in the middle of a peritoneal sarcoma of a rat, and disagreeing with Borrel's opinion that the *Cysticercus* was the cause. He believed that the parasite had penetrated a preformed sarcoma. I think that Blanchard was correct, as liver sarcoma appears to be rare in Sydney and as far as I know has not been found there associated with *C. fasciolaris*.

Hymenolepis diminuta Rud.

The large unarmed tapeworm is now recorded from the mouse in Brisbane. I have also identified as belonging to this species a few cestodes collected by Dr. J. B. Cleland from two rats *Epimys terræ-reginæ*, captured on an oversea vessel in Sydney. The specimens have a much greater breadth than that generally met with but their anatomy resembles that of *H. diminuta*. This constitutes the first record of any entozoon from this rat. I also found the cestode in a white mouse in Sydney in 1909.

Reference has already been made (J. 1909*a*, p. 219) to the relatively great length to which this cestode may occasionally attain, viz., 45 inches (and one-eighth of an inch broad), the usual length being from 8 to 24 inches.

Records of infection obtained in Sydney from August 1909 to February 1910, revealed the presence of this tapeworm in eleven out of 119 *Ep. rattus*; seventeen out of 121 *Ep. norvegicus*; ten out of 100 *Ep. alexandrinus*; and one out of 73 mice, the percentage of infected animals being 9.2, 14, 10 and 1.3 respectively. The greatest numbers counted from one host were 16 and 14 from *Ep. norvegicus*, the usual numbers being from one to three.

Hymenolepis nana Sieb. (*H. murina* Duj.).

This small cestode is now reported for the first time from Brisbane, having been found in *Epimys norvegicus*, *E. rattus* (*alexandrinus*) and *Mus musculus*.

During the examination of Sydney rats (August 1909—Feb. 1910) I found it in nine out of 119 *Ep. rattus*; seven out of 100 *Ep. alexandrinus*; seventeen out of 121 *Ep. norvegicus*; and two out of 73 mice,—the percentage infection thus being approximately 7.5, 7, 14, and 2.7. The greatest numbers counted from any one host were 40, 15 and 10 from *E. rattus*, 16 and 13 from *E. norvegicus*, and 11 from *Mus musculus*. It occurred commonly in company with *Hym. diminuta* and other entozoa.

Davainea sp.

I have received recently a specimen of a *Davainea* collected in Brisbane by Miss B. B. Taylor from *Epimys norvegicus*, this constituting the first record of the occurrence of the genus in any Murid in Australia.

Heligmosomum braziliense Travassos.

(Figures 1-9.)

In 1909 I drew attention to the occasional presence of tiny reddish coiled nematodes in the upper part of the duodenum of the brown rat (*Epimys norvegicus*) in Sydney, mentioning that they produced anæmia if abundant (J. 1909*a*, p. 590; 1910*b*, p. 81). The parasite was identified rather casually as *Oesophagostomum* owing to the presence of cephalic expansions. These, however, are purely cuticular, the mouth region being of the Trichostrongyle type. In 1914 Travassos gave a short unfigured account (1914, p. 6) of a new parasite *Heligmosomum braziliense* from the small intestine of *Mus decumanus* from Rio de Janeiro, Brazil. His account has been translated by Hall (1916, p. 154). There is no doubt as to the identity of the worms from Sydney and Rio de Janeiro. I have recently received a number of specimens of the same species collected in Brisbane (1918) by Miss B. B. Taylor—also from the brown rat. The known distribution is thus Rio de Janeiro, Sydney and Brisbane.

H. braziliense appears to be rather uncommon in the two Australian capitals. It was met with on only a few occasions in Sydney though some hundreds of brown rats were dissected.

The parasite, when present, generally occurs in enormous numbers in the blood-stained duodenal contents of the host. It sets up serious constitutional disturbance, partly through the loss of blood caused and partly no doubt on account of some toxin actually added to the blood. The superficial vessels of some of the viscera and especially those of the peritoneum become inflamed and the general appearance of the body cavity is very much like that caused by plague (see plate—McCoy 1910*a*).

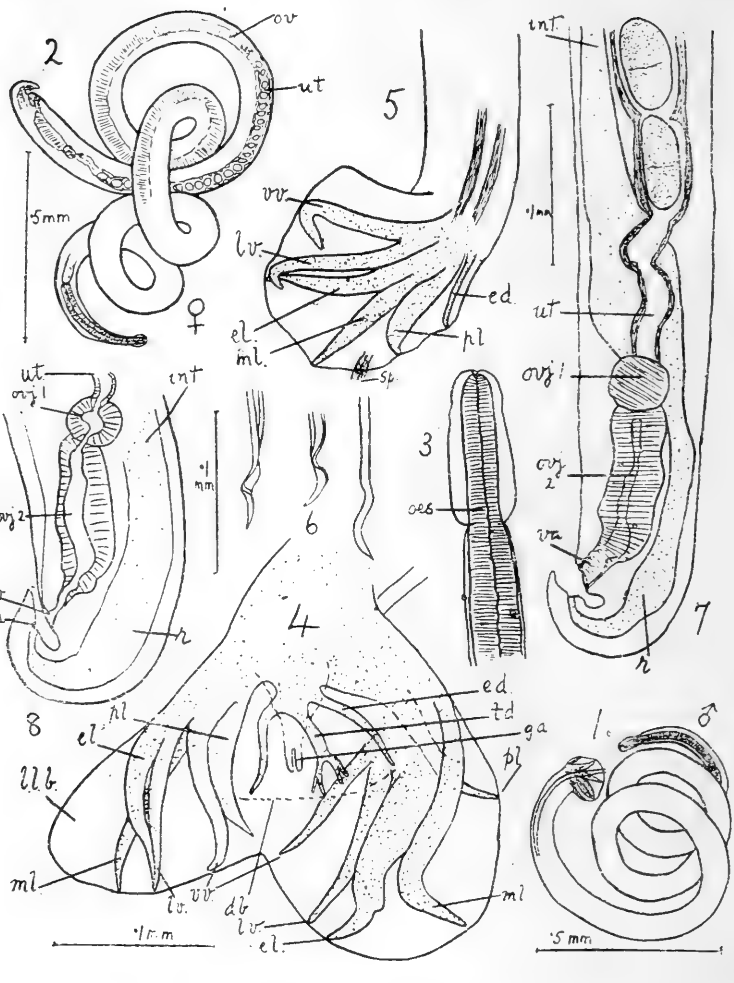
The parasite is normally coiled in a rather close spiral, the worms not straightening even when killed with hot alcohol though they may uncoil slightly. Some specimens killed by using formalin became uncoiled though still bent.

The male measures from 2.6 to 3.3mm., the female 3.5 to 4.0 mm. in length, the latter thus being only slightly longer than the former. The body in both sexes has an almost uniform thickness, .07 to .08mm., which is rather less than that given by Travassos. The width is maintained from the posterior end almost to the head, the breadth decreasing gradually at the anterior end. The cuticle is thick and ornamented by very numerous, closely set, transverse striations with a few longitudinal markings. The lateral lines are prominent. The cuticular expansions at the anterior extremity vary somewhat in length (.05 to .10 mm—generally about .08mm.) and project laterally from 3 to 6 micra, extending slightly in front of the tiny mouth. The oesophagus which is not sinuous in my specimens, reaches a length of .27 to .35mm., the anterior end being occasionally slightly more swollen than the succeeding portion.

The male bursa (fig. 4 and 5) is prominent, its edges being usually folded inwards somewhat like that of *Nematodirus neotoma* as figured by Hall (1916, fig. 177). The two lateral lobes are extensive, while the dorsal is short. The dorsal ray system* consists of a small externo-dorsal on each side and of a rather thicker median portion which bifurcates, each terminal dorsal being again divided so that the central ray ends in four little rays. The lateral ray system comprises three well-defined rays, the postero-lateral being the smallest, while the medio-lateral and externo-lateral are of about the same size. The last named is rather closely associated with the latero-ventral ray (of the ventral system) from which the ventro-ventral ray is widely separated.

The general arrangement is shown in figures 4 and 5. The rays are more opaque than the bursal membrane though the dorsal rays are almost transparent. The spicules are very long and slender, each measuring from .40 to .53mm., averaging about .50mm. One has its sides bent so as to form a groove for the reception of the other spicule. The

*The nomenclature of the rays is that given by Ransom (1911, p. 21) and by Hall (1916).



Heligmosomum braziliense.

Fig. 1. male; 2. female; 3. head of male; 4. bursa (ventral view); 5. bursa (side view); 6. spicules (terminal portion); 7. posterior end of female; 8. ditto. Figs. 1 and 2 are drawn to one scale; figs. 3 to 8 are drawn to one scale.

References to lettering:—*a* anus; *db* edge of the dorsal lobe of the bursa; *ed* externo-dorsal ray; *el* externo-lateral ray; *ga* genito-anal aperture; *int* intestine; *llb* lateral lobe of bursa; *lv* latero-ventral ray; *ml* medio-lateral ray; *œs* œsophagus; *ov* ovary; *ovj* 1, *ovj* 2 anterior and posterior parts of the ovijector; *pl* postero-lateral ray; *r* rectum; *sp* spicules; *td* terminal dorsal ray; *ut* uterus; *v* vulva; *va* vagina; *vv* ventro-ventral ray.

end is sharply pointed and just near the tip there is a bend and a partial twist. Thus the termination is somewhat sickle-shaped.

The posterior end of the female may seem, at first sight, to be bluntly rounded but this appearance is due to the bending round of the tiny tail and anal region so as to lie more or less closely against the adjacent part of the body, covering the vulva. The anus lies quite close to the tip of the tail (.01-.02mm.), the vulva being only .05 to .07mm. from the extremity of the worm. They are much closer than in Travassos' specimens. The single ovary is very long (about 1.5mm.) and the uterus about a millimetre in length. The latter contains eggs which reach the two-celled stage before extrusion. The lower end of the uterus is narrowed and thicker-walled, just before it enters the muscular ovijector. The anterior part of the latter structure is thick-walled and more or less spherical with an outside diameter of .035mm. This is followed by a wide thick-walled portion, .09-.10mm. long and .035-.04mm. wide. The main muscles of the latter are transversely arranged, while in the spherical part they are more obliquely placed. The terminal portion of the vagina is thin-walled. Eggs measure 50 to 65 micra in length by 30 micra in breadth.

H. braziliense exhibits most of the characters possessed by members of the genus *Viannaia* as given by Travassos, but differs in possessing distinct transverse striation and long spicules.

Protospirura muris Gm. (syn. *Spiroptera obtusa* R.).

The following results were obtained in Sydney from examinations between August 1909 and February 1910. Stomach worms were found on two occasions in *Ep. rattus* (119 examined): three times in *Ep. norvegicus* (121 examined); once in *Ep. alexandrinus* (100 examined); and seven times in the mouse (73 examined). The percentage was thus approximately 1.6, 2.4, 1 and 9.6. The greatest number obtained during the period was 16 (from a mouse). Fifteen were found on another occasion (in a mouse also) and fourteen in *Ep. rattus*, but usually only a few were present.

Hall (1916, p. 206) has referred to their abundance in a mouse in U.S.A. One can readily understand that when such a small animal as a mouse, carries fifteen or sixteen of these relatively large worms (measuring between an inch and an inch and a-half) in its stomach, its movements are likely to be impeded. I have frequently seen the stomach in a balloon-like condition owing to extreme distension, the nematodes being easily visible through the thin walls.

Heterakis spumosa Schn.

Though Hall (1916, p. 47) does not quote this nematode as a parasite of the mouse I have found it on a few occasions in this host in Sydney (J. 1909*a*, p. 417; 1910*b*, p. 80). From August 1909 to Feb. 1910 I found this roundworm once in 119 *Ep. rattus* examined; once in 100 *Ep. alexandrinus*; once in the mouse, 73 being examined; and thirty times in *Ep. norvegicus* (121 examined). It is thus essentially a parasite of the brown rat where it occurs commonly (25%), sometimes in abundance, the greatest number actually counted from one host being 266 (Oct. 1909). There are usually from two to eight present.

Lane (1914, p. 660) described a roundworm *Gangulеterakis gangula* from *Mus decumanus* in India but it is undoubtedly *H. spumosa* as Hall has already pointed out.

Oxyuris (Syphacia) tetraptera, Nitzsch.

This small roundworm has not previously been recorded from Australia. I have taken it on many occasions from the mouse in Sydney district where it appears to be much less common than *O. obvelata*.

Oxyuris (Syphacia) obvelata Br.

The following results were obtained in Sydney during August 1909-February 1910. *O. obvelata* was found in 11 out of 119 *Ep. rattus*; two out of 100 *Ep. alexandrinus*; two out of 121 *Ep. norvegicus* and nineteen out of 73 *Mus musculus*.

The percentage infections are thus approximately 10, 2, 1.6 and 26. These Oxyurids appear to be essentially parasites of the mouse and house rat. The greatest numbers counted from one host during the period were 340 (from an *Ep. rattus*), 276 (*E. rattus*), 76 (*E. rattus*), 62, 51 and 41 (from mice). There are usually found from one to six.

Gongylonema sp.

In March 1909 I found in the liver of a mouse (Sydney), in addition to *Hepaticola hepatica*, a number of Filariid eggs containing well developed embryos. Similar ova were found in the liver of a white mouse in September 1909; I believe that they all belonged to a *Gongylonema*.

Trichosomoides crassicauda Bellingham.

During the months of August, September, October and November 1909 and February 1910 I examined a large number of urinary bladders taken from Muridæ in Sydney, for the purpose of ascertaining the frequency of this parasite. Out of 163 specimens of *Epimys rattus*, only one was found infected (Sept. 1909), six worms being found in it (% infection=.6); out of 246 *Epimys alexandrinus* only one contained *T. crassicauda*, a single specimen being found (Sept. 1909). Thus 409 specimens of the house and ship rats (which are really only varieties of the one species *Epimys rattus*) yielded two with parasitised bladders (% infection=.5); 83 bladders collected from mice were all found to be free from the nematode.

The parasite was found in 74 out of 205 *Ep. norvegicus* examined (=31.2%), the greatest number of females obtained from any one host being 15 (twice), 11, 10 (twice) and 9 several times. There were usually found from one to three.

A re-examination of my material has convinced me that my record of the single occurrence of this worm in the mouse (1909*a*, p. 591) is incorrect, having been based on the thin anterior portion of a damaged *Trichuris muris* which during the dissection of the host had evidently been set free into the cœlome and become associated with the bladder when the latter was removed by my assistant for examination.

Trichuris muris Schr. (Syn *Trichocephalus nodosus* R.).

The whip worm was not found in 121 *Epimys norvegicus* collected and examined in Sydney between August 1909 and February 1910. It occurred three times in 119 specimens of *E. rattus* and once in 100 *E. alexandrinus* in the same period. The greatest number obtained from any one animal was twenty-two (*E. rattus*). In three cases no other intestinal parasites were present while in one case (*E. rattus*) *Hym. nana* occurred also.

Tr. muris was found to be much commoner in Sydney mice during the same period, occurring in 12 out of 73 examined. The greatest number found was 34 (once—*Protospirura muris* and *Cysticercus fasciolaris* being also present). Eleven were taken on two occasions, once alone, and once in company with *Oxyuris obvelata*. Six were found several times but usually from one to three were present. In three cases no other entozoa were obtained but usually *Oxyuris obvelata* and sometimes *O. tetraptera* occurred as well. On one occasion (Sept. 1909) there were six *Tr. muris* in addition to *Protospirura muris*, *Heterakis spumosa*, *Oxyuris obvelata*, *Cysticercus fasciolaris* and *Hepaticola hepatica*.

The percentage infections were, then, *E. norvegicus* nil; *E. rattus* 2.5%; *E. alexandrinus* 1%; *Mus musculus* 16.4%.

Hepaticola hepatica Bancroft (Syn. *Trichosoma hepaticum*).

This parasite is fairly common in the liver of Australian rats and mice. Hall (1916. p. 32) mentions as hosts only *Epimys norvegicus* and *E. alexandrinus*. I have reported it from *E. rattus* and *Mus musculus* in addition (J. 1909*a*, p. 218, etc.). Railliet recorded it from a French mouse in 1889 (1889, p. 63) and various authors have noted its presence in *Ep. rattus*.

It was found in four out of 119 specimens of the last-named rat in Sydney (August 1909 to Feb. 1910): 2 out of 100 *Ep. alexandrinus*; and 2 out of 73 *Mus musculus*. The percentage in *Ep. norvegicus* is probably much higher owing to cannibalistic habits of this species. Dr. Bancroft (1893, p. 86) found that nearly all the Brisbane rats examined by him (species not indicated*) were affected, even those as young as two months, whereas white rats were free from it but could become infected by feeding them with eggs from parasitised livers.

The normal habitat is the liver but in March 1909 I obtained nematode eggs, presumably belonging to this

*Dr. Shipley assumed the species to be *Mus decumanus* (Journ. Econom. Biol., 3, 1908, p. 80).

species, from within the spleen of an *Ep. norvegicus.* In February 1909 a liver from *Ep. alexandrinus* was found so heavily parasitised that about two-thirds of the entire surface, both upper and lower, were studded with the yellowish-white tubercles, some in large masses measuring one and a-half inches by an inch on one surface and extending through the liver substance to form an irregular patch of nearly an inch and a-half in diameter on the other side. On the main lobe, not a square centimeter of the upper surface in any one place was free from it. Worm tracks and worms were abundant, eggs being present in thousands, all the lobes being heavily infected. In spite of this gross infestation the organ was not enlarged, though its substance was much lighter in colour than normal.

A good account of the parasite was published by Dr. T. L. Bancroft in 1893, who gave the length of the parent worms as 40 to 50mm. (*i.e.*, $1\frac{1}{2}$ to 2 inches). A summary of his description is given by Hall (1916*b*, p. 31) who mentions 4 to 5 inches (10-12cm.) as the length. Leidy (1890, p. 412) in his account of the worm which he called *Trichosomum tenuissimum* n.sp.,* estimated it to be two inches long. Owing to the manner in which the nematode threads itself through the liver, it is difficult to extricate it—hence the doubt regarding its length.

Railliet (1889, p. 62) gave a summary of the earlier references† to the parasite in Europe. Chaussat in 1849 thought that the nematode eggs in the rat's liver were *Coccidium oviforme.* In 1860 Davaine believed them to belong to a *Trichosoma* and gave measurements, while Colin in 1862 discovered the worm and definitely placed it in that genus. Railliet found the eggs in a mouse in 1885

* Not Trichosoma tenuissimum Diesing, 1851, from the pigeon and other Columbidæ.

†These are quoted from Railliet's paper (1889)—Chaussat, Hæmatozoaires du Rat, C.R. Soc. Biol., 1, 1849, p. 22; C. Davaine, Traité des Entozoaires, Paris, Edit. 1, 1860, p. 261; G. Colin, Sur la présence d'un Helminthe dans certains tubercules du foie. Bull Soc. imper. de Med. vet., (2), 7, 1862, p. 156; Kitt, *Triœnophorus nodulosus* in der Leber einer Ratte. Munchnr. Jahrsb., 1879-1880, p. 28; Railliet, Zool. Medicale et agricole, Paris, 1885, p. 164.

but regarded it as *Trichocephalus nodosus*, the whip worm which frequents the caecum, as did Kitt in 1880. In 1889 Railliet gave an account of the lesions and the eggs as well as of a series of experiments carried out with the latter with a view to tracing the life history. He believed that the parasite was a *Trichosoma* peculiar to the liver and distinct from the species of the genus which were known to occur in the intestine of Muridæ.

In the same year he and Lucet (Railliet and Lucet 1889) investigated the verminous tumours of the liver of the hedgehog, *Erinaceus europæus* L. and found them to be due to the presence of a *Trichosoma* distinct from those then known from that host.

In 1889 Bulloch referred to the presence of eggs in the liver of a rat in the United States and believed them to belong to *Trichocephalus dispar*. In 1893 Perugia* wrote upon the *Trichosoma*, while in the following year Dr. T. L. Bancroft published his account of the worm (which he named *Trichocephalus hepaticus*) and gave an interesting account of his efforts to trace the life history. He also described the pathology of the infection.

In 1898 Magalhaes referred to the presence of eggs of a *Trichosoma* in verminous tumours of the liver of *Mus decumanus* in Brazil (1898, p. 316). In the same year Railliet labelled the parasite as *Trichosoma hepatica* (Bancroft†.) A little later Bossuet (1902, p. 192) gave an account of the work done by Railliet but did not add many new facts.

In 1901 Galli-Valerio referred to the presence of the parasite in two *Mus decumanus* in Switzerland,‡ and in 1903 gave a short account of the pathology of the invasion (1903, p. 88). In 1905 he referred to the occurrence of

*Perugia. Sul Trichosoma del fegato dei muridi. Atti Soc. Ligust. di sc. nat., Genova, 4, 1893, pp. 206-210 (quoted by Hall, 1916).

†Railliet. Rectification de la nomenclature d'après les travaux recents. Rec. med. vet. Paris, 75, 1898, pp. 171-174. (quoted by Hall, 1916).

‡Galli-Valerio B. La collection de parasites du laboratoire d' hygiene et de parasitologie de l' Université de Lausanne. Bull. Soc. Vaud. d. sc. rat. Lausanne, (140), 37, 1901, pp. 343-381.

Trichosoma hepatica in *Mus rattus* in Lausanne and mentioned that he had found it only in six out of about 200 rats (*M. rattus* and *M. decumanus*) examined by him (1905, p. 240). In 1906 he wrote on the worm tumours of the liver of the hedgehog, which he believed to be caused by *Trichosoma tenue* Duj., and noted the similarity to the condition seen in rats (1906, p. 746).

McCoy, Mink and Robinson* all referred to the presence of *Tr. hepatica* in the United States. My own references to the occurrences of the parasite in Australian rats and mice are given in the catalogue at the end of this paper. In 1916 Dr. Hall published his excellent paper on the nematode parasites of rodents, etc., giving in it a short account of the anatomy and life history of this worm, based on published information (1916, pp. 30-33 and plate 1). He made the nematode the type of a new genus *Hepaticola*, separating it from *Trichosoma* (or *Capillaria*).

In 1911, Nicoll drew attention to a pathological condition in the liver of an English hare, caused by a *Trichosoma*, the appearance resembling that seen in rats. Hall believed that the parasite was probably *H. hepatica*.

The pathological condition set up has been carefully described by Bancroft (1893, p. 87-8, pl. 7, fig. 7, pl. 8, fig. 4) and Galli-Valerio (1903, p. 89 and text-fig. 2). The tubercular or pseudo-tubercular appearance is very noticeable especially when the infection is heavy, and reminds one of *Coccidiosis*. Haaland† in writing on spontaneous cancers in mice mentioned that the only explanation given for the chronic irritation was the presence of nematodes.

A very brief summary of the life history has been made by Hall (1916, p. 31). Railliet (1889), Bancroft

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*McCoy, G. Pathological conditions found in rats, etc., San Francisco. Publ. Health Rep. Washington D.C., 23, (39), 1908, pp. 1365-1371. Mink, O. Preliminary note on a nematode found in the liver of a wild rat. U.S. Naval Med. Bull., Washington, 3 (11), 1909, p. 52. Robinson, G. The rats of Providence and their parasites. Amer. Journ. Publ. Health., New York, 3 (8), 1913, pp. 773-776. These three references are quoted from Hall, 1916.

†M. Haaland. Royal Soc. London, 16th March, 1911. Abstract in Nature, 23rd March, 1911, p. 134

(1893) and Galli-Valerio (1905) carried out experiments to determine manner of infection. Bossuet (1902) summarised Railliet's finding.

Railliet's results are of interest. He placed some eggs obtained from a mouse liver in a moist chamber early in March, 1885, segmentation commencing in June. By the end of that month some eggs contained embryos and by the middle of July these were present in most of them. After four months incubation (*i.e.*, at the end of July) some were fed to two rats and in five days afterwards one of these animals died, free embryos being found in the caecum and liver. The other rat died two months later, *i.e.* seventy-five days after ingesting the eggs and the liver was found to be invaded by worms, tumours and egg masses being present.

In another series of experiments, eggs were taken in the middle of October, 1885, incubated for 26 months *i.e.*, until December 1887. Segmentation was apparent in some in June 1886 (*i.e.*, eight months later), embryos appearing between July and December, 1886. Some of these embryos containing eggs were kept until December 1887 (seventeen months after the embryos had appeared in them) when they were fed to two white rats. In February 1888 one died in a state of emaciation, its liver being found to be heavily infected with *Trichosomes*, but no eggs were present. The second rat was killed in December, 1888, but its liver was quite unparasitised.

In a third series, Railliet took some eggs incubated in October 1885, and fed them to a white rat in December 1888, after having been three years and two months incubationg, and two years and five months after embryos had been formed in them. This rat was killed ten weeks later (Feb. 1889), its liver being found to contain *Trichosomes* devoid of eggs.

He showed that eggs removed from water for two days but kept in a moist room, still underwent development but five days' drying in air prevented it. Four months dessication (December to April) killed the eggs or embryos.

Bancroft, in 1891, fed rat-livers containing eggs to white rats and recovered eggs unchanged in the faeces. The animals were killed several months later but no worms were found. Healthy rats living in cages with infected ones did not become infected. Eggs kept in water had not undergone segmentation after a period of three months, but when examined after fifteen months immersion. were found to contain coiled embryos which by gentle pressure on the coverglass were easily expelled from the eggs.

Six weeks later (August, 1892) mature eggs were fed to white rats and in three weeks produced serious symptoms —dyspnœa, emaciation and diarrhœa. One was killed and the other died (Sept. 1892) the liver of both being very heavily infected with worms, eggs being in abundance. When large numbers of eggs were fed to rats, the latter died in from three to four weeks, but if only a small number was given, the animals recovered and an examination of the liver some months later showed the organ to be normal except for the presence of the whitish egg masses. The eggs ultimately die and undergo calcification in the liver, this being noted in the case of an animal six months after a light experimental infection, when many of the eggs were found to be calcified. They never produced abscesses. Bancroft stated that they do not pass to the intestine by the bile duct.

Exposure of the eggs in water to sunlight destroyed them. Eggs were placed in the shade in water in July 1892; six weeks later there was no apparent change; five weeks later segmentation had begun; in six weeks more, the embyro worms began to be outlined; and in three weeks more (*i.e.*, five months from the date of commencement of the experiment) the embryos were mature, but even then considerable pressure was needed to cause them to be liberated from the egg shells. The embryos were able to maintain vitality within the shells in water for over eighteen months.

Experiments to determine the route of the embryos after their entry into the digestive canal were not successful. He found that in a fortnight immature worms could be found in the liver.

During 1909 and 1910 I carried out a series of experiments with the eggs. Some were taken from *Ep. alexand-*

rinus and placed in water on 2nd Aug. 1909, the majority segmenting by 26th Sept., embryos being found in several on 30th Oct. 1909. No further changes were noted between that date and 13th July, 1910, the embryos being alive but still within the shell.

Eggs taken from *E. rattus*, *E. norvegicus* and *Mus musculus* were immersed in water on 28th April, 1910, a few showing two-celled segmentation on 10th May. On 15th June there were 2, 4 and 8 cell stages but most of them showed a multicellular condition while in one egg the outline of a vermiform embryo was visible. A month later the same stages were to be seen though immature embryo worms were more abundant. A month later (10th October, 1910) practically all the eggs contained mature embryos and these continued to live for many months until killed by accidental dessication.

In another case, eggs from *E. norvegicus* immersed on 30th Dec. 1909, were found to contain fully-formed embryos on 29th Jan. 1910, *i.e.* in about thirty days in midsummer. Some of the eggs were allowed to dry overnight and then replaced in water in a room. About 30% failed to develop, though development of the rest was retarded somewhat, embryos appearing to be fully formed nearly three weeks later than in the case of eggs not allowed to dry.

Eggs placed in a tube with water and exposed to the sun and weather continuously, were all killed within 30 days.

Bancroft gives egg measurements as 55 micra by 30 to 35 micra: Hall 40 to 52 in length by 30 to 35 in breadth; Davaine 50 to 55 in length; Railliet 52 to 55 by 29 to 32; Galli-Valerio 50 by 22. My measurements show a range in length from 46 to 60 micra, and in breadth from 28 to 32. The shell is about 3.5 micra thick, and the polar openings have a diameter of 7 micra. The stippled appearance of the shell has already been noted.

Bancroft gives 156 micra as the length and 7 as the breadth of enbryos extruded from the shell. I found the length to vary from 160 to 195 micra and the breadth from 5.5 to 7 micra. The anterior end is slightly narrower than the other. The cuticle is quite smooth and the body conains abundant round fat-like globules.

Hormorhynchus moniliformis Br.

This echinorhynch was found in six out of 119 specimens of *Epimys rattus* (percentage = 5); 2 out of 100 *Epimys alexandrinus* (2%), and 2 out of 121 *Epimys norvegicus* (1.65%) collected and carefully examined in Sydney during the period August, 1909 to February, 1910.

The greatest number obtained from any one host was 244—from *Epimys rattus*—no other parasites being present. The lumen of the intestine was filled with them. Their length ranged from about half an inch to seven and a-half inches, most of the females being exceptionally long. In October, 1909, I obtained approximately 200 from a brown rat (*E. norvegicus*), one being eight inches long and another female seven and a-quarter (J. 1909*a*, p. 219). The next greatest numbers obtained in one animal were 25 (from *E. rattus*), 21 (from *E. norvegicus*), and 19 (from *E. alexandrinus*). The usual number appears to be from two to four.

My record of this parasite from the mouse is an error (J. 1909*b*, p. 583).

Heavy Multiple infections found in Sydney.

Under the heading of *Trichuris muris* reference has been made to a good example of multiple infection, but it was not heavy. In *E. norvegicus* I found on one occasion (Feb. 1910) the liver riddled with *Hepaticola hepatica*, the stomach contained 51 *Protospirura muris*; the intestine held several hundred *Heterakis spumosa*, hundreds of *Heligmosomum braziliense*, six *Hymenolepis diminuta* and four *Hym. nana*; while in the bladder were two *Trichosomoides crassicauda*.

In an *E. norvegicus*, examined in March 1909, were 43 *Protospirura muris*, 21 *Hormorhynchus moniliformis*, a few *Oxyuris obvelata* and some *Heterakis spumosa*, while the liver contained abundant *Hepaticola hepatica*. An example of *E. rattus* (Sept. 1909) yielded 276 *Oxyuris obvelata* and 40 *Hymenolepis nana*. In one specimen of *E. norvegicus* I counted six large *Hymenolepis diminuta* and six *H. nana*; in another, three of the former and thirteen of the latter; and in a third, five of the former and nine of the latter. In some cases other parasites were present as well.

Catalogue of the Endo-parasites Recorded from Rodents in Australia.

A list of the helminth entozoa known to occur in rodents in this continent up to 1909 was published in Johnston 1910*b*, but no references to literature were given. Since that date a number of new records have been made. The parasites known to infest rats and mice in Queensland are mentioned in my Census (1916*b*). Stiles, Hassall and Crane (1910) have published information regarding the entozoa of Muridæ.

A tabular statement of the ectozoa found whilst examining rodents in the Bureau of Microbiology, Health Department, Sydney, during 1909-1911, was published by me (1910*c* and 1912*b*), the work being continued by Mr. G. Darnell-Smith (Bur. Microbiol, N.S.W., Rep. 3, 1912 [1914], p. 19) and Dr. J. B. Cleland (later reports of the Bureau)*. Banks (1910) has given an account of those known to occur in the United States.

Mus musculus L.

Trypanosoma lewisi Kent. I regard my record (1909*b* p. 581)† of this haematozoon from the mouse as an error.

Cysticercus fasciolaris R. (= *Tænia taeniæformis* Bl.) Perrie 1892, p. 821 ; Jnstn 1909*a*, p. 417 ; 1910*b*, p. 80 (Sydney) ; 1916*b*, p. 42 (Brisbane).

Hymenolepis diminuta Rud. J. 1909*a*, p. 218 ; 1909*b*, p. 582 ; J. 1918 (Brisbane).

Hym. nana Sieb. (*H. murina* Duj.) J. 1909*a*, p. 218; J. 1918 (Brisbane).

Oxyuris (*Syphacia*) *tetraptera* Nitzsch. J. 1918 (Sydney).

O. (*Syphacia*) *obvelata* Brems. J. 1909*a*, p. 417 ; 1912*a*, p. 75 (Brisbane).

Heterakis spumosa Schn. J. 1909*a*, p. 417 : J. 1918.

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*A paper on the rat fleas and how to distinguish them has been published by Rothschild in the Bull. Economic Entomology, Vol. 1.

†All records are based on specimens collected in Sydney unless otherwise stated.

Trichuris muris Schr. (syn. *Trichocephalus nodosus* R.) J. 1909*a*, p. 218; 1909*e*, p. 480; Tidswell & Jnstn. 1912, p. 112.

Hepaticola hepatica Bancr. (generally known as *Trichosoma* or *Capillaria hepatica*) J. 1909*a*, p. 218; 1909*e*, p. 480 1912*a*, p. 75 (Brisbane). Tidswell & Jnstn 1912, p. 112.

Gongylonema sp. J. 1918 (Sydney).

Protospirura muris Gmel.* (syn. *Spiroptera* or *Acuaria obtusa* Froel) J. 1909*a*, p. 218; 1912*a*, p. 75 (Brisbane).

MUS MUSCULUS ALBUS—White mouse.

Hymenolepis diminuta Rud. J. 1918 (Sydney).

Oxyuris obvelata Brems. J. 1918 (Sydney).

Gongylonema Sp. J. 1918 (Sydney).

EPIMYS RATTUS AND ITS VARIETY ALEXANDRINUS.

The latter is much commoner than the former in Eastern Australia.

Spirochæta ratti J. & C.† J. & C. 1909, p. 507 and in Bur. Microbiol. Rep., 1, 1909 (1910), p. 35.

Trypanosoma lewisi Kent. Pound 1905, p. 36 (Brisbane); J. 1909*b*, p. 581; 1909*d*, p. 409; 1916*b*. p. 43 (Brisbane); J. & C. 1909, p. 502, 510.

Hæmogregarina (*Hepatozoon*) *muris* Balf. Cleland 1906*a*, p. 516, 519; and 1906*b*, p. 296 (as *Leucocytozoon ratti* (?) and *L. balfouri* from *Mus decumanus* but host was subsequently determined as *Ep. alexandrinus*, West Austr.); J. & C. 1909, p. 501 (W.A.); J. 1909*b*, p. 581 ("rat"—W.A.).

Sarcocystis muris Blanch. J. 1909*a*, p. 418; J. & C. 1909, p. 510; J. & C. 1911, p. 305; J. & C. 1912, p. 115. Also in Rep. Bur. Microbiol, 1, p. 45.

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* *Agamonema* sp. found in the rat fleas, *Xenopsylla cheopis* and *Ceratophyllus fasciatus* in Sydney (J. 1912*a*, p. 81-2) is probably the larva of *Protospirura muris*. It resembles the form figured by Leuckart, (copied by Hall, 1916, fig. 267).

†At least two other spirochætes are known from Muridæ, viz., *S. minor* Carter, 1887, in rats, and *S. muris* Wenyon, 1906, in mice. A brief account is given in Doflein's Lehrb. d. Protozoenkunde, 1909, p. 334.

Tænia tæniæformis Bl. (larval form = *Cysticercus fasciolaris* R.). Perrie 1892, p. 821 (from house rat—Sydney ?); J. 1909*a*, p. 417 (N.S.W.; W.A.); 1910*b*, p. 80 (N.S.W., W.A.); 1912*a*, p. 67 (Brisbane).

Hymenolepis diminuta R.* J. 1909*a*, p. 218; 1909*b*, p. 582, 1910*b*, p. 80 (Perth, W.A.); 1912*a*, p. 65 (Brisbane).

Hym. nana Sieb. (Syn *H. murina* Duj.) J. 1909*a*, p. 218, 590; 1918 (Brisbane).

Hormorhynchus moniliformis Br. (Syn. *Gigantorhynchus moniliformis*)† J. 1909*a*, p. 218, 590; 1909*b*, p. 583; 1912*a*, p. 83 (Brisbane).

Oxyuris (*Syphacia*) *obvelata* Brems. J. 1909*a*, p. 417; 1912*a*, p. 75 (Brisbane).

Heterakis spumosa Schn. J. 1909*a*, p. 417; 1912*a*, p. 74 (Brisbane).

Trichosomoides crassicauda Bellghm. (Syn. *Trichodes crassicauda*) J. 1909*a*, p. 591. Uncommon in this host in N.S.Wales.

Trichuris muris, Schr. J. 1909*a*, p. 218, 590.

Hepaticola hepatica Bancroft. Bancroft, 1893, p. 87 (Brisbane); J. 1909*a*, p. 218; 1909*c*, p. 480; 1912*a*, p. 75 (Brisbane); Tidswell & Jnstn. 1912, p. 112.

Protospirura muris Gmel. J. 1909*a*, p. 218 (Sydney); 1912*a*, p. 75 (Brisbane). This worm occurs in *Epimys alexandrinus* in Perth, West Australia.

EPIMYS NORVEGICUS Erxl. (Syn. MUS DECUMANUS Pall).

Spirochæta ratti J. & C. J. & C. 1909. p. 507; and in Rep. Bur. Microbiol., 1, 1909 (1910), p. 35.

Trypanosoma lewisi Kent. Pound 1905, p. 36 (Brisbane); 1907, p. 160 (Brisbane), J. 1909*b*, p. 581; 1909*a*, p. 218; 1909*d*, p. 409; J. & C. 1909, p. 502, 510, and in

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*The cysticercoid of *H. diminuta* has been recorded from two species of rat fleas, *Ceratophyllus fasciatus* and *Xenopsylla cheopis* from Sydney and from the former from Melbourne, whilst the cysticercoid of *H. nana* has been found in the same two species of fleas from Sydney. (J. 1912*a*, p. 69-70.)

†Recently transferred to the genus *Hormorhynchus* by H. B. Ward. Jour. Parasitol., 3 (3), 1917, p. 41).

Rep Bur. Micr., 1, 1910, p. 44. I have recently examined a brown rat in Brisbane whose blood contained myriads of this flagellate.

Hæmogregarina (*Hepatozoon*) *muris* Balf. J. 1909*a*, p. 218; 1909*b*, p. 581: 1909*d*, p. 402: J. & C. 1909, p. 501. Also in Rep. Bur. Micr., 1, p. 44. In the United States the parasite is transmitted by a Gamasid mite *Lælaps echidninus* Berl. (W. Miller, Bull. 46, Hyg. Lat., U.S. Publ. Health Service, 1908). In Australia the transmitter is no doubt the common species of *Lælaps* which I have recorded as being probably *L. agilis* Koch. This mite occurs in N.S.W., Victoria and Queensland.

Sarcocystis muris Blanch. J. 1909*a*, p. 418; J. & C. 1909, p. 510; J. & C. 1911, p. 305; J. & C. 1912, p. 115 ("Sarcosporidia")—also in Rep. Bur. Micr., 1, p. 45.

Tænia tæniæformis Bl. (cystic stage=*C. fasciolaris*), J. 1909*a*, p 417; 1910*b*, p. 80 (N.S.W. & W.A.); 1912*a*, p 67 (Brisbane)

Hymenolepis diminuta R. J. 1909*a*, p. 218; 1909*b*, p. 582; 1910*b*, p. 80 (W. A.); 1912*b*, p. 65 (Brisbane); 1913, p. 88 (Townsville N.Q.).

Hym. nana Sieb. (*H. murina* Duj.) J. 1909*a*, p. 218; 1918 (Brisbane).

Davainea sp. J. 1918 (Brisbane).

Hormorhynchus moniliformis Br. J. 1909*a*, p. 218; 1909*b*, p. 83; 1912*a*, p. 83 (Brisbane); 1913, p. 93 (N.Q.).

Oxyuris (*Syphacia*) *obvelata* Br. J. 1909*a*, p. 417; 1912*a*, p. 75 (Brisbane).

Heterakis spumosa Schn. J. 1909*a*, p. 417; 1912*a*, p. 74 (Brisbane).

Hepaticola hepatica Bancr. J. 1909*a*, p. 218; 1910*b*, p. 80; 1912*a*, p. 75 (Brisbane).

Trichosomoides crassicauda Bell. J. 1909*a*, p. 417, 591; 1912*a*, p. 75 (Brisbane).

Heligmosomum braziliense Travassos. J. 1909*a*, p. 590; 1910*b*, p. 81—recorded as *Oesophagostomum* sp.; J. 1918 (Sydney and Brisbane).

Protospirura muris Gmel. J. 1909*a*, p. 218; 1912*a*, p. 75 (Brisbane).

WHITE RAT ? EPIMYS NORVEGICUS var.

Hepaticola hepatica Bancr. Bancroft 1893, p. 87 (Brisbane).

EPIMYS TERRÆ-REGINÆ.

Hymenolepis diminuta Rud. J. 1918 (Sydney).

RATS (unspecified).

Trypanosoma lewisi Kent. Bancroft 1888, p. 31 (as *Hæmatomonas* sp.—Brisbane); Cleland 1906*a*, p. 519 (W.A.); Breinl 1913, p. 30 (in 15% of rats examined, N.Q.).

Coccidium sp. Bancroft P.R.S. Q'land, 8, 1891, p. xiii (=ova of *Hepaticola hepatica* Bancr.)

Tænia sp. Cleland 1906*a*, p. 518 (W.A.). I have identified the specimens as *Hym. diminuta*.

Tænia tæniæformis Bl. (cystic stage). Krefft 1871, p. 206; Cleland, 1906*a*, p. 518 (as *Tænia* sp. from rat's liver W.A.). The presence of the adult worm in cats in Melbourne (J. 1910*b*, p. 80) is sufficient evidence for concluding that the Cysticercus (*C. fasciolaris*) occurs in Victorian rats and mice.

Hymenolepis diminuta R. The occurrence of the cysticercoid stage of this cestode in the rat flea, *Ceratophyllus fasciatus* in Melbourne (J. 1912*a*, p. 70) is evidence that the adult is to be found in Victorian rats and mice.

Hormorhynchus moniliformis Br. Nicoll, 1914 (N.Q.).

Hepaticola hepatica Bancr. Cleland 1906*a*, p. 518 (—ova in liver of rats—somewhat like those of *Trichocephalus dispar*—Perth, W.A.).

Protospirura muris Gmel. Cleland 1906*a*, p. 518 (roundworms like ascarids in stomach, Perth, W.A.).

CAVIA PORCELLUS (C. CUTLERI)—Guinea pig.

I have already given a list of the entozoa recorded from this host in Australia (1909*c*, p. 343).

ORYCTOLAGUS CUNICULUS L. (Rabbit).

See J. 1909*c*, p. 342-3 for list to 1909.

Eimeria stiedæ Lind. (*Coccidium oviforme* Leuckt.) J. 1909*b*, p. 584 (N S.W.—various localities).

Cysticercus pisiformis Zed. Brown 1902, p. 614 (Vict.); Sweet 1908*a*, p. 478 (Vict.); Sweet 1908*b*, p. 506 (Vict.); J. 1909*a*, p. 412; 1909*b*, p. 584.

Cœnurus serialis Gerv. (=larva of *Multiceps serialis*). Sweet 1908*b*, p. 507 (? Vict.) ; J. 1909*a*, p. 412 ; 1909*b* p. 584 ; 1916*a*, p. 194 (destroying a rabbit's eye—N.S.W.) The adult has been recorded from the dog and fox in N.S.W. (J. 1909*a*, p. 412-3).

Echinococcus veterinorum R. (hydatids=larva of *Echinococcus globosus* Batsch.). Sweet, 1908*b*, p. 506 (Vict) ; J. 1909*a*, p. 412 ; 1909*b*, p. 584.

Oxyuris (*Passalurus*) *ambigua* R. Johnston, P.L.S. N.S.W., 1911, p. 157—from Braidwood, N.S.W.—I have received it also from the Monaro district, N S.W. (collected by Mr. O. Hirschfeld).

Spiroptera megastoma R. Dr. Sweet (1908*a*, p. 491) quotes a newspaper reference by Dr. A. Brown to the occurrence of this equine parasite in the intestine of the rabbit in Victoria. The nematode is probably *Oxyuris ambigua.*

Graphidium strigosum Duj. J. 1909*b*, p. 584 ; 1910*b*. p. 80.

LEPUS TIMIDUS (The Hare).

Cysticercus pisiformis Zed. Brown 1902, p. 614 (Vict.).

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THE COMPONENTS PER MONTH OF THE RHIZOPODAN FAUNA OF A BRISBANE LAGOON.

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(*Read before the Royal Society of Queensland, 27th May,* 1918).

The lagoon which was selected for this investigation is situated in the Brisbane Botanic Gardens, near the old bird house, and material for examination was collected approximately at the end of each month from January—December, 1917.

The following are the monthly lists of Rhizopods, the forms indicated by an asterisk * being represented only by empty tests :—

I. January (collected 30th Jan.) :—*Arcella artocrea* Ldy., **A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., **Centropyxis aculeata* Stn., **Difflugia constricta* Ldy., *D. lobostoma* Ldy., *D. oblonga* Ehr., **Euglypha acanthophora* Ehr., *E. tuberculata* Duj., **Trinema enchelys* Ldy.

Arcella vulgaris was numerous, and one specimen was observed in the amoebula condition.

II. February (collected 28th Feb.) :—*Amoeba proteus* Ldy., *A. radiosa* Ehr., *Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., *Difflugia lobostoma* Ldy., *D. oblonga* Ehr., *Euglypha acanthophora* Ehr., *E. tuberculata* Duj., **Trinema enchelys* Ldy.

A number of large *Difflugia oblonga* was present, which appeared to range from the typical pyriform condition to acuminate.

III. March (collected 29th Mar.) :—*Amoeba proteus* Ldy., *Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., *Difflugia oblonga* Ehr., *Euglypha acanthophora* Ehr., **E. tuberculata* Duj.

Large *Difflugia oblonga* common.

IV. April (collected 2nd May) :—*Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., **Difflugia corona* Wallich (unspined), **D. lobostoma* Ldy., *D. oblonga* Ehr., *Euglypha acanthophora* Ehr., **E. tuberculata* Duj., *Trinema enchelys* Ldy.

Euglypha acanthophora observed in conjugation.

V. May (collected 31st May) :—*Amoeba proteus* Ldy., *A. radiosa* Ehr., *Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., *C. ecornis* Ldy., **Difflugia lobostoma* Ldy., *Euglypha acanthophora* Ehr., *E. cristata* Ldy., *E. tuberculata* Duj., *Pareuglypha reticulata* Pen., *Trinema enchelys* Ldy.

Euglypha cristata was observed for the first and only time from this locality, and both *E. acanthophora* and *E. tuberculata* were seen in conjugation. This phenomenon was also noticed in the case of two *Centropyxis*, of which one appeared to be a one-spined *aculeata* and the other an *ecornis*.

VI. June (collected 28th June) :—*Amoeba proteus* Ldy., *A. radiosa* Ehr., *Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., **Difflugia corona* Wallich (spineless), **D. oblonga* Ehr., *D. tuberculata* Wallich, *Euglypha acanthophora* Ehr., *Pareuglypha reticulata* Pen., *Trinema enchelys* Ldy.

Pareuglypha reticulata observed in conjugation.

VII. July (collected 1st Aug.) :—*Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., *Difflugia corona* Wallich (spineless), *D. corona* Wallich (spined), **D. leidyi* Wailes., **D. oblonga* Ehr., **D. tuberculata* Duj., *Pareuglypha reticulata* Pen., *Trinema enchelys* Ldy.

Only one specimen of *Difflugia leidyi* seen: it was an empty test provided with three cornua. This record is believed to be the first for Australia.

VIII. August (collected 31st Aug.) :—*Arcella artocrea* Ldy., * *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., **Centropyxis aculeata* Stn., **Difflugia corona* Wallich (spineless), *D. oblonga* Ehr., **D. lobostoma* Ldy., **Euglypha acanthophora* Ehr., **E. tuberculata* Duj., *Pareuglypha reticulata* Pen., *Trinema enchelys* Ldy.

IX. September (collected 28th Sept.) :—*Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy , *A. vulgaris* Ehr., **Centropyxis aculeata* Stn., *Euglypha acanthophora* Ehr., **E. compressa* Cart., **E. tuberculata* Duj., **Trinema enchelys* Ldy.

X. October (collected 2nd Nov.) :—*Arcella artocrea* Ldy., *A. discoides* Ehr., *A mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., **Difflugia lobostoma* Ldy., **D. oblonga* Ehr., *Euglypha acanthophora* Ehr., **E. tuberculata* Duj., *Trinema enchelys* Ldy.

In a 9-spined test of *Centropyxis aculeata* two of the spines were united at their bases, forming a double spine. This type of variation in connection with the spines of *C. aculeata* is uncommon.

XI. November (collected 30th Nov.) :—*Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., **Centropyxis aculeata* Stn., **Difflugia corona* Wallich (unspined), *D. lobostoma* Ldy., *D. oblonga* Ehr., **Euglypha acanthophora* Ehr., **E. tuberculata* Duj., *Trinema enchelys* Ldy.

Arcella discoides tests were common, apparently the material was collected soon after a maximum for the species.

XII. December (collected 29th Dec.) :—*Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., **C. ecornis* Ldy., **Difflugia corona* Wallich (spineless), *D. oblonga* Ehr., **Euglypha acanthophora* Ehr., **E. tuberculata* Duj. **Trinema enchelys* Ldy.

List of species observed :—*Amoeba proteus* Ldy., *A. radiosa* Ehr., *Arcella artocrea* Ldy., *A. discoides* Ehr., *A. mitrata* Ldy., *A. vulgaris* Ehr., *Centropyxis aculeata* Stn., *C. ecornis* Ldy., *Difflugia corona* Wallich (spined), *D. corona* Wallich (spineless), *D. leidyi* Wailes., *D. lobostoma* Ldy., *D. oblonga* Ehr., *D. tuberculata* Wallich, *Euglypha acanthophora* Ehr., *E. compressa* Cart., *E. cristata* Ldy., *E. tuberculata* Duj., *Pareuglypha reticulata* Pen., *Trinema enchelys* Ldy. Total, 19.

TABLE OF LIVING RHIZOPODS OBSERVED.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec	Total.
1. *Amoeba proteus* Ldy.		x	x		x	x							4
2. *A. radiosa* Ehr. ..		x			x	x							3
3. *Arcella artocrea* Ldy.	x	x	x	x	x	x	x	x	x	x	x	x	12
4. *A. discoides* Ehr. ..		x	x	x	x	x	x		x	x	x	x	10
5. *A. mitrata* Ldy. ..	x	x	x	x	x	x	x	x	x	x	x	x	12
6. *A. vulgaris* Ehr. ..	x	x	x	x	x	x	x	x	x	x	x	x	12
7. *Centropyxis aculeata* Stn.		x	x	x	x	x	x			x		x	8
8. *C. ecornis* Ldy. ..					x								1
9. *Difflugia corona* Wallich (spined) ..							x						1
Do. do. (spineless)							x						1
10. *D. lobostoma* Ldy. ..	x	x									x		3
11. *D. oblonga* Ehr. ..	x	x	x	x				x			x	x	7
12. *D. tuberculata* Wallich						x							1
13. *Euglypha acanthophora* Ehr...		x	x	x	x	x			x	x			7
14. *E. cristata* Ldy. ..					x								1
15. *E. tuberculata* Duj. ..	x	x			x								3
16. *Pareuglypha reticulata* Pen...					x	x	x	x					4
17. *Trinema enchelys* Ldy.				x	x	x	x	x		x	x		7
	6	11	8	8	13	11	9	6	5	7	7	6	

The recorded Rhizopodan fauna of this lagoon consists of nineteen species either living or represented by empty tests ; of this number three occur only once, viz. :—*Difflugia leidyi* Wailes (July) ; *Euglypha compressa* Cart. (Sept.) ; *E. cristata* Ldy. (May) ; while *Arcella artocrea* Ldy., *A. mitrata* Ldy., and *A. vulgaris* Ehr., are present in every instance. With reference to *Arcella* it must be mentioned, however, that this genus received special attention. The largest number of living forms is recorded from May, viz., 13., and the least from September, viz., 5. It seems that the large form of *Difflugia oblonga* Ehr., prefers the warmer months of the year, and *Trinema enchelys* Ldy., and *Pareuglypha reticulata* Pen., the cooler ones. This record of the latter species is believed to be the first for Australia.

My thanks are due to Mr. E. W. Bick, Curator of the Brisbane Botanic Gardens, for permission to obtain the material used in this investigation.

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AN INTERIM CENSUS OF CYANOPHORIC PLANTS IN THE QUEENSLAND FLORA.

By F. Smith, B.Sc., F.I.C.
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C. T. White
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(*Read before the Royal Society of Queensland, 27th May,* 1918).

The summaries made by Greshoff showed a wide distribution of hydrocyanic acid in the vegetable kingdom. The list of cyanophoric plants published by him in 1906 [1, 2], embodying his own observations at Buitenzorg and those of previous and independent workers, comprised nearly 100 genera, and these were later considerably supplemented by the examinations of plant material at Kew.[3] The number of plants ascertained to be cyanophoric is continually being added to. Dr. J. M. Petrie [4, 5, 6], has recently investigated the occurrence of hydrocyanic acid in plants indigenous to and naturalised or cultivated in New South Wales, and has defined as containing cyanogenetic glucosides 61 new species and varieties, including 22 grasses. The present paper presenting the results of observations instituted in 1914, and continued with intermission till the present, is, therefore, while including a number of species dealt with by Petrie, to be regarded as extending the work on the Australian flora.

Upward of 700 plants have been examined, and were mostly specially collected for the purpose. The test

(1) See references at end of paper.

adopted was the action of hydrocyanic acid vapour upon Guignard's soda-picrate paper, after plasmolysis of the living cells by chloroform, which brings about the reaction of the glucoside with the enzyme with which, so far as our experience goes, it is invariably associated.

The list following comprises 68 indigenous plants, in 22 natural Orders, which have definitely been shown to be cyanophoric in Australia. Further species of wide geographic range recorded as containing hydrocyanic acid elsewhere, but of which specimens could not be obtained by us, are also listed but marked†. In view of the finding of Armstrong and Horton[7], that *Lotus corniculatus* may contain no hydrocyanic acid in certain geographical situations, and Petrie's[5] negative results in New South Wales with species of Gramineae, elsewhere cyanophoric, the possession by these of cyanogenetic properties is probable rather than certain.

Where possible the examination of each plant was more than once repeated at seasonal intervals. The periodicity very frequently noted in the occurrence of hydrocyanic acid in plants renders it possible that certain species examined at one season only and found to be negative in reaction might at other times have been cyanophoric.

Of the plants listed 13 are found in the Gramineae, 10 among the native ferns, and 9 in the natural order Proteaceae. Passifloraceae and Droseraceae are also prominently cyanogenetic families. We believe the order Chenopodiaceae has not been previously recorded as containing any cyanophoric plant.

Twenty-two plants are recorded for the first time as yielding hydrocyanic acid.

Where interest attaches to the plant as a reputed poison, or where from its herbaceous character, it is likely to be eaten by stock, it is the subject of a special note.

MAGNOLIACEAE.

Drimys dipetala F.v.M. (Petrie, 1912).

LINACEAE.

Linum marginale A. Cunn. (Petrie, 1912).

Rutaceae.

Zieria laevigata Sm. (Petrie, 1912), *Z. Smithii* Andr. (Petrie, 1912), *Z. Smithii* Andr. var. *macrophylla* (Bonpl. Benth), *Z. furfuracea* R. Br.

Z. Smithii is a fairly common plant in Southern Queensland; it has been accused of causing losses amongst stock in Tasmania.

Olacineae.

†*Ximenia americana* Linn. (Ernst, 1867).

Sapindaceae.

Nephelium tomentosum F.v.M. (*Alectryon tomentosus*, Radlk.), *N. coriaceum* Benth. (*Alectryon coriaceus*, Radlk.), *Heterodendron oleaefolium* Desf. (Petrie, 1917).

The last is looked upon as one of the best of our indigenous fodder trees.

Leguminosae.

Lotus australis Andr. (Dunstan, Henry, 1900), *L. corniculatus* Linn. (Petrie, 1912; Armstrong and Horton, 1912), †*Phaseolus Mungo* Linn. (Leather, 1906).

Lotus australis has several times been suspected of causing the death of stock in Queensland.

Saxifrageae.

Davidsonia pruriens F.v.M. (Petrie, 1912).

Droseraceae.

Drosera spathulata Labill. (Petrie, 1912), *D. binata* Labill. (Greshoff, 1909), *D. peltata* Sm. (Petrie, 1912).

Drosera peltata has been looked upon as harmful to cattle; this and *D. binata* are comparatively large-growing species which often occur abundantly on wet, swampy land. In August, 1910, J. Dansey, Stock Inspector, Chinchilla, forwarded specimens of *Drosera auriculata* and *D. spathulata* to the late F. M. Bailey, then Government Botanist, as suspected of causing the death of a number of young calves in his district.

Passifloraceae.

Passiflora Herbertiana Lindl. (Petrie, 1912), *P. brachystephana* F.v.M. (Petrie, 1912), *P. aurantia* Forst. (Brunnich, 1914), *P. aurantia* Forst. var. *pubescens* Bail.*

*Fresh material was kindly forwarded to us by Dr. T. L. Bancroft, Eidsvold.

Passiflora Herbertiana and *P. aurantia* have been accused of poisoning stock. *P. suberosa* var. *minima* and *P. foetida* are common naturalised weeds in Queensland; both are powerfully cyanophoric, and have been accused of poisoning stock. *P. alba*, another naturalised species, is poisonous to stock, and is the subject of a special paper by S. Dodd[9]; several tests of it carried out by us have always given negative results. It is, however, recorded as cyanogenetic by Petrie[6].

Rubiaceae.

Canthium vaccinifolium F.v.M., *Pomax umbellata* Sol. (Petrie, 1912).

Pomax umbellata is a very common plant often seen as a pasture and roadside weed.

Goodenovieae.

Dampiera Brownii F.v.M. (Petrie, 1912).

Convolvulaceae.

†*Ipomaea dissecta* Willd. (Prestoe, 1874), †*I. sinuata* Ortega (v. Romburgh, 1894).

Myoporineae.

Eremophila maculata F.v.M. (Brünnich and Smith, 1910).

This shrub has long been looked upon as fatal to stock; it is the subject of a special paper by Brünnich and Smith[10].

Illecebraceae.

Dysphania myriocephala Benth.

Has several times been accused of causing losses amongst stock; an illustrated article dealing with it will be found in the "Queensland Agricultural Journal" for June, 1915[11].

Chenopodiaceae.

Chenopodium carinatum R.Br.

A very common, strong-smelling herbaceous weed.

Proteaceae.

(*a*) *Macadamia ternifolia* F.v.M. (Greshoff, 1909), *M. ternifolia* F.v.M. var. *integrifolia* Maid. and Betche (Petrie, 1912), (*c*) *M. minor* Bail., *M. Lowii*, Bail.*, (*b*) *M. Whelani*

*Perhaps identical with *M. minor*.

Bail. (Brunnich, 1904), *Xylomelum pyriforme* Knight (Petrie, 1912), (*d*) *Hicksbeachia pinnatifolia* F.v.M., (*e*) *Lomatia silaifolia* R.Br., (*f*) *Grevillea Banksii* R. Br., (*g*) ? *G.* sp. ("Silver Oak.")

(*a*) *M. ternifolia*, the common "Queensland Nut," produces an exceedingly pleasant-flavoured edible seed.

(*b*) The seeds of *M. Whelani*, which are powerfully cyanophoric, are used as food after careful preparation by the aborigines in North Queensland; some nuts gathered by Meston's Bellenden Ker Expedition in 1904, and tested by us 11 years after, in 1915, gave a positive reaction.

(*c*) Mr. R. Illidge informs us that the seed of the "Small Queensland Nut," *M. minor*, a small tree, fairly common in the Gympie and Blackall Range "scrubs," was always regarded by the settlers in the early days, and by the aborigines, as poisonous, and tests carried out with both foliage and fruit gave strong positive reactions; the nut, however, is commonly eaten in moderation without any ill effects: its bitter taste was noted by Tryon[12], who suggested the presence therein of prussic acid.

(*d*) Both foliage and seed of *Hicksbeachia pinnatifolia* gave a positive reaction; the pericarp of the fruit a negative test: the seeds are commonly eaten, but not in very great quantity, for, as far as our observations go, the trees do not bear very large crops, and the nut is of poor quality; in Southern Queensland it is known as the "Beef Nut."

(*e*) A. G. Hamilton[13] has recorded the fact that flies feeding on the nectar of *Lomatia* flowers died in numbers, and further stated that Dr. Petrie was of the opinion that hydrocyanic acid was the cause. Some flowering sprays of *L. silaifolia* were recently brought in to us by Mr. T. A. Brown, Wellington Point, who observed that bunches placed on the table attracted and killed flies. The panicles cut up and tested in the usual way gave a positive reaction. The foliage gave a negative test.

(*f*) Leaves gave a negative, flowers and fruit a strong positive test.

(*g*) Fresh leaves of the tree known in the Atherton tableland area in Northern Queensland as "Silver Oak" gave a positive test; our specimens are imperfect, and do not allow us to determine the tree botanically; it probably represents an undescribed species of Grevillea.

Euphorbiaceae.

Bridelia exaltata F.v.M.

Very commonly seen as a secondary growth in paddocks in the scrub areas of Southern Queensland.

Flagellariaceae.

Flagellaria indica Linn. (Petrie, 1912).

Juncaceae.

Juncus prismatocarpus R.Br. (Petrie, 1917).

Aroideae.

Alocasia macrorrhiza Schott. (Harris and Smith, 1916), *A. macrorrhiza* Schott var. *brisbanensis* Bail., *Colocasia antiquorum* Schott.

A. macrorrhiza is a very common "scrub" plant known commonly as "Cunjevoi," and has at times been thought to cause the death of cattle[14]; its use as a fish poison has also been referred to.[15]

Gramineae.

Andropogon intermedius R.Br. (Petrie, 1913), *Chrysopogon parviflorus* Benth. (*Andropogon micranthus* Kunth), (Petrie, 1913), *C. Gryllus* Trin. (*Andropogon Gryllus* Trin.) (Petrie, 1913), *Sorghum halepense* Pers. var. *mutica* (*Andropogon halepensis* Sibth. var. *mutica* Hack.) (Petrie, 1913), *Anisopogon avenaceus* R.Br. (Petrie, 1913), *Danthonia racemosa* R.Br. (Petrie, 1913), *D. semiannularis* R.Br. (Petrie, 1913), *Chloris truncata* R.Br. (Petrie, 1913), *C. ventricosa* R.Br. (Petrie, 1913), *Eleusine aegyptiaca* Pers. (Petrie, 1913), *E. indica* Gaertn. (Petrie, 1913), *Leptochloa decipiens* Staph. (Petrie, 1913), *L. subdigitata* Trin.

Filices.

Davallia pyxidata Cav., *D. elegans* Swartz. (Greshoff, 1909), *D. solida* Swartz., *Lindsaea linearis* Swartz. (Petrie, 1912), *L. microphylla* Swartz. (Petrie, 1912), *L. Fraseri* Hook., *L. ensifolia* Swartz., *L. incisa* Prentice, *Lomaria Patersoni* Spreng., *Asplenium flabellifolium* Cav. (Petrie, 1912).

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SOME FURTHER NOTES ON THE LIFE-HISTORY OF *CERATODUS* (*NEOCERATODUS*) *FORSTERI*.

By Thos. L. Bancroft, M.B. Edin.

(With text-figure 9.)

(*Read before the Royal Society of Queensland, 24th June,* 1918.)

I have already recorded some observations on the Burnett River *Ceratodus*,* particularly the absence of small forms; fish about six pounds in weight were the smallest seen up till May 18th, 1914, when one 20 inches in length and weighing 2lbs. was caught in a mullet net, and on April 11th, 1915, a smaller one still was taken by dynamiting; it was 16½ inches in length and weighed 1½lbs. Mention was made in the Memoirs of the Queensland Museum† of a still smaller specimen, 367mm. in length.

In October, 1914, with the intention of rearing some *Ceratodus* from the ova under more favourable conditions than hitherto, a large hollow log was requisitioned to act as an aquarium. It was 20 feet in length, 2 feet in diameter and gave a depth of water 14 inches. It was placed in position on the river bank thirty feet above the normal water level, and a hand pump was fitted so that the trough could be filled with river water, while sand, mud, and water weeds were introduced to resemble closely a bit of the river. About 80 young *Ceratodus*, from 2 to 6 weeks old, which had been reared in glass jars, were introduced into the trough and their growth recorded from time to time.

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*Proc. Roy. Soc. Q'land, xxiii, 1911, p. 251-5; xxv, 1913, pp. 1-3; xxvii (1), 1915, pp. 58-9.

†Q'land Museum, Memoirs, i, 1912, p. 65.

Very few, however, survived, and the last one died when two years of age. Compared with the growth that obtains in most fishes, that of *Ceratodus* is very slow; at birth, the fish is about half an inch in length and in two years it had hardly reached the length of five inches.

Not being satisfied with the results obtained, I removed the trough and set it up near my house in Eidsvold. For two seasons I introduced over fifty young *Ceratodus*, several weeks old, only to see them all disappear within a couple of months, possibly having been devoured by dragon fly larvae, of which there was abundance. Endeavours are again being made, this time in the direction of excluding water-beetles, dragon-fly larvae, frogs, and other animals, some or all of which attack the little fish.

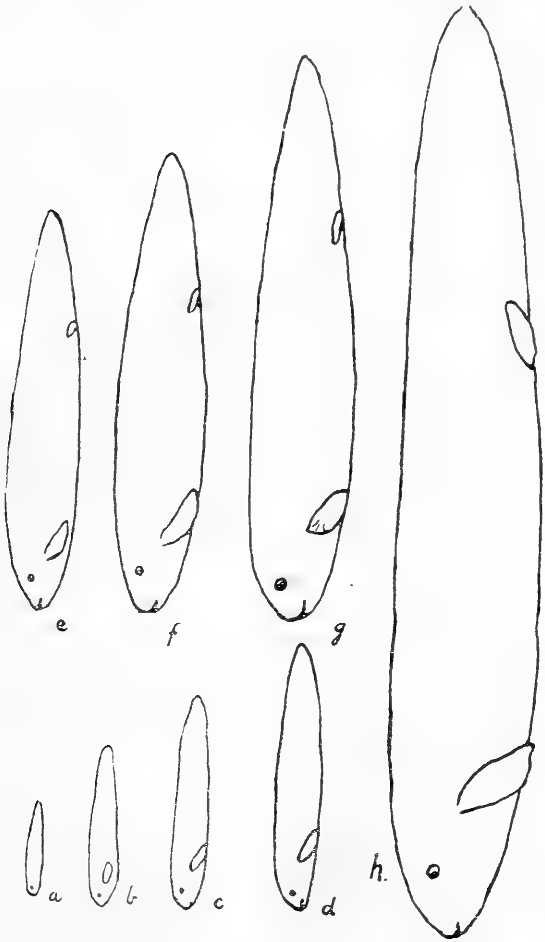
Any one having read the descriptions of *Ceratodus* as given in books would have learnt some erroneous ideas of the fishes habits, amongst others, in the matter of the frequency of coming to the surface of the water to take in air. For instance, Dr. Bashford Green, from observations made on two *Ceratodus* in captivity at the Zoological Gardens, London,* writes:—"At intervals of 40 to 60 minutes the fish shows uneasiness in the water, gasps several times, then rises to the surface, exhales and draws in a mouthful of air somewhat spasmodically;" then again, Richard Semon, in his book "In the Australian Bush" p. 92, states:—"I kept *Ceratodus* alive in great barrels and self-dug water holes; I saw them appear at the surface every thirty or forty minutes, etc." At Eidsvold I kept two large *Ceratodus* alive in a tank with water-weeds under favourable conditions for two years, and during that time I never once was fortunate enough to see one rise to the surface to breathe; one might remain quietly a whole afternoon at a lagoon on the Burnett River, in which lagoon there were numerous large *Ceratodus*, and never once see or hear a fish rise; at other times he might see several rises in that time; were the statements, as made in books, true one would expect to see hundreds of rises.

With regard to Semon's observations I can only conclude that his fish were sick or dying. The fish at the

* "The Animals of Australia," Lucas and Le Souef, p. 300.

London Zoo are healthy enough, but it may be that too much light or noise irritates them; at any rate, fish in their natural home do not behave so.

During flood time they rise more frequently; as a general statement it might be fairly accurate to say *Ceratodus* breathes air several times in a day of twenty-four hours.



Text-figure 9.—Outlines of *Ceratodus*.

a. At birth (13mm.); *b.* two months old (23mm.); *c.* three months (30 mm.); *d.* four months (36mm.); *e.* five months (53mm.); *f.* six months (62mm.); *g.* seven months (75mm.—weight, 30 grains); *h.* two years (123mm.—weight, 144 grains).

I believe myself that they can stay at the bottom for days together; I know that they resemble eels in being able to exist buried deep in mud after a lagoon had dried up. When a heavy thunderstorm has caused much mud to enter the river suddenly *Ceratodus*, like mullet, cat fish, and perch, have died, but I have never seen an eel die from that cause.

I have had the opportunity of seeing the river in a prolonged drought and find that, contrary to what I had expected would have obtained in a large, deep lagoon * water-weeds follow the receding water and up till the last the general appearance of the lagoon is similar to its normal state, that is to say, there are always water-weeds with the associated fauna—small fish, insects, shrimps, etc.

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*Proc. Soc. Roy. Q'land, xxiii, 1911, p. 253.

VARIATION IN THE SEPALS OF *BRUGUIERA RHEEDII* BLUME.

By C. D. GILLIES, M.Sc.,
Biology Department, University of Queensland.

(With text-figure 10).

(*Read before the Royal Society of Queensland, 24th June,* 1918.

During the visit to Caloundra in May, 1918, of the Biology students of the University of Queensland, I availed myself of the opportunity for collecting material for the study of the variation in the number of sepals in the calyx of the mangrove, *Bruguiera Rheedii* Blume.

The calyx of this form is a conspicuous red structure and is commonly found in the tidal debris along the shores of Pumice-stone Passage, which separates Bribie Island from the mainland. The specimens used in the investigation came from this locality and were gathered partly off the plant and partly from the tidal debris. Altogether 118 calyces were collected, and it was found that the number of sepals varied from 9 to 13, the frequencies being as follows :—

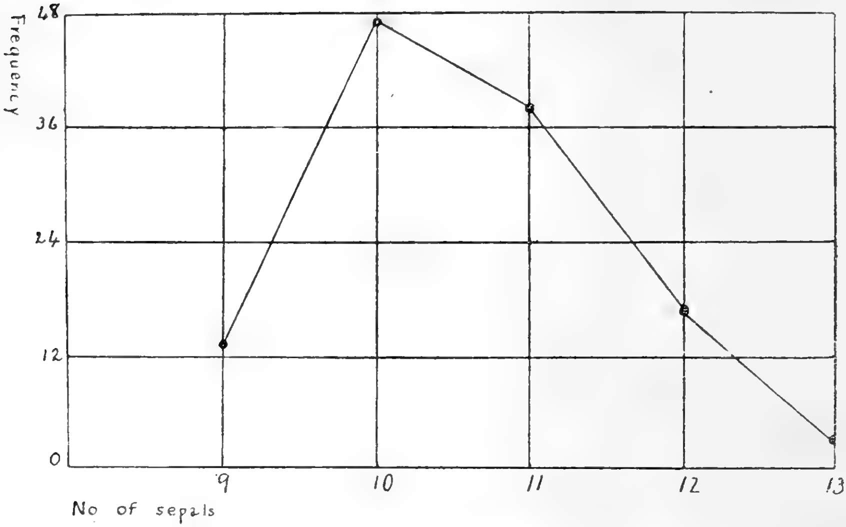
No. of sepals	9	10	11	12	13
Frequency	13	47	38	17	3

Total number of variates : 118.

The following biometric constants have been calculated from the data given above :—

Mean : $10.576 \pm .002$. Mode : 10.471.
Index of variability : $.3 \pm .001$. Coefficient of variability : $2.84 \pm .001$.

One calyx apparently was composed of 10 sepals, including one of abnormal size. On examination it was seen that the latter was formed of two fused sepals, so the calyx actually contained 11 sepals. As this was the only case of such variation, out of the 1,284 sepals examined, the ratio of fusion or gamosepaly to the free condition or polysepaly is 1:623.



Text-fig. 10.—Frequency polygon of the sepals of *Bruguiera Rheedii* Blume.

It will be observed that—

(*a*) The frequency polygon is unimodal (see text-fig. 10).

(*b*) The theoretical mode is 10.471 ; that is, the actual mode is 10.

(*c*) The co-efficient of variability, 2.84, is a low value, as usually this constant ranges from 10-20.

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THE BUILDING STONES OF QUEENSLAND.*

By H. C. Richards, D.Sc.
Lecturer in Geology, University of Queensland.

(With 3 Plates and 10 Text-Figures).

(*Read before the Royal Society of Queensland, 29th July,* 1918).

* The Council of the Royal Society of Queensland desires to acknowledge its gratitude to the University of Queensland, for its assistance towards the printing of this paper; also to the Government Tourist Bureau and Government Savings Bank Department, for the loan of blocks for the text-figures.

Introduction.

Some years ago the late Prof. W. C. Kernot, speaking of the University of Melbourne, said "by selection of inferior stone and bad workmanship the Melbourne University has in 50 years attained an appearance of antiquity which it has taken the Colleges of Oxford and Cambridge half a dozen centuries to acquire." These remarks as to the selection of inferior stone at least might very well be applied to several buildings in Brisbane—notably the old R.C. Church alongside St. Stephen's Cathedral.

The question of stone-selection for building purposes is one of very great importance not only on economic grounds but also aesthetically.

Queensland is, relatively speaking, a young State, so that an earnest consideration of her possibilities as a producer of stone suitable for building purposes is one of considerable moment.

The utilisation of stone for Government and Municipal buildings, Churches, Banks, Bridges, etc., is one that is likely to persist in spite of the increasing uses which are being found for reinforced concrete, brick, etc.

Stone structures have an air of solidity and quality which the best imitations of cement, etc., fail to reach and which will always call forth from the people a demand that their important structures be built in stone.

The feelings of security and trust engendered in the public mind by adequate solid stone Government Buildings, Banks, etc., are by no means unimportant and are well worthy of encouragement and development.

The policy which Queensland has adopted of utilising stone in the construction of the very fine structures housing the various Government Departments, is one which causes much admiration not only from the citizens of this State but also from visitors.

A considerable number of different stones have been used in Brisbane and other Queensland towns and, in many cases, the buildings containing them have been erected for upwards of half a century, so that an investigation into the manner in which these stones are weathering is one that can be made with much advantage.

Brisbane has a kindly climate for building stones and yet evidence of badly-weathered material is available in many places.

Owing to the high initial cost of stone structures, a long life is a necessity, so that the greatest insistence should be placed on the sound weathering qualities of the stone. The abundant evidence as to the cost of repairs and upkeep, through unwise selection, furnished by the older European cities, the American Cities, and even our own city, should impress us forcibly with the wisdom of exercising all possible caution. In the Official Year Book of the Commonwealth of Australia, No. 9, 1916, there is a section dealing with the Building Stones of the Commonwealth. Under the Queensland sub-section, however, it is stated :—"Unfortunately there is not sufficient information available to permit of a detailed statement being given in regard to the quantity and quality of Queensland Building Stones."

As the author has been collecting the available information for some time and has studied the question somewhat closely for some years it is hoped that the present paper will help in the direction of furnishing that information.

Previous Literature.

There has been very little published with respect to the subject of this paper. In 1888, Parliament appointed a Select Committee to report on the Sandstone Quarries of the Southern District. The report is to be found in Votes and Proceedings, iii, 1888, pp. 1021—1044. It shows that the matter was very closely investigated and quarries in the Warwick, Highfields, Murphy's Creek, Helidon, Grandchester, Brisbane, Logan Village and Beaudesert districts were inspected and a great deal of evidence collected.

Generally speaking the views offered in evidence as to the respective values of the different stones have been borne out by the weathering in the buildings.

In 1905, Mr. L. C. Ball, B.E., published an article in the Government Mining Journal, p. 457, on the Queensland Stones for Architectural and Monumental Purposes. The article is quite a brief one and while mention is made of the important granites and marbles the section on sandstones is rather incomplete. In the previous year, in Publication 194 of the Geological Survey, Mr. Ball dealt very fully with the limestones and marbles of the Central District, giving full descriptions of the fine marble deposits in the Duke Group of the Northumberland Islands, between Rockhampton and Mackay, also of the marbles in the Calliope area, near Gladstone.

In 1911 a paper by the writer on the Building Stones of St. John's Cathedral was published by the Royal Society of Queensland in its Proceedings.

The Queensland Mineral Index by B. Dunstan, F.G.S. contains references to limestones and marbles.

Acknowledgments.

My best thanks are due to many who have helped me to obtain information for this paper. The officials of the Public Works Department and Chief Engineer's Branch of the Railway Department have been especially good and have kindly granted me permission to publish the results of the official tests which have been carried out from time to time. Mr. Brady, the Government Architect, and Mr. Pye, the Deputy Government Architect, have afforded me much help, while from Inspector G. Cryle, of the Public

Works Department, I have obtained a great amount of information as to dates of erection of many buildings throughout the State and the sources of the stones used in them. Mr. T. Wright, the owner of the Helidon quarries, kindly furnished many details as to the periods over which quarries worked and also as to the stones used in various structures. To Mr. C. C. Dornbusch, Architect, Warwick, I am indebted for details as to stones used in the various stone buildings of that town, while Mr. F. M. Allan, of Rockhampton, kindly afforded information as to the periods of erection of the important structures in the latter place.

Building Stones of Queensland.

For general purposes we may divide these into three groups: (*a*) Igneous; (*b*) Sedimentary; (*c*) Metamorphic.

Igneous Building Stones.

Under this heading we have:—(*a*) "Granites"; (*b*) Rhyolites and Trachytes; (*c*) Basalts.

GRANITES.

The term "granite" as used by architects, builders and masons is much wider than that of the petrologist, but the more popular term will be used here. It may be mentioned, however, that granite in its strict petrological sense is a rather rare rock in Australia, and the "granites" used in Australia almost invariably come under the description of granodiorites.*

Enoggera Granite.

This is a stone which is in close proximity to Brisbane; it has been used to some extent in public buildings, and for kerbing purposes.

The granite is of late Palæozoic age, occurs a few miles to the west of Brisbane and outcrops over an oval area about four and a quarter miles long in a N. and S. direction and two and three-quarter miles in an E. and W. direction.†

The quarries have been made on the eastern side of the outcrop, about one third of a mile from the contact of the granite and the schist. They are situated at the "Gap,"

* See Hatch "Text Book of Petrology," 1910 Edition, p. 164.

† Bryan, W. H., Proc. Roy. Soc. Qld., xxvi, 1914, p. 147.

where the Enoggera Creek makes its way between Enoggera Range and Taylor Range, and are on the north side of the Waterworks road across the creek. Several small quarries have been worked, and in one of them a felspar-porphyry dyke about nine inches wide is seen passing through the granite. The jointing is not at all regular and it is a matter of difficulty to quarry the stone in an economical manner. The stone when fresh is grey but it takes on a pinkish tinge, owing to iron staining, when the boulders have become weathered.

The granite in the hand specimen has a "pepper and salt" appearance and is made up of translucent quartz, white cloudy felspar, small flakes of biotite or black mica, and in some cases hornblende and occasional crystals of pyrites. It is a fine-grained granite and this, coupled with the rather small amount of fine crystals of biotite and hornblende, results in a lack of "relief." The stone takes a very good polish, but it does not repay in added appearance for the extra cost.

A microscopical examination of the stone shows it to have an average grain-size of from 1.5—2mm. The fabric is granitic, although in places it is micrographic.

The minerals present are plagioclase, orthoclase, quartz, biotite, hornblende, pyrites and chlorite in decreasing order of abundance (see microphotograph 13, plate X). The felspars are rather cloudy and the biotite in most cases is very much altered into chlorite. The pyrites present in the sections is invariably fresh.

The occurrence of crystals of pyrites throughout the rock, and of cavities or "vughs" containing calcite, pyrites, etc., is a great disadvantage to this stone. The pyrites rapidly oxidises to hydrated iron oxide which has a dirty brown colour and much depreciates the appearance of the stone. An examination of this stone in the base of the Executive Building or Central Technical College well illustrates this objection.

A noteworthy feature of the stone is the comparative absence of segregations and in this respect it compares very favourably indeed with the Moruya granite of New South Wales and the Harcourt granite of Victoria. Segregations of either an acid or basic nature are rare but, unfortunately, the stones used in the base-course under the recently-laid foundation stone of the proposed new Town Hall show a very pronounced acid vein through them. For building-stone purposes the presence of pyrites and its subsequent oxidation will always be a grave objection to this stone, but this difficulty could be overcome by opening up stone in those portions of the granite free from pyrites. The Enoggera granite mass is extremely variable* and this is shown not only in the nature and relative proportions of the minerals but also in the size of the grains and the fabric of the rocks. Bryan records the granite mass as being made up of two main types, the major portion being a uniform flesh-coloured granite made up of quartz, pink orthoclase, plagioclase and black-mica phenocrysts set in a fine-grained flesh-coloured groundmass; this type is usually free from pyrites. The other type is characterised by the rock which has been worked at the quarries and it has a greater proportion of hornblende and biotite, is lacking in pink orthoclase and contains a marked quantity of pyrites.

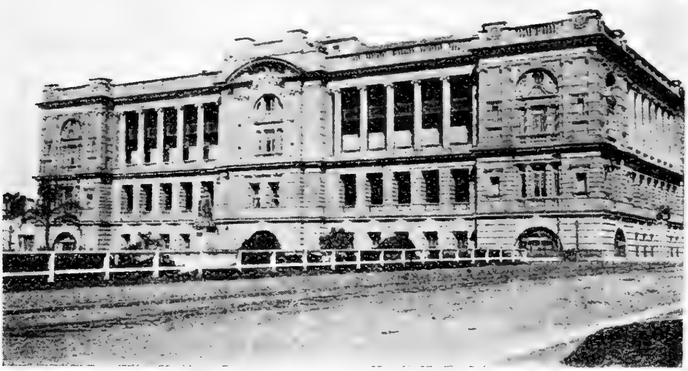

Fig. 11. Executive Building, Brisbane.

View from William Street. Erected 1901-5 of sandstone from Helidon and Yan Gan on base of alternate layers of Enoggera and Mt. Crosby granites.

* Bryan, W. H., Proc. Roy. Soc. Q'land, xxvi., 1914, p. 148.

The stone has been used in the bed blocks on the abutments of the Victoria Bridge (1894-97)*, in the base of the Executive Building (1901-05) together with alternate courses of the Mt. Crosby granite, in Shaw and Sons' buildings (1904) in Queen Street, in George St. entrance to the Government Printing Office (1912), in the front steps and side steps of the administrative block at the Central Technical College (1912-14), in the base of the foundation stone of the proposed new Town Hall in Albert Square, as kerbing stones along the recently relaid tram lines in Queen and George Streets, and to a large extent all over Brisbane as pitchers about fire-plugs.

As to its general weathering properties no exception can be taken except the oxidation effect of the pyrites which in itself is very serious. The stone used in the steps at the base of Queen Victoria's statue was carefully worked over, the pyrites chiselled out and the holes subsequently filled with cement. The advantage of doing this is realised after an inspection of the stone in the base of the Executive building alongside and the base of the adjoining George Street fence. The rapidity of oxidation of the pyrites is rather surprising and in the space of a few months the effect is quite pronounced, and it becomes increasingly so for some time at least.

The Enoggera granite looks better rock-faced than patent-hammered as it is naturally a light grey fine-grained granite and patent-hammering, owing to the crushing effect, results in the colour of the stone becoming lighter.

For the purposes of pitching and kerbing the stone is an excellent one, being naturally very tough—especially the hornblende-bearing material—and its fine-grained character is an advantage, as it resists abrasion better than coarser-grained granite.

This stone has not been tested for resistance to crushing but it is certain to give high results. During last year samples of Enoggera granite and Bowral "trachyte" were subjected to sand-blast tests to determine the resistance to abrasion. The tests were conducted in the Engineering Department of the University, and the Enoggera granite

* Dates in brackets after buildings indicate the years of erection.

resisted better in that it lost less weight of material, but its abraded surface was not so smooth as that of the "trachyte."

A chemical analysis of a representative sample of the rock from the quarry was made some years ago by Mr. N. Christensen of the Agricultural Chemical Laboratory. The results are shown in the table on page 150.

The norm gives the following calculated mineralogical composition :

Quartz	34.14	per cent
Orthoclase	17.24	,, ,,
Albite	25.15	,, ,,
Anorthite	11.68	,, ,,
Corundum	1.84	,, ,,
Hypersthene	7.65	,, ,,
Magnetite	0.93	,, ,,
Ilmenite	0.76	,, ,,
Apatite	0.67	,, ,,
Pyrites	p.n.d.	
Water	0.42	,, ,,
	100.48	

Classification : I. 3.2.3. *Tehamose.*

Although the norm is only the calculated and not the actual mineralogical composition it serves to show the great preponderance of light-coloured minerals and the paucity of ferro-magnesian minerals in the stone.

The density is 2.59 which is on the low side for a granite ; as a result the stone would weigh 162lbs. per cubic foot.

Mt. Crosby "Granite."

This handsome stone occurs in the neighbourhood of Mt. Crosby, and the material used in Brisbane was obtained from Bendley's selection, boulders only being worked.

The "granite" is a dark green rock of medium grain and it has a much greater proportion of dark ferro-magnesian minerals than either the Enoggera granite or the Greymare granite.

It may be seen in the base of the Executive Building in alternate courses with Enoggera granite. An opportunity exists therefore of comparing it with the Enoggera granite, and it is seen to be free from pyrites and to be much darker. It has been both rock-faced and patent-axed, and in both modes of work it looks well.

The specific gravity of this stone is 2.84 so that its weight per cubic foot is 177.5lbs.

The stone is rather more coarsely crystalline than the Enoggera granite and has an average grain-size of about 2mm. The rock is made up of plagioclase felspar, augite and biotite for the most part. These minerals can be detected easily by an examination with a lens. Under the microscope the fabric is seen to be granitic and the minerals constituting the rock to be plagioclase, augite, biotite, orthoclase, quartz, and magnetite in order of decreasing abundance (see microphotograph 14, plate X).

In comparison with the Enoggera granite it is seen that the dark ferro-magnesian minerals are much more abundant and the individual crystals are much larger. Augite is very abundant and occurs up to 3mm. in length; it is generally in a fresh condition but in some places it is altered to chlorite. All the minerals are very stable. Petrologically this rock would be known as quartz-diorite.

It has been used for bed plates and as a cut-water in the Albert Bridge (1893-95) at Indooroopilly, for two or three courses in the base of the Executive Building (1901-05) and in the base of the Royal Insurance Building (1906) in Queen Street.

This stone has much to commend it; it does not seem to have any mineralogical or structural defects, but on the other hand it has a very handsome appearance and looks well when worked. Consequently a more extensive use of this stone is to be hoped for. The outcrop is within a very few miles of the Brisbane river at a point from which gravel barges now ply to Brisbane, so that it is reasonably accessible to Brisbane.

Greymare Granite.

This occurs in the neighbourhood of Greymare, 20 miles west of Warwick and 180 miles from Brisbane, and outcrops over a large area. No proper quarrying has been done, and surface boulders only have been worked. These have been worked in the immediate neighbourhood of the Greymare railway station and consist of material much fresher than the general mass of granite. The freshness of the stone in these boulders right up to their outer surface is remarkable, as the material surrounding the boulders is in a highly weathered condition. Very large stones are available, as large boulders with joints far apart occur, and the stone works freely.

The granite is a grey one and is made up of quartz, felspar and the black mica, biotite. The rock seems to have

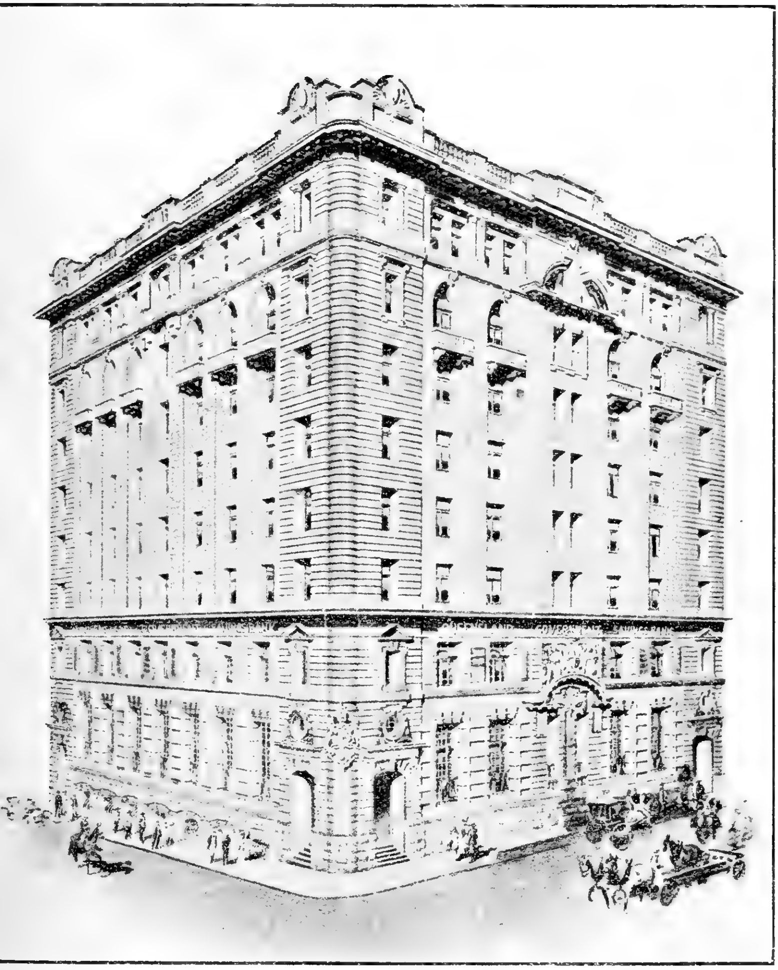

Fig. 12 GOVERNMENT SAVINGS BANK, BRISBANE.

Erected 1915 —. Helidon sandstone on base of Greymare granite. This illustration has been made from an architectural drawing in the Public Works Department.

undergone a movement prior to its final consolidation as the minerals have been orientated in a definite manner. This is particularly noticeable with the biotite, the flat flakes of which are arranged in a parallel manner.

The result is that the stone has a very different appearance according to whether it has been worked with the rift or the grain. When worked with the rift, that is parallel to the flat flakes, the large flat flakes of black mica are very pronounced and the rock has a distinctly spotted appearance; when worked in any other direction the thin edge only of the dark flakes show up and render the stone a lighter grey than is perhaps desirable. The stone takes an excellent polish which may be seen in the steps of the Government Savings Bank.

This is probably the best grey granite which has yet been worked in Queensland, and although it lacks "relief" owing to the paucity of the dark minerals it has a clean black and white appearance, is quite coarse enough in the grain and is exceptionally free from either basic or acid segregations. Its working qualities seem to be excellent so that the stone may quite well be used a great deal in the future. The distance from Brisbane and the absence of a proper quarry are factors against its development.

The resistance to crushing has not yet been determined. but its density has been measured and is 2.66 giving a weight of 166lbs. to the cubic foot.

A chemical analysis was carried out by Miss Ilma Sterne, B.Sc., and the results are shown in the table on page 150.

The calculated mineral composition or norm is,

Quartz	39.36
Orthoclase	8.34
Albite	26.20
Anorthite	11.40
Corundum	6.99
Hypersthene	3.43
Magnetite	2.78
Ilmenite	0.46
Water	0.72
Total	99.68

Classification: I. 3. 3(2). 4. near *Alsbachose.*

A microscopical examination of this rock shows it to have an even-grained granitic structure and to be of medium grain-size. The quartz and felspar crystals are about 2 mm. long while the average biotite flake is 1mm. long, but flakes occur up to 2.5 mm. in length.

The minerals present are quartz, plagioclase, orthoclase, biotite, chlorite and magnetite in decreasing order of abundance. The quartz and plagioclase are approximately equal in amount (see microphotograph 15, plate X). The biotite has to some extent been altered into chlorite, but generally speaking it is fresh. The plagioclase is occasionally cloudy but as a rule it is clear. It shows zoning to a very great extent and is acid andesine. The magnetite is present in very occasional inclusions in the biotite. A noticeable feature is the comparative scarcity of biotite. Pyrites is absent.

This granite has been used in the Technical College erected at Warwick a few years ago, in the base and as a kerbing along the front drive. The base of the Government Savings Bank, Brisbane, is composed of this material and lately it has been used as kerb stones alongside the tramrails in parts of George and Queen Streets, Brisbane.

Magnetic Island "Granite."

This is a very light-coloured granite with a pale pinkish tinge which is derived from the felspars. It is of medium grain and is composed of quartz, felspar, biotite, hornblende and magnetite in decreasing order of abundance. The dark minerals are not plentiful enough to give the rock the necessary "relief." Biotite occurs as very small flakes while the hornblende which is not abundant occurs as occasional rods. The stone is clean-looking but rather pale. It has been used in the base course and steps of the Custom House at Townsville.

Mackay "Granite."

L. C. Ball has described this as a pink to grey syenite and granite of very variable composition and appearance, occurring over an area of about 1 mile in diameter. He also states that the rock has been quarried for material for the breakwater at the mouth of the Pioneer River.

Townsville "Granite."

This is a medium to coarse-grained red granite. It is composed of clear quartz, felspar, both pink and white, the former predominating, and small dark-grained patches of ferro-magnesian minerals which have been altered very largely into chlorite. While the stone has a rich red colour and would polish well, it has not enough relief. L. C. Ball* states that the area near the town is 1 mile in diameter but that there is a much larger area 15 miles to the east; also on the coast. He records that the town material has been used for breakwater purposes.

Cooktown "Granite."

This has been recorded by L. C. Ball* as a light grey porphyritic granite occurring over an area of 3 miles in diameter. This material has been used to form the base of Captain Cook's monument which is of Murphy's Creek sandstone.

Stanthorpe "Granite."

This is a coarse-grained pale red granite composed of quartz, orthoclase, plagioclase and biotite in decreasing order of abundance.

The average grain-size is from 3 to 4mm., the orthoclase ranging up to 5mm. long. The pink colouration is due to the orthoclase. A very extensive area is occupied by this material which E. C. Saint-Smith† calls the "Stanthorpe" granite to distinguish it from the other granite of the area. The stone has not been used for structural purposes but has had a limited use for monumental purposes. It is not likely, however, to be used to any great extent.

Wallangarra Granite.

There is a porphyritic granite occurring near Wallangarra that is thought very highly of as a possible ornamental granite. Mr. E. C. Saint-Smith, of the Geological Survey, has drawn my attention to it and furnished me with a specimen. It is a dark-grey granite of coarse grain with large crystals of light-pink orthoclase up to $1\frac{1}{4}$ inches long set in a groundmass of quartz, orthoclase, plagioclase, horn-

* Q'land Govt. Min. Jour., vi., 1905, p. 457.

† Q'land Geol., Surv., Pub. 243, p. 39.

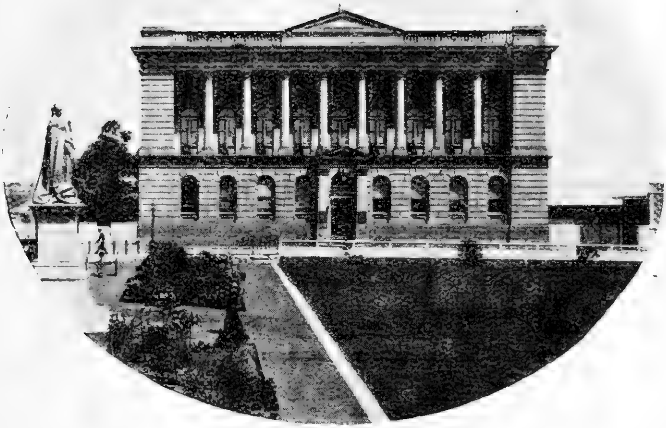

Fig. 13. PUBLIC LIBRARY, BRISBANE (OLD MUSEUM).

Erected 1877-79 of Murphy's Creek sandstone; on left, statue of Queen Victoria on base of Enoggera Granite.

blende, augite and sphene. The darker minerals are very abundant and of reasonable size. The average grain-size of the groundmass is about 4mm. The presence of the lighter felspar phenocrysts set in the darker groundmass gives the stone a handsome appearance. The distance from Brisbane will be a factor against the use of this stone.

Imported Granites.

Very little importation of granites for structural purposes has taken place in Queensland although for monumetal purposes it has gone on to quite a large extent.

Peterhead Granite.—The coarse red granite from Peterhead, Scotland, may be seen in polished panels at either end of Victoria Bridge (1894-97), in polished columns in the corridor and vestibule of the Town Hall, Brisbane (1864), and along the front of the 2nd floor level of this building, also in polished columns at the Queen Street entrance to the Union Bank (1916). The latter columns are of much deeper red than the columns in the Town Hall and must be regarded as excellent in every way.

Harcourt Granite.—This grey granite in the form of polished columns is seen in front of Shaw & Sons' building (1904) in Queen Street, Brisbane. It has also been used to a very limited extent in the base and foundations of St. John's Anglican Cathedral.*

"RHYOLITES" AND "TRACHYTES."

Glass House Mountains.—South-eastern Queensland is noted the world over for its development of alkaline rhyolites and trachytes. The development at the Glass House Mountains is particularly well-known owing to the peculiar occurrence of these isolated peaks.

More than one writer has drawn attention to the possible utilisation of these rocks for structural purposes, but no attempt has yet been made to work the stones. Each of the eight or nine peaks yields a different rock and remarkable variation in appearance is exhibited in each of the particular occurrences. For a full description of the various rocks the reader is referred to the writings of Dr. H. I. Jensen† and of the author‡.

All the rocks are fine-grained volcanic rocks of a light grey colour; sometimes the colour is a distinct bluish-grey. The rocks may be regarded as being made up essentially of sanidine (a clear variety of orthoclase) felspar, and of soda-rich augite; quartz occurs in several of the varieties (see microphotographs 10, 11, plate IX). The occurrence throughout the rocks of dark blue and dark green ferro-magnesian minerals often results in a very pretty effect owing to their disposition. The dark minerals may be evenly distributed and exist as small specks with a resultant "pepper and salt" appearance. They may occur as rods and as the rocks typically show fluxion structure the rods are arranged with the longest axes parallel and equidistant apart. On other occasions the dark minerals are arranged in moss-like aggregates. The stone is in close proximity to the railway line between Beerburrum and Glass House Mountains, a little over 40 miles from Brisbane.

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* Richards, H. C. Proc. Roy. Soc. Q'ld., xxiii (2), 1911, p. 204.

† Proc. Linn. Soc. N.S.W., xxxi-xxxiv., 1906-1909.

‡ Proc. Roy. Soc. Q'ld., xxvii (2), 1916, p. 40.1

The stones work freely and although more expensive to dress than the sandstones at present used they would be much cheaper to work than the Enoggera or Greymare granites. Provided fresh and unweathered material is used there is no doubt as to the lasting qualities of the stone. Either rock-faced or smooth-dressed it would look well, but in the rock-faced condition it would be very good and easily worked. It is difficult to say whether large stones could be quarried, as the jointing is not regular as a rule and is rather more frequent than usual with igneous rocks. Small stones, rock-faced and used as the Brisbane Tuff has been used in St. John's Cathedral, Brisbane, and elsewhere, would undoubtedly have a very handsome effect; the same stone smooth-dressed could be used for the facings. The quantity of stone is unlimited, and quarrying operations on a large scale could be carried on without detriment to the peaks.

These stones need earnest consideration and will probably be much used in the future. The cost of quarrying and working will be greater than that of the sandstones used at present, such as the Helidon sandstone, but the lasting qualities are infinitely better.

The specific gravity of the stones ranges from 2.47 to 2.71 which gives a variation of from 154 to 169lbs. per cubic foot. The stones are practically non-porous and will withstand a high crushing strain.

Rhyolite from Glen Rock, Esk.

At Glen Rock, Esk, there is an immense mass of a light yellow-brown rhyolite. The Esk Council has a quarry in this material from which it obtains road metal. The stone is very fine in grain, being only 0.75 mm.* and the arrangement of the crystals shows a poor fluxion structure. The minerals present are quartz, and the felspars, anorthoclase and sanidine (see microphotograph 9, plate IX). This rhyolite works very freely indeed for an igneous rock, dresses well, and would take a very sharp arris. The rock is rather frequently jointed where it is being quarried at present but no doubt a quarry site for obtaining reasonably large stones could be obtained.

* Richards, H. C. Proc. Roy. Soc. Q'ld., xxvii (2), 1916, p. 139.

The situation of the mass alongside the railway line and above it in level is very advantageous, whereas the distance from Brisbane of 70 miles only is reasonable. The remarks made earlier as to the use of the Glass House Mountains stones might be made with advantage here also.

This stone is worthy of investigation and the use of our rhyolites and trachytes for the proposed Town Hall is worthy of much consideration.

The rock is practically non-porous and would have a reasonably high resistance to crushing. The specific gravity is 2.43 giving a stone weighing only 152lbs. per cubic foot—a light stone.

Imported "Trachyte."

The only imported "trachyte" used in Brisbane is the Bowral "trachyte" from New South Wales. Strictly speaking this is not a trachyte but a syenite. It is a dark olive-green or dark grey in colour and of finer texture and more homogeneous nature than our granites. It takes a very fine polish.

It has been used in Brisbane, in conjunction with the Sydney sandstone, in the E.S. & A. Bank, in Eagle Street (1913), where it has been used in the base and the front to the first cornice. The base courses of Parbury House, in Eagle Street (1915), are of this stone, also the front of the Colonial Mutual Insurance Building, in Queen Street, up to the first cornice. In the latter building and in the E.S. & A. Bank the very fine polish the stone takes is well seen.

BASALTS.

Toowoomba Basalt.

This has been used in Toowoomba for rubble work but apart from that, to a very little extent for structural purposes. It is used extensively, however, for guttering and kerbing. The quarry is on the Range and shows magnificent columnar structure. This structure is availed of in quarrying the stone and in working it up.

The basalt is an olivine basalt and occasionally contains pockets of olivines which are eagerly sought for gem purposes (see microphotograph 7, plate IX).

Imported Basalt.

The *Footscray Basalt* from Victoria has been used to some extent in Brisbane. It is a dull, dark, bluish-grey in colour and has been used to a large extent in the recently-erected Union Bank (1916), in Queen Street and Creek Street fronts up to the level of the first cornice.

A great deal of work has been put into the basalt in this building and the carved heads show the extent to which the basalt can be worked. Quite large stones of this basalt are obtainable but in this bank the stones appear to be rather on the small side for the part they have to play, and they might have been larger with advantage to the appearance of the building.

In several of the stones little groups of holes over a circular area of a few square inches may be seen. These mark the passage of steam particles up through the basalt when in a molten condition.

This basalt has, among other places in Brisbane, been used in the base courses of the London Bank, of the Queensland Trustees Building, of Perry Bros. Warehouse, and in the foundations in part of St. John's Cathedral.

Sedimentary Building Stones.

SANDSTONES.

It is a noteworthy fact that almost all the most serviceable building sandstones of the Eastern Australian States are lacustrine deposits of Lower Mesozoic age.

In Queensland all the sandstones which have been used and, as far as the author knows, all those which have received any serious attention belong to these deposits.

In New South Wales the famous Hawkesbury sandstone, used to such a large extent and to so much advantage in Sydney and elsewhere, belongs to a lake deposit of Triassic age. That State, however, has two grey sandstones of Permo-Carboniferous age which have been used to some extent—the Waratah and the Ravensfield sandstones.

Victoria has utilised very many sandstones at different times but the one most extensively used is the brown Barrabool Hills stone from the Geelong district, which is a lacustrine deposit of Jurassic age. Another very

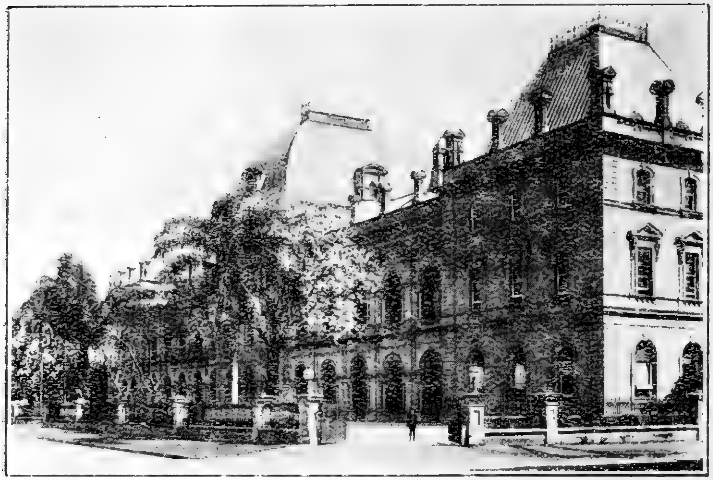

Fig. 14. Parliament House, Brisbane.

View along George Street front. Main structure erected 1865-67, of sandstone from Jeay's Quarry, Goodna; George Street colonnade of sandstone from Murphy's Creek.

serviceable sandstone of the same age and origin is the Apollo Bay stone.

The Carboniferous sandstones of Stawell and Dunkeld are probably better weathering stones but they are "cold" in appearance, very costly to work, and a great distance from Melbourne.

In Tasmania* there are numerous quarries in the Trias-Jura sandstones and they have supplied the material for numerous public and private buildings in Tasmania, as well as for many important buildings in Melbourne.

The sandstones used in Queensland are all of the same class, although there is a considerable variation in colour, grain-size, and amount of cementing material. The application of microscopic investigations to building stones is frequently of great value and the methods for sandstones as worked out by Hirschwald† are in many cases of distinct help.

* Comm. Year Book, No. 9, 1916, p. 465.

† Hirschwald, J., Berlin, 1908.

"Hirschwald takes the binding number (Bz) to mean the number of grains which appear to be combined with each single grain in the plane of the transparent section, and the measure of binding (Bm) is the quotient of the sum of those portions of the grain-circumference which have intergrown with the neighbouring grains and of the entire circumference of the grain. While as a general rule the number of texture pores increases with the 'grain binding number,' the size of the pores decreases with increasing measure of binding. The greater the quotient $\frac{Bm}{Bz}$ the larger the areas on which the grains adhere to each other, and therefore the more considerable the resistance opposed by the grain adhesion to weathering agencies." *

An attempt to apply this method to the several sandstones used in Queensland in the hope of drawing up a table of comparative binding qualities has been unsuccessful owing to the fact that in nearly all our stones the cementing medium is so abundant that it is frequently difficult to find two sand grains in contact one with the other.

Breakfast Creek Sandstone.

This stone was worked from the sixties to the eighties of the last century in Petrie's and Brydon's quarries on the Reservoir Hill, above Breakfast Creek, at Albion.

Petrie's quarry in particular is a very extensive quarry and a great deal of material has been removed. The quarry has been worked out now but an inspection shows that there were beds of good thickness and that the jointing of the stone was fairly regular and reasonably far apart. Current bedding, however, is a particularly common feature about the stone.

The stone is a very friable, coarse, sandstone with rather poor weathering properties. It has an average grain-size of .5 mm. and is made up of quartz grains, rounded to subangular, weathered felspar granules and occasional secondary mica particles. Some of the quartz grains are built up of fragmentary quartz particles. The percentage of felspathic cement is very large and considerably more than 50% of the stone is cement (see microphotograph

* Int. Ass. Testing Mats., ii, No. 11, July 15th, 1912.

12, plate IX). Like most sandstones it hardens on exposure but the cementing medium is too abundant and consequently the binding property of the cement is weak. In colour it varies from greyish-white to light brown according to the amount of iron-staining it has undergone.

The sandstone is nearly horizontally bedded and occurs near the base of the Ipswich series of coal-measures of Triassic age. It has been used extensively and where it has been kept free from moisture it has lasted reasonably well, but where it has been used in base courses and allowed to become wet it has fretted away badly. Like all sedimentary stones, great variation exists in the different beds and even in different parts of the same bed; the result is that both good and poor stones have been obtained from here.

Fig. 15. St. Stephen's Roman Catholic Cathedral, Brisbane.

View from Elizabeth Street. Erected 1874; main structure of Brisbane tuff. Facings of sandstone from Breakfast Creek. Old building on right built 1860-61 of sandstone from Geary's quarry, Goodna.

The fact that there is so much variation in sedimentary stones is not at all appreciated and the utmost discrimination should be made in, first of all selecting the quarry, and then in seeing that the stone put into the structure is carefully selected by a thoroughly competent person, otherwise the results are extremely likely to be unfortunate.

Among other places this stone has been used in the upper story of the Commercial Banking Co. of Sydney (1866), in the old building of the General Post Office (1871-74), the facings of St. Stephen's Cathedral (1874), the base course of the Roma Street Railway Station (1875), the facings of St. Paul's Presbyterian Church in Leichhardt Street. It was used to a large extent in what is now the Deanery at St. John's Cathedral, but which was erected as a residence for Dr. Hobbs. This building is well over 50 years old and the stone has weathered very well. The Australian Bank of Commerce was constructed of the stone and it was also used in the Caretaker's Lodge and fence for the Supreme Court, the base course of the present Tourist Bureau and Geological Survey Office. The manner in which the stone frets away when allowed to become moist is well seen at the Tourist Bureau and Geological Survey Office.

Goodna Sandstone.

Some of the best sandstone which has been used in Brisbane came from Goodna.

The largest quarry and hat producing the best stone was Jeay's quarry, which is within the grounds of the Woogaroo Asylum. The quarry is in the Bundamba sandstone and was worked chiefly from 1860-70, after which the Breakfast Creek stone began to come to the fore. This quarry supplied the stone for the old Government House (University) (1860-62), the Brisbane Town Hall (1864) above the first cornice, and Parliament House (1865-7) except the colonnades facing George Street and Alice Street (see text-figs 14, 16).

The sandstone is one of medium grain and has a felspathic or argillaceous cement. The average grain-size is .25 mm. The grain-size is rather irregular and the particles are angular to subangular. The cementing medium is to some extent stained with limonite. There is not such an abundance of it as in the Breakfast Creek stone (see microphotograph 5, plate VIII). In colour it is rather a light pink or light brown, often arranged in concentric bands. The appearance is warm and not so harsh as that of the Murphy's Creek sandstone or the white Helidon sandstone, although it is not as warm as the brown Helidon stone.

The excellent weathering properties of this stone may be noted on examining the buildings mentioned, Parliament House especially. Where the stone has been allowed to become moist it has fretted away, but any sandstone with an argillaceous or clay cement,

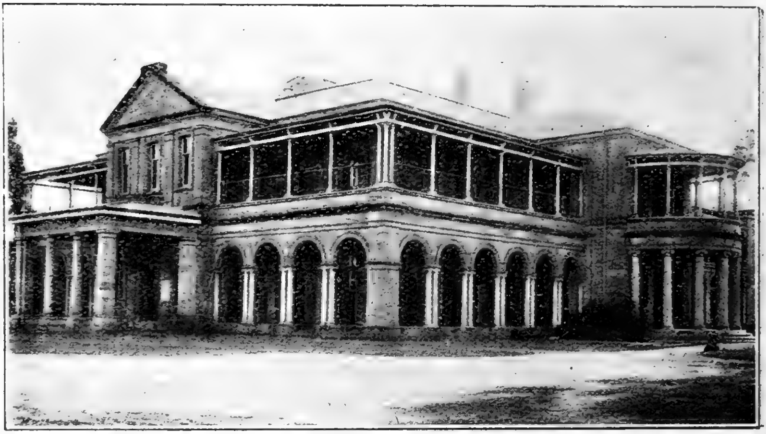

Fig. 16. UNIVERSITY, BRISBANE.

Erected 1860-62 as Government House. Built of sandstone from Jeay's Quarry, Goodna. Portico in front of Murphy's Creek sandstone.

which this stone has, would fret in a similar manner. This is especially the case around the base course of the University or old Government House. The smooth-dressed stones used as kerbing stones around the verandahs have exfoliated badly, also the columns have lost their flanges near the base. Where the stones have not been habitually moist they have weathered in an excellent manner and one cannot help being impressed by the fresh, clean appearance of the stone. The stone does not become dirty, as do some stones which are no harder.

In the Town Hall some of the smooth-dressed stones in exposed positions have exfoliated to some extent, but when compared with the Sydney sandstone which was used in the front to the first cornice, the Goodna stone shows up very well. The stone in the wall around the Botanic Gardens along Alice Street was derived from Jeay's quarry and was at one time a retaining wall at the old gaol at Petrie Terrace.

Geary's quarry at Goodna supplied the stone for the old St. Stephen's R.C. Church in Elizabeth Street. This was erected in 1860-61, Pugin, the celebrated architect, designing it. This church is noted for its very beautiful tracery window and unfortunately also for the bad state of preservation of the stone in the building (see text-fig. 15). The stone is a coarse-grained, light greenish-brown in colour with abundant clayey cement and containing a great deal of carbonaceous material. The stone has weathered very badly indeed and is quite beyond repair.

The "Woogaroo" Quarry which was worked by Smith and Rees is situated on the river bank and supplied stone for the fence wall in front of the South Brisbane Cemetery, for certain alterations in the Supreme Court and for the tower and tracery in St. Paul's Presbyterian Church (1887) in Leichhardt Street. This quarry after being well opened up was flooded; after being cleaned out and operations recommenced it was reflooded; this caused it to be abandoned.

Although the Goodna sandstone from Geary's quarry in the old St. Stephen's Church furnishes the worst example we have in Brisbane of inferior stone, Parliament House with its stone from Jeay's quarry has been erected for something over half a century, and except for slight fretting away in the base course it is in excellent condition and has a very fresh appearance.

Moggill Sandstone.

This stone was used in the west part of the Alice Street front of Parliament House and in the arcade facing the same street. It is a brown sandstone of poor cementing qualities, and after being in the arcade for about 9 years it crumbled and became unsafe. The arcade was pulled down and rebuilt with Murphy's Creek sandstone. The stone from

Lyons's quarry was tested by the Railway Department along with several other stones about 1875 in connection with the Dry Dock at South Brisbane. It was rejected, but the following results are the averages of tests on four samples: absorption, 2.98 per cent. by weight; specific gravity, 2.39, giving a weight of 149lbs. per cubic foot.

Calvert Sandstone.

This is a very friable, soft, dark brown sandstone. It is an even and fine-grained stone, the grains average .20 mm. in diameter. The particles are angular to sub-angular and are set in a small amount of clay cement which is deeply stained with limonite. The stone has much less cementing material than most of the sandstones used (see microphotograph 4, plate VIII). It has been used to a slight extent in Perkins' Brewery, there being about 2,000 feet of stone facings. It is well-protected from the weather but several stones are in a badly-weathered condition. It has been used to some extent for monumental purposes but with little success. As far back as 1896, Mr. W. H. Knott reporting to the Chief Engineer for Railways stated that he considered this stone very unreliable, and the three examples of it in the South Brisbane Cemetery were all decayed.

Brodie's Quarry supplied the stone used in the railway tunnels, culverts, etc., from Grandchester to Helidon. The Select Committee* on Sandstone Quarries in 1888 reported that Brodie's quarry supplied stone in all railway tunnels, culverts, etc., from Grandchester to Helidon. In 1896 this stone was tested with others by the Railway Department in connection with the Bremer Bridge at Ipswich. The stone came from the quarry of Beatty and Walsh, and had a specific gravity 2.39, weight per cubic foot of 149lbs. and absorption of 4.47% of dry weight. Its resistance to crushing was 3,733 and 4,485lbs. per sq. inch on two samples crushed. The stone was rejected in favour of brown Helidon stone from Wright's quarry. Many years ago this stone was subjected to compression at the Technical College, Sydney, and gave an average result of 4,595 lbs. per sq. inch for three samples crushed. This

* Votes & Proc. Q'ld. Session, iii., 1888, p. 1021.

stone from practical experience of its weathering qualities cannot be regarded as a good stone.

Lockyer Creek Sandstone.

This sandstone was used in parts of the Dry Dock (1877-81) at South Brisbane. It was used for coping on both sides of the dock and along the quay walls, also for the upper stones of the altars and for steps. The quarry was midway between Murphy's Creek and Helidon and apparently yielded a very fair stone. The tests carried out in 1875 in connection with the dock gave the following results: absorption, 3.7 per cent., and specific gravity 2.45, giving a weight of 153lbs. per cub. foot.

Helidon Sandstone.

This stone has been very extensively used and several quarries have been opened in the neighbourhood of Helidon. The sandstone probably forms part of the Walloon series of coal measures of Jurassic age. The several quarries are a few miles to the north of the railway line on the sandstone ridges. The stone is variable in colour, ranging through white, brown and pink. For many years now this sandstone has been largely used by the Public Works Department.

Wright's Quarries.—These quarries are situated four or five miles from Helidon on the northern side of the railway line on the barren sandstone ridges. The sandstone is approximately horizontally bedded and there is very little overburden. The quarries are all shallow excavations as the stone does not extend to any depth. The beds are not thick and stones more than 3-4 feet through are not obtainable although they can be got with considerable length and width. Considering the nature of the quarries and the almost surface character of the stones it is a matter of surprise that this stone is as good as it is. The usual improvement of stone with depth does not hold here at all. In the hand specimen the stone is seen to be made up of quartz grains cemented with an abundant cement which is stained brown by iron oxide. Under the microscope the stone is seen to be made up of quartz grains and felspathic cement. The proportion of cement is very high, being at least 50 per cent. and present to such an extent that it is difficult to find two sand grains in contact with one another (see microphotograph 1, plate VIII). The brown colouration of the stone is due to the brown staining of the cementing medium by limonite, also to the occurrence of small patches of this mineral. Its sand grains are angular to subangular and show very little sign of having been transported far. The grains are roughly equidimensional and of even size. The average grain-size is .25 mm.

The microscopic investigation shows how largely the stone is made up of cement, and it is easily understood how the stone is very readily worked, also how it is unable to stand in moist situations.

All the stone in the quarries is not stained brown, white stone occurring also. The stone is of variable character and needs very careful selection. It works freely and very easily owing to the large amount of cementing medium. It takes a sharp arris and if kept dry, owing to the kindly climate of south-eastern Queensland, it gives very fair weathering results.

The stone has a warm brown appearance and shows very abundant concentric iron-banding and in some cases numerous, small, brown patches of limonite about the size of a pin's head. These iron bandings and the variation in the iron contents in the different stones give a structure of this material a very handsome appearance and warm in comparison with the cold, harsh appearance of the white sandstone. It wears freshly, and possesses a very clean appearance. A comparison of the Executive Building with the Treasury building well illustrates these points.

Very many tests have been carried out from time to time. Its specific gravity ranges from 2.26 to 2.42 with an average of 2.34 for seven determinations. This gives an average weight of 146lbs. per cubic foot. The absorption in percentage of dry weight ranged from 2.8 to 4.8 over nine determinations with an average of 3.96. The resistance to crushing on twenty-one tests ranges between 2,250 lbs. and 8,381lbs. per sq. inch, with an average of approximately 4,700lbs. per sq. inch.

The brown stone from Wright's Quarry was first used in Brisbane in the Countess Street railway bridge in 1896. The stone was not well selected and is under rather severe conditions with respect to moisture; it has not weathered well in this job, but this is not a fair example on which to judge the stone. The more important structures of this stone are the additions to the Old Government House (University) in 1901, the major portion of the Executive Buildings (1901-05) (see text-fig. 11), all the internal sandstone work in St. John's Anglican Cathedral (1909-11), the main George Street entrance to the Government Printing Office (1912), the facings, sills and keystones of the Central Technical College buildings (1912-14) and the Government Savings Bank in course of erection since 1915 (see text-fig. 12). In this latter structure the manner in which stones showing rather pronounced purple colouration when freshly dressed and put into position, tone down a few months after has been well seen. The renewals of certain weathered sandstones near the base of the General Post Office were made with this stone, which was also used for the stone facings in the Elizabeth Street front of the General Post Office. At Ipswich, the stone was used in the Bremer Bridge (1897) and in the additions to the Post Office. At Toowoomba, it has been used in the Willowburn Asylum.

This stone weathers well provided it is kept dry, but water to any extent and especially constant moisture is fatal. It should never be used in the base courses. The effect of using it in the base courses may be seen in the renewed stones of the General Post Office. Within the space of three or four years after being put into position they showed signs of fretting away, which is steadily increasing. In the administrative block of the Central Technical College the sandstone facings in the base courses at both front corners showed fretting within two years of erection. The cementing medium expands when wetted, contracts when drying, and as such a large percentage of the stone is cementing material, disruption is soon brought about by repeated wetting. The stone should be well protected from the ground moisture by a waterproof course. The effect of smooth dressing does much to disturb and weaken the surface of the stone, so that the use of rough-dressed or rock-faced stones in the base course might be made with advantage if the material is to be used there.

The practice of using granite as the base on which to build, as in the Executive building and new Government Savings Bank, is the most satisfactory method however.

Pearson's Quarries.—These are situated to the north-west of Helidon station on the same sandstone ridge as Wright's quarries.

The same general remarks which have been made with respect to the stone from Wright's quarries apply here, and also to the stone from several other quarries at Helidon. Pink, white, and brown stone has been quarried, and probably the hard pink stone has the best weathering properties.

Sandstone from these quarries was used in the South Brisbane Town Hall (1891) also in the retaining wall and fence on to Vulture Street. Both brown and white stones were used and the stone in the retaining wall has decayed rather badly in places owing to moisture. In the Albert railway bridge (1893-95) at Indooroopilly, all of the sandstone used, with the exception of some large blocks of Sydney sandstone, came from here also. Alternate courses of brown and white stone were used in the Victoria Bridge (1894-97). The pink sandstone in the Central Railway station (1901) came from here and it constitutes about 30 per cent. of the stone in the building. A small amount of white stone was used in the newer wing (1890-93) of the Treasury building.

In connection with the Central Railway Station the Railway Department conducted a large number of tests, and the average results of these on the different coloured stones from Pearson's quarries are summarised below :—

Colour.	Specific Gravity.	Weight in lbs. per cub. ft.	Absorption in per cent. of dry weight.	Crushing resistance in lbs. per sq. in. of dry stone on bed.
White	2.22 (3)*	139 (3)	3.53 (3)	5130 (5)
Pink	2.32 (3)	145 (3)	3.34 (3)	6875 (5)
Brown	2.24 (3)	140 (3)	3.33 (3)	4300 (4)
Purple	2.38 (1)	149 (1)	2.7 (1)	6700 (1)

* The numbers in brackets represent the number of samples tested.

The purple and pink stones, on these tests, show up to the best advantage and in actual weathering properties the pink stone in the Central Railway Station has proved excellent.

Miller's Quarry.—This is situated a few miles west from Helidon station. Brown stone from this quarry has been used in the fence around the Toowong Cemetery (1915), in the Roman Catholic Church at Ipswich and in the Presbyterian Church at Toowoomba. In 1911, tests were carried out on this stone in connection with the Government Printing Office entrance from George Street. The stone was not used, but gave the following results: specific gravity, 2.31; weight per cubic foot, 144lbs.; absorption, 4.36 per cent.; resistance to crushing, 5,110lbs. per sq. inch. Those samples crushed in connection with the Government Savings Bank gave an average resistance of 2,900lbs. per sq. inch.

Jude's Quarry.—White stone from this quarry was used in the second wing of the Treasury Building (1890-93). It is rather a cold harsh stone and not so warm in appearance as the brown Helidon stone, nor so good in weathering qualities. Much of the stone shows rather pronounced current bedding which does not improve its appearance. While most of the stone in the wing erected by Jude as contractor came from this quarry, he also used a small amount from Pearson's quarry, and for the columns on the George Street front, Murphy's Creek sandstone was utilised. In 1896, a small amount of this sandstone was placed in the Bremer Bridge at Ipswich while the bulk of the stone came from Wright's quarry.

Phippard's Quarry.—This is a white sandstone quarry and is near Wright's brown sandstone quarries. The stone has given good results in the Central Railway Station (1901) where about 70 per cent. of the sandstone used came from this quarry. The quarry has not been worked since then. Tests carried out on the stone by the Railway Department gave the following results: specific gravity, 2.257 for the coarse stone and 2.326 for the fine stone; absorption, 3.54 per cent. of dry weight; resistance to crushing, an average of 5,570lbs. per sq. inch for six samples crushed dry and 3,325lbs. per sq. inch for two samples crushed wet.

Murphy's Creek Sandstone.

This is a rather coarse-grained white sandstone and from a weathering point of view is one of the best sandstones which has been used in Brisbane. It is very irregular in grain and while having an average grain-size of .4mm. many of the sand grains are more than 1mm. in length. The cementing material, which is argillaceous for the most part, also contains secondary silica which makes it stronger. The cementing material is very abundant and it is a matter of difficulty to find two grains of sandstone in contact (see microphotograph 2, plate VIII).

The main quarries worked were those of Cameron, four miles from Murphy's Creek railway station, and of Montgomery, McLachlan and Sheddon, 1½ mile from the station. The stone was used mainly over a period from the late seventies till the beginning of the present century. It is a clean-wearing stone and in comparison with the white Highfields and white Helidon stones it shows up very well. The old part of the General Post Office built in 1871-74 has a little of this sandstone in it, although the main stone used came from Petrie's Quarry at Breakfast Creek. The columns, fascias, caps and other stone facings in the Roma Street Railway Station (1875) are of Murphy's Creek material, the Breakfast Creek stone being used in the base course. The stone front of the Public Library or old Museum (1877-79) is entirely of this stone, and it affords an excellent example of its good weathering powers and fine appearance (see text-fig. 13). The Queensland National Bank (1882) affords perhaps the best instance of the use of this stone. The columns of this building are of Oamaru limestone, also some of the upper part of the structure was made of Pearson's sandstone from Helidon; this latter material recently needed considerable attention and renovation. Some Murphy's Creek stone was used in the Customs House (1887).

The colonnades of Parliament House facing George Street and Alice Street are built of this material (see text-fig. 14). The latter colonnade was built in 1899 and replaced one which had been built of Moggill sandstone but which had become unsafe. The stone was obtained from Montgomery's quarry in Harley's paddock. Other examples of this stone are to be seen in the facings of the Police Commissioner's Building, the gate piers of the Botanic Gardens fence, the portico of the University, the fountain at the intersection of Queen and Eagle streets and the columns of the George Street front of the Treasury Building.

In Toowoomba, this sandstone has been used in the Railway Station, Post Office, and Court House.

In Ipswich, it has been used in part in the Post Office and also in a fountain.

In Maryborough, the stone facings of the Customs House are of this stone, while at Cooktown the monument erected to Captain Cook is of this material on a base of the local granite. I understand from Mr. G. Cryle in the latter use the stone has fretted rather badly.

Tests on this sandstone were made prior to the erection of the Executive Buildings. The absorption was determined as 5 per cent., the specific gravity, 2.605 and the average resistance to crushing of three samples was about 3,500lbs. per sq. inch. The weight per cub. ft. would be 163lbs. The resistance to crushing is fair while the absorption is rather high. The use of this stone has, however, been accompanied with considerable success.

Highfields Sandstone.

This stone has been obtained from quarries 1½ mile west of Spring Bluff. The stone is of particular importance owing to its use in the first wing erected of the Treasury building (1887-89). The wing facing Queen, William and west part of Elizabeth Streets is built of this stone on a base course of the Brisbane Tuff (see text-fig. 17). The stone has not been a success from a weathering point of view, its appearance also is poor owing to its tendency to wear rather dirty and the very pronounced current bedding. It is a very soft sandstone, white in colour. In grain-size it is uneven, with an average of about ,4mm. Weathered felspar granules are abundant, and the cementing material forms a large proportion of the stone (see micropotograph 17, plate X).

The quarries are 9 miles from Toowoomba and 91 miles from Brisbane. There were at least three quarries but the one adjoining the railway line was the one from which the stone for the Treasury building was obtained. In the Parliamentary Report of 1888 on the Sandstone Quarries of the Southern Districts, J. Valentine stated that the stone in the quarries varied a great deal but that the best stone was not obtained for the Treasury building. Prior to the use of this stone in the Treasury building it was used in railway tunnels, culverts, cuttings, etc., but the results were then known not to be very satisfactory. The stone for the Treasury buildings from this quarry was accepted on the advice of Mr. George Connolly, the Colonial Architect, as the "only stone that could be got free from discolouration."*

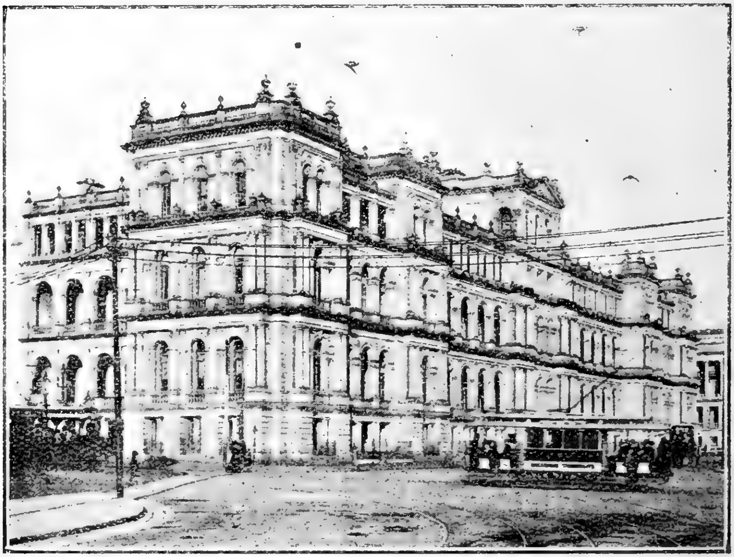

Fig. 17. Treasury Building, Brisbane.

View from North Quay. Wing shown in figure erected 1887-89 of sandstone from Highfields on a base of Brisbane Tuff.

It is noteworthy that in the evidence tendered the Select Committee on sandstone quarries in 1888, opinions adverse to this stone were given by almost all witnesses, iucluding the Hon. A. C. Gregory.

* Parl. Report, 1888, p. 1041.

Evidence of weathering is very pronounced on the Queen Street front in places, and its use in the Treasury buildings seems to have been unfortunate. The main point which appears to have actuated the selection was a desire to obtain a white stone free from discolouration.

Absorption tests by the Government Analyst of New South Wales, in 1888, gave an average value of 4.8 per cent. for three tests, while W. A. Dixon, of Sydney, got an average result of 7 per cent. on two samples.

The great variability in the quarries and in the stone from the same quarry is very striking in the case of this stone, and many thousands of feet were rejected as unsatisfactory in the construction of the Treasury building.

Yan Gan Sandstone.

This brown sandstone is probably the best sandstone in use in Queensland at present. It is quarried in close proximity to the Yan Gan railway station, which is 172 miles from Brisbane, and 13 miles south-west from Warwick. It belongs to the Walloon series of coal-measures and there are available large quantities of stone.

It is a fine-grained sandstone, much finer than most of the other sandstones in the Warwick district. It has a warm brown colour and shows very pronounced concentric iron-staining at times. The brown colour is not quite as warm as that of the Helidon stone. A microscopic examination shows this stone to be an even, fine-grained sandstone with an average grain-size of .20mm. The particles are angular to subangular and the amount of felspathic cementing material is less than in most of the sandstones used. It is much the same in grain-size and proportion of cement as the Calvert sandstone used in Perkin's Brewery but is a much superior stone (see microphotograph 3, plate VIII).

The stone works well and takes a very sharp arris. Several quarries have been opened in the same locality and the present main quarry has a very fine back in it. Stones of considerable size can be obtained, as the beds, which are fairly horizontal, are rather thick and while the stone is well jointed the joints are far apart. Blocks of sufficient size can be obtained for making good-sized columns with the bedding horizontal. The columns in the Executive building are of this stone and are a little over 8 feet long.

The stone is easy to quarry as there is little over-burden, the jointing is far apart and the bedding horizontal, the situation of the quarry is good as it is at the foot of a hill and can be worked back a long way, and it is within half a mile of the Yan Gan railway station.

Tests on this stone in 1901 gave the following results: an average resistance to crushing of about 2,800lbs. per sq. inch on three samples tested, absorption of 8.7 per cent., and a specific gravity of 2.611, which gives a weight of 163lbs. per cubic foot. Three tests for absorption by the author on specimens from the present quarry face gave an average of 6.1%. This is higher than one would anticipate from the stone and considerably more than 3-4% which is generally regarded as the safe limit in cities with a trying climate. The low resistance to crushing is in keeping with the high absorption.

The stone has been used in the Executive Building (1901-5) in the columns and recessed walls of the William Street, Queen's Park and George Street fronts, and for the upper stories in the front on to Stephens Lane (see text-fig. 11). It has been used in the front of the Royal Insurance Co. Buildings (1906) in Queen Street, on a base of Mt. Crosby granite, also in the Byrnes' Statue on a base of Enoggera granite. The very fine manner in which this stone dresses can be well seen in these structures.

In Warwick, it has been used in the Police buildings, the Post Office, the sandstone facings of the Technical College and the 1912 additions to the Warwick railway station.

Swan Creek or Mt. Sturt Sandstone.

This is a brown sandstone which is known under both the above names. The quarry is about 9 miles from Warwick and the stone is entrained at Mt. Sturt railway station. The stone appears to be quite good and in the Parliamentary Report of 1888 it is very well spoken of.

It has been used in the front of the Warwick Town Hall, and the Old Railway Station, built in 1888; in the latter building it was used with sandstone from Mt. Tabor quarry. The stone is rather argillaceous or clayey and does not take a good arris, being much inferior to the Yan Gan stone in this respect. It is finer-grained than the local Warwick sandstones.

Warwick Sandstones.

Sandstone in the immediate vicinity of the town has been quarried in several places and used locally. Consequently stone buildings and houses are much more abundant in Warwick than most towns of its size in Queensland. Most of the local stone is rather coarse-grained, shows current bedding freely, and while good for filling in, it is not good where work has to be put on the stone.

The stone in the Warwick Hospital obtained from a quarry on the Waterworks Hill is amongst the best of the local stone and is finer-grained than most of it.

Mt. Tabor Quarry*, which belongs to D. Connolly, is on a ridge running north-west from Mt. Tabor in the direction of the town. It has been extensively worked and the stone used in the following buildings in Warwick: Police buildings (1885), Barnes & Co. (old building), Railway Station (old portion 1888), Town Hall (rear portion), Hyslop's Stores, Court House, Ward's buildings (1901), and the Queensland National Bank (1880).

Gunn's Paddock Quarry.—This is a quarry in the sandstone about 2 miles north of Warwick, and adjacent to the railway line on the east side. The stone from here has been used in the Presbyterian Church.

Sidling Quarries.—These consist of a number of small quarries commencing at Gunn's Paddock and extending through Bishop Tuffnell's quarry and four other quarries towards the Freestone road. The stone quarried is coarse, and very soft and crumbly when quarried, but becomes hard after exposure. Bishop Tuffnell's quarry is situated on the Weewondilla Estate. The stone from these quarries has been used in St. Mark's Anglican Church (1867), St. Mary's R.C. Church, Methodist Church, Masonic Hall,

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* I understand, on the authority of Mr. Kingsford, Assistant-Town Clerk, and an old resident of Warwick, that the correct spelling is "Thabor"; the spelling used here is that in most general use.

Australian Bank of Commerce, Caledonian Stores, and the Stock Inspector's office.

Mitchell's Quarry.—This has other names—Hongkong quarry and Gollan's quarry ; the latter is the original name. It is about a half mile further out than the quarry in Gunn's Paddock, and is near Campbell's Gully. This stone has been used for the Convent (1892), and also for the additions in 1914.

The stone is a rather coarse, light brown sandstone with abundant clayey cement. Under the microscope this stone is seen to be very uneven and while the average grain is .5mm., some of the quartz particles reach a diameter of 1,25mm. (see microphotograph 16, plate X). The cementing material is felspathic and rather abundant, while containing much more than the Yan Gan sandstone it has less than the sandstone from Helidon. Two tests for absorption gave an average of 6.7 % showing that it is rather a porous stone. The beds are from 2 feet to 4 feet thick and are fairly regularly jointed. The overburden is small and the stone shows pretty concentric iron-staining.

Beaudesert, Logan Village, Etc.

A sandstone of rather poor qualities has been referred to by E. O. Marks* as occurring on Jenyn's selection, about 4 miles west of Beaudesert. It has been used for monumental purposes and also for grindstones but in the latter capacity it proved a failure.

At Logan Village one or two quarries have been opened in the sandstone which forms part of a belt of the Bundamba sandstone running from Wolston to the foot of Tamborine Mt. Watt's quarry, four miles from Logan Village, has a rather coarse-grained stone apparently of poor quality. Caradini's quarry on the bank of the Logan River and one mile from the station yields a more inferior stone still.

At Mundoolun, about 10 miles south of Logan Village, a church has been erected of stone from the locality by the Collins family. It is a coarse-grained, brown sandstone and from the belt of Bundamba sandstone mentioned above.

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* Q'ld. Geol. Surv., Pub. 225, p. 43.

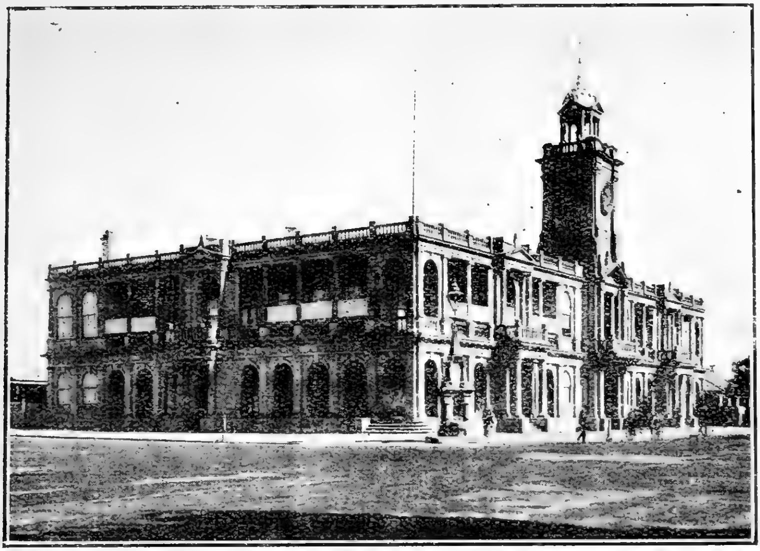

Fig. 18. Post Office, Rockhampton.

Erected 1890 of sandstone from Stanwell.

Stanwell Sandstone.

This sandstone has been extensively used in Rockhampton for some considerable time. The quarries are situated about two miles from the Stanwell railway station and are connected by a rail siding. The sandstone is of Lower Mesozoic age and the amount to be obtained is very great. Owing to the nearness to Rockhampton—less than 20 miles—the quarries are in a handy position. The stone for all the best buildings in Rockhampton has been obtained from there and with satisfactory results (see text-figs. 18, 19).

Many of the structures have been erected for a considerable period; the Anglican Cathedral, 35 years, the Commercial Bank and the Bank of Australasia, 30 years, the Post Office, 24 years, the Roman Catholic Cathedral, 20 years, the Customs House, 15 years, while the stone has been in the Technical College and State Savings Bank for about 3 and 2 years respectively.* This stone was also used in the Customs House at Townsville.

* These figures were kindly furnished by F. M. Allan, Monumental Mason, Rockhampton.

Fig. 19. Customs House, Rockhampton.
Erected 1899 of sandstone from Stanwell.

It is a medium-grained, light brown sandstone and works well. It takes a fair arris and weathers very cleanly. The average grain-size is about .5mm., while occasional grains reach 1mm. in length. Many of the grains are brecciated and strain polarisation is common. Felspar grains are abundant (see microphotograph 6, plate VIII). Very careful selection is needed in order to prevent subsequent fretting. The material quarried in recent years is better than that quarried earlier owing to a better bed being worked. The Railway Department state that the stone has stood well in railway culverts.

Pentland and Torrens Creek Sandstone.

This sandstone, which in appearance very much resembles the Sydney sandstone, is quarried between Pentland and Torrens Creek, and is used to a considerable extent for monumental purposes in Charters Towers and Townsville.

Imported Sandstones.

Sydney Sandstone.—This stone has been used to a moderate extent in Brisbane although there does not appear any real necessity for the importation of the stone into this

State. The most extensive use in any one building is in the recently erected Union Bank (1916), where it is used as the super-structure on Footscray basalt which extends to the first cornice. Not only were both these stones brought into this State but they were already dressed, practices which naturally do not commend themselves to people here.

A comparison of this sandstone with some of our sandstones might be made with advantage.

With respect to weathering properties, as far as can be seen up to the present, the sandstone from Jeay's quarry at Goodna, Murphy's Creek, the brown stone and pink stone quarries at Helidon, and Yan Gan compare very favourably indeed.

As regards appearance, each of the sandstones mentioned has naturally a warmer appearance as the deeper yellow-brown colour in the Sydney sandstone is usually produced by artificial oxidation of the naturally-occurring iron carbonate through the stone. The stone naturally darkens on exposure to the weather, but it does not take on such a warm brown tint as our brown sandstones.

The more important structures in which this stone has been used in Brisbane are the Town Hall (1864) up to the first cornice, the Commercial Banking Co. of Sydney (1866-67) up to the first cornice, the Commercial Bank of Australia (1877), the National Mutual Insurance Co., the external sandstone facings of St. John's Anglican Cathedral (1909-11), the facings of the New Zealand Insurance Co., the front of the E.S. & A. Bank (1913) above the first cornice, the facings of Parbury House (1915), the Union Bank (1916) above the first cornice, and the Queensland Trustees.

TUFF.

The Brisbane tuff, which is more usually called "Porphyry" in the trade, is a stone which has been extensively used over a long period.

It is an invaluable material to Brisbane owing to its utilisation for road-making, kerbing, and building purposes. It occurs along a belt stretching for several miles through Brisbane in a north and south direction and has an average width of perhaps a half-mile. The more important quarries are at Kangaroo Point, Spring Hill, near the Exhibition, and at O'Connelltown.

The stone is a variable one as regards colour and compactness. It needs very careful selection, which is easily understood when one realises its mode of origin. It is formed from a volcanic ash of a rhyolitic nature and has been subsequently consolidated and hardened very largely by the passage through it of solutions containing silica. The influence of the silicification has not been equal in all parts of the mass so that the stone varies a great deal in the same quarry. All shades of colour from white to pink, green, yellow, brown and purple are obtainable; these colours are due to the influence of iron and manganese oxides.

The jointing is not very regular and much variation exists as to the size of blocks obtainable in the different quarries. This stone will not stand much pressure without cracking, and an investigation of any job on which this stone has been used where it is subjected to much pressure will bear this out.

Many instances are available where this stone has become very much weathered and it is particularly prone to

Fig. 20. St. John's Anglican Cathedral, Brisbane.

View from East. Erected 1908-10. Main structure of Brisbane tuff, external facings of Sydney sandstone. Building on right was built, in part, of sandstone from Breakfast Creek quarry well over 50 years ago.

decay in moist positions, which is what we might expect. The lighter the colour the more ready the decay, is the general rule. Rough-dressed stones weather better than smooth-dressed ones owing to the lesser disturbance to the stone in dressing.

An examination under the microscope shows the stone to be made up of occasional small crystals of quartz, orthoclase, and plagioclase, set in a devitrified felspathic ground mass which often shows the peculiar curved outlines of the originally glassy particles (see microphotograph 8, plate IX).

The density and porosity of this material vary greatly but it might be taken as a general rule that the more dense the stone the smaller its absorption will be and the better its weathering properties.

The tests on the tuff from the Spring Hill Quarry which was used in the Dry Dock in 1877 show the absorption was 7.2 per cent. and the specific gravity 2.16, which gives a weight of 135lbs. per cubic foot. This absorption is rather high and considerably more than seems advisable. Three tests for absorption by the author on representative specimens of green, white and pink colour, gave results of 4.6, 3.9 and 7.7 per cent. respectively; the white specimen was very much silicified.

Several important structures have been built of this material in the rough-dressed condition with sandstone used for the facings, and as the tuff has been well selected the use of the stone has been attended with much success.

The tuff is multi-coloured with a predominant pink to purple tint so that the lighter-coloured sandstone gives the necessary relief.

The stone in the Normal School (1863) was obtained from the Spring Hill quarry, that in St. Stephen's Cathedral (1874) from Skyring's quarry, near All Hallows Convent, that in St. Paul's Presbyterian Church (1887) in Leichhardt Street from the Spring Hill and O'Connelltown quarries, and that in St. John's Cathedral (1909-11) from the O'Connelltown quarry.

The building occupied by the Police Commissioner in George and Elizabeth Streets is regarded as one of the best examples of the use of this stone. This structure, together with the four mentioned above, probably represents the most important in this stone.

The Rosemount Hospital was built in 1855-56 of stone from the O'Connelltown quarry, but owing to the perishing of the mortar in 1890 it had to be considerably repaired.

The base of the General Post Office (1871-74) is of this stone and it has weathered very well, much better than the sandstone above it. The first three courses in the Roma Street Station (1875) are of the Spring Hill tuff. The base course of the Treasury building is from the O'Connelltown quarry. Several large stones have been used here, but they have cracked rather badly in many cases. The stone has been used in the base course of the additions to the Government Printing Office (1912), and it was also used in the abutments of Victoria Bridge (1894-97). It has also had a very extensive use all about the metropolis for retaining walls and in this respect it is of much greater value than the Brisbane Schist. For cellar work, etc., the stone has been extensively used, but it is being replaced now by concrete in this particular direction.

Metamorphic Building Stones.

MARBLES AND LIMESTONES.

Queensland has only quite recently commenced to exploit her marble and limestone for monumental purposes. Hitherto her limestone deposits have been used for fluxing and lime-producing purposes only.

Ulam Marble.

The discovery of a white marble at Ulam, some 25 miles south of Rockhampton, has resulted in the Government subsidising to the extent of £1,000 the company working it, and it is to be hoped that the deposit opens up satisfactorily. The marble which has been obtained is somewhat coarse but no coarser than much of the Sicilian and Italian white marbles which are used for mural and staircase purposes. All reasonable tests with respect to working and strength have been well stood by this marble. It is to be hoped that this deposit develops in a satisfactory manner as there is a big demand in Australia for a good white marble which has not yet been satisfied by any Australian product.

Mr. L. C. Ball has described the Central Queensland marbles and limestones and the following remarks have been taken mainly from his writings.*

Gladstone District. The area of country within a 50 mile radius contains deposits which range from granular white to fine-grained dark-blue and red. A great deal of the stone is fit for monumental purposes.

The most conveniently situated deposits are at Calliope, where a brecciated limestone has been worked and very fine brecciated red and pink marble probably suitable for cutting into slabs occurs.†

Raglan. On Raglan Creek, 10 miles above the mouth of the Fitzroy River considerable deposits occur.

Rockhampton District. To the north of the Fitzroy River at four and at twenty miles above Rockhampton there are large areas of pink to blue limestone.

At the Marmor quarries, 26 miles south of Rockhampton and adjacent to the railway line, there is a dark-blue marble with very large white fossil encrinites through it.

Northumberland Islands. These are about 14 miles from the mainland and midway between Rockhampton and Mackay. On Marble, Hunter and Iron Islands, marbles of very fine quality occur. There are white, pink and blue marbles, uniform in colour, also variegated and mottled varieties. The area over which they occur is many acres.

Broken River Marbles. Mr. Ball reports from Broken River, 130 miles west of Townsville, fine marbles taking a good polish.

Imported Marbles.

Marbles have been imported to a very considerable extent in Queensland and their use for shop fronts and for internal use in fish, fruit and refreshment shops is increasing very much. Reference to a few instances of the use of imported marbles will be made here.

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* Q'ld. Geol. Surv., Pub. 194; Q'land. Govt. Min. Jour., 1905.

† Q'ld. Min. Index, p. 647 (Q'land Geol. Surv., Pub. 241).

In the front of Shaw & Sons building (1904) and the fronts of Finney's building (1910) on both Queen and Adelaide Streets friezes of dark marble with white stripes were placed.

In each case the marble was polished and exposed to the weather. The result has been that the polish has been lost and the marble is opening up along the cracks. It will be a question of only a few years before the marble will have to be removed. Marble slabs, and particularly polished ones, are quite unsuitable for external work if they are to be exposed to the weather. In the Queen Street front of Finney's building the marble front on either side of the entrance was exposed to the weather and lost its polish within a very short time, with the result that the firm erected show cases over the places the marble had previously occupied.

In Parbury House there is a good deal of mural decoration in marble which was imported from Italy.

In the Government Savings Bank the marble being used for mural decoration was obtained from New South Wales, also the black and rouge marbles used in the State Fish Shop.

Imported Limestones.

The *Oamaru limestone* from New Zealand has been used to some extent in Brisbane.

The columns and carved work above them on the Queensland National Bank (1882), are of this stone and it appears to be weathering very well.

In the Albert Street Methodist Church (1886) the stone has been used to a large extent for the facings, spire and fence around the church. The stone is not weathering well and in the fence it has decayed particularly, so much so, that at the end of 1916 the limestone was plastered over. Erosion of the soft stone by wind-borne particles played a large part in the wearing away of the fence material.

The Mansions (1887) in George Street contains a good deal of this stone in the facings and fence ; the ornamental cats at each end of the building are of this material.

On St. Stephen's Cathedral there are two spires constructed of this stone, while at the Brisbane Grammar School there is a porch of the same material.

This stone is a very porous limestone and there is very little excuse for importing it into Queensland as it is such a poor stone in weathering qualities.

SERPENTINE.

Queensland serpentine has not been used hitherto in this State, although there are deposits of this material in different parts of the State. The value for ornamental work has not yet been determined but near Kilkivan* serpentine, fine to coarsely granular and generally dark-green in colour, outcrops over a considerable area. At Cawarral* there is a large belt running north-west from the mouth of the Fitzroy River. At Broken River*, 130 miles west of Townsville, specimens taking a good polish have been obtained. At Pine Mountain, near Ipswich, and in other localities in the Brisbane Valley there are deposits of serpentine. The Pine Mt. occurrence is rather schistose and it is difficult to obtain blocks of any size.

List of Structures with the Stones Used.

BRISBANE.

Government Structures.

Parliament House —Erected 1865-67, the main structure of sandstone from Jeay's quarry, Goodna. In 1890, sandstone from Moggill was used in the west part of the Alice Street front and in a colonnade facing that Street. This became unsafe and was replaced in 1898 by white sandstone from Montgomery's quarry at Murphy's Creek, built on a base course of brown Helidon sandstone from Wright's quarry. The colonnade facing George Street is built of Murphy's Creek sandstone also.

Treasury.—The first wing facing Queen Street, William Street and west part of Elizabeth Street built in 1887-89, by Phippard, of sandstone from Highfields, near Spring Bluff, on a base course of tuff from O'Connelltown quarry. The second wing on George Street front and remainder of Elizabeth Street front built in 1890-93, by Jude, of white Helidon sandstone from Jude's quarry. The columns on the George Street front are of Murphy's Creek sandstone, and the base of tuff from O'Connelltown quarry.

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* Ball, L. C., Q'land Govt. Min. Jour., 1905, p. 457.

Executive Building. Erected 1901-05, by Midson. Sandstone from Wright's brown stone quarry at Helidon, except Yan Gan sandstone in columns on three fronts, in the facings of the recessed walls behind the columns and in the top stories in the front on Stephen's Lane; base, alternate layers of light Enoggera granite and dark Mt. Crosby granite.

General Post Office.—1871-74. Sandstone from Petrie's quarry at Breakfast Creek, Albion, on base of tuff. Some sandstone from Murphy's Creek was also used. In 1908-9 some of the weathered stone at the base of the columns, etc., was replaced by brown Helidon sandstone. The brown sandstone facings in the Elizabeth Street front is Helidon stone from Wright's quarry.

State Savings Bank, 1915—.—This is being built by Mason, of brown Helidon sandstone from Wright's quarry on a base of grey granite from Greymare, near Warwick. The marble used for internal mural decoration comes from New South Wales, the quarries supplying the marble being Springhill, Broca Dilla, King Edward and Caleula.

University.—(Government House) 1860-62. Sandstone from Jeay's quarry, Goodna; some tuff used in the rear portion; 1901 addition, brown Helidon sandstone (Senate room); portico in front, Murphy's Creek sandstone.

Custom House, 1887.—Sandstone from Helidon and also Murphy's Creek. Columns and pilasters of Helidon stone, also most of the sandstone in the landing, stairs and coping.

Public Library (Museum) 1877-79.—Murphy's Creek sandstone.

Police Commissioner's Building.—Tuff from O'Connelltown quarry with facings of sandstone from Murphy's Creek.

Government Printing Office.—Sandstone in William Street front from Breakfast Creek and some from Jones' siding, Grantham; brown sandstone at main entrance, George Street (1912) from Wright's quarry, Helidon; base of Enoggera Granite and tuff from O'Connelltown quarry.

Central Technical College, 1912-14.—Brown sandstone columns and facings from Wright's quarry, Helidon; granite steps in portico and side entrance to hall from Enoggera.

Normal School, 1863.—Main structure of tuff from Spring Hill quarry ; sandstone facings probably from Jeay's quarry, Goodna.

Central Railway Station, 1901.—Sandstone facings from Helidon, pink stone from Pearson's quarry and white stone from Phippard's quarry.

Roma Street Railway Station, 1875.—The first courses of tuff from Spring Hill quarry ; base course of Breakfast Creek sandstone ; columns, fascias, caps and other stone facings, Murphy's Creek sandstone.

Dry Dock, 1887-91.—Sandstone from Lockyer's Creek and a little from Sydney tuff ; granite from Victoria and small amount from Enoggera.

Botanic Gardens Wall.—Sandstone from Jeay's quarry, Goodna, originally in retaining wall at old gaol in Petrie's Terrace ; gate piers of Murphy's Creek sandstone.

Albert Railway Bridge, Indooroopilly, 1893-95.—Abutments and pier, Helidon sandstone from Pearson's quarry ; few large blocks of Sydney sandstone ; cut-water faced with Mt. Crosby granite.

Victoria Bridge, 1894-97.—Abutments and bays of tuff ; superstructure, alternate courses of brown and white Helidon sandstone from Pearson's quarry ; bed blocks on abutments, Enoggera granite ; polished panels, Peterhead granite.

State Fish Shop, 1918.—White Italian marble ; black and rouge marbles from New South Wales.

Municipal Buildings.

Town Hall, Brisbane, 1864.—Sydney sandstone to first cornice ; sandstone from Jeay's quarry, Goodna, above this ; columns inside on ground floor and first floor, also those in front outside second floor, of Peterhead granite.

Town Hall, South Brisbane, 1891.—Sandstone facings, entrance and wall, both brown and white, from Pearson's quarry, Helidon.

Churches.

St. John's Cathedral, 1909.—Main structure of tuff from O'Connelltown ; external sandstone facings of Sydney sandstone ; internal sandstone ceiling, walls and piers, brown sandstone from Wright's quarry, Helidon ; base and foundations, Harcourt granite, Trawool granite and Footscray basalt, all from Victoria.

St. Stephen's Cathedral, 1874.—Main structure of tuff from Skyring's quarry near All Hallows' convent ; external sandstone facings from Petrie's quarry, at Breakfast Creek ; belfry of Oamaru limestone.

St. Stephen's Church, next to the Cathedral, 1860-61. Sandstone from Geary's quarry, Goodna.

Albert Street Methodist Church, 1886.—Facings, spire, and fence railings and top, of limestone from Oamaru, New Zealand.

St. Paul's Presbyterian Church, Leichhardt Street, 1887.—Main structure, tuff from the Spring Hill and O'Connelltown quarries ; sandstone facings from Petrie's quarry at Breakfast Creek ; sandstone for the tower and tracery from Smith's quarry at Goodna.

Banks.

Queensland National Bank, 1882.—Main structure of sandstone from Murphy's Creek ; columns and carved work above of Oamaru limestone ; some sandstone from Pearson's Waterfall quarry at Helidon originally used in the top cornice, but this was renovated and replaced by cement some few years ago.

Union Bank, 1916.—Basalt from Melbourne up to first cornice ; Sydney sandstone above ; red granite columns at entrance, from Peterhead, Scotland.

English, Scottish and Australian Bank, 1913.—Bowral trachyte to first cornice ; Sydney sandstone above.

Australian Bank of Commerce.—Sandstone from Petrie's quarry, at Breakfast Creek.

Commercial Banking Company of Sydney, 1866-67.—Sydney sandstone to first cornice ; sandstone from Petrie's quarry, Breakfast Creek, above.

Commercial Bank of Australia, 1877.—Sydney sandstone.

London Bank.—Base of Melbourne basalt.

Insurance Buildings.

Royal Insurance, 1906.—Front of sandstone from Yan Gan; base, Mt. Crosby granite.

New Zealand Insurance, 1911.—Facings of Sydney sandstone.

Colonial Mutual Insurance Co.—Front, up to first cornice, Bowral trachyte.

National Mutual Insurance Co.—Sydney sandstone.

Australian Mutual Provident Society, 1885-87.—Breakfast Creek* sandstone front on base of Sydney sandstone.

Miscellaneous Buildings, etc.

Shaw & Sons, 1904.—Front of Enoggera granite; marble frieze above verandah, imported; grey granite columns from Harcourt, Victoria.

Queensland Trustees.—Sydney sandstone, on a base of Melbourne basalt.

Parbury House, 1915.—Facings of Sydney sandstone; base of Bowral trachyte; Italian marble dados.

Paris Café.—Black Marble front from Spring Hill quarry, near Orange, N.S.W.

Finney, Isles & Co.—Marble frieze above verandah in both Queen Street and Adelaide Street, Italian marble.

Mansions, George Street.—Limestone facings and ornamental cats, from Oamaru, New Zealand.

Stone Fence, Toowong Cemetery, 1915.—Brown sandstone from Miller's quarry, Helidon.

Byrnes' Statue, 1902.—Yan Gan sandstone on a base of Enoggera granite.

IPSWICH.

Post Office.—Murphy's Creek sandstone in part, brown sandstone from Wright's quarry, Helidon, in part

Roman Catholic Cathedral—Helidon sandstone from Miller's quarry with a small amount from Wright's quarry

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* The Manager of the A.M.P. wrote stating that Helidon sandstone was used in this building, but Mr. Andrew Petrie, a member of the firm that erected the building, has definitely informed me that picked Breakfast Creek sandstone was used on a base of Sydney sandstone.

Bremer Bridge, 1897.—Sandstone abutments, from Wright's quarry, Helidon, except for a small quantity obtained from Jude's quarry.

TOOWOOMBA.

Post Office.—Sandstone facings from Murphy's Creek.

Court House.—Sandstone facings from Murphy's Creek.

Railway Station.—Sandstone facings from Murphy's Creek.

Willowburn Asylum.—Sandstone facings from Wright's quarry at Helidon.

WARWICK.

Post Office, 1897.—Yan Gan sandstone on a base of Brisbane tuff.

Railway Station.—Old station, built in 1887, of stone from Mt. Tabor quarry together with some from Mt. Sturt quarry. The additions in 1912 were of Yan Gan sandstone.

Technical College. Base of Greymare granite and sandstone facings from Yan Gan.

Court House, 1886.—Sandstone from Mt. Tabor quarry.

Police Buildings.—Erected in 1885 of Mt. Tabor sandstone; subsequent additions of Yan Gan sandstone.

Stock Inspector's Office.—Sidling sandstone.

Town Hall.—Built 1887, in front, of sandstone from Mt. Sturt quarry and sides and back of local sandstone from Mt. Tabor.

Hospital, 1880.—Sandstone from Scrub quarry about one mile from the Hospital.

St. Mark's Anglican Church, 1867.—Sidling sandstone.

St. Mary's R.C. Church.—Sandstone from Sidling quarry.

Convent, 1892.—Sandstone from Gollan's quarry, and 1914 additions from Mitchell's quarry.

Presbyterian Church.—Sandstone from Gunn's Paddock.

Methodist Church.—Sandstone from Sidling quarries.

Masonic Hall.—Built in 1886, of sandstone from what was known as Bishop Tuffnell's quarry.

Barnes & Co.—Old building (1882-3), Mt. Tabor sandstone; new building, Yan Gan sandstone.

Caledonian Stores.—Sandstone from Sidling quarries.

Hyslop's Stores.—Sandstone from Mt. Sturt and Mt. Tabor.

Wards' Buildings, 1901.—Sandstone from Mt. Tabor.

Queensland National Bank, 1878-80.—Sandstone from Mt. Tabor.

Australian Bank of Commerce.—Sandstone from Sidling quarries.

MARYBOROUGH.

Custom House.—Sandstone facings from Murphy's Creek.

ROCKHAMPTON.

Sandstone from Stanwell is the only sandstone which has been used. Reference should be made to the section on this sandstone for a list of the buildings and the time of erection.

TOWNSVILLE.

Custom House.—Steps and base course of granite from Magnetic Island. Sandstone from Stanwell.

TABLE SHOWING CHEMICAL ANALYSES OF SOME QUEENSLAND BUILDING STONES.

Stone.	Locality.	Silica.	Alumina.	Ferric Oxide.	Ferrous Oxide.	Magnesia	Lime.	Soda.	Potash.	Water, etc.	Other constituents determined.	Total.	Analyst.
Granite	Enoggera ..	71.50	14.13	0.60	3.23	1.17	2.70	2.97	2.86	0.42	0.76	100.34	N. Christensen
Granite	Greymare ..	69.70	17.70	1.94	1.40	3.12	2.29	3.12	1.36	0.72	0.19	99.61	Miss I. Sterne, B.Sc.
Granite	Stanthorpe ..	76.19	11.53	0.84	1.25	0.60	1.14	3.80	4.14	0.28	0.50	100.27	G. Patten
Rhyolite	Mt. Ngun Ngun, Glass House Mts.	72.38	12.21	3.36	0.69	0.17	0.18	3.52	5.20	1.55	1.00	100.26	H. I. Jensen, D.Sc.
Rhyolite	Mt. Conowrin, Glass House Mts.	74.20	11.75	1.92	1.30	0.30	0.19	4.25	5.00	0.33	0.94	100.12	H. I. Jensen, D.Sc.
Rhyolite	Glen Rock, Esk	72.73	13.57	0.69	1.43	0.42	1.00	4.98	3.74	1.45	0.11	100.12	G. Patten
Basalt	Municipal Q'rry, Toowoomba ..	50.27	12.50	2.44	8.18	10.25	7.52	3.29	1.42	1.60	3.04	100.51	G. Patten
Sandstone, brown	Wright's Quarry, Helidon	90.8	0.7	3.7	—	tr	nil	—	—	4.9	—	100.1	Govt. Analyst, 1911
Sandstone, white	Pearson's Q'rry, Helidon	94.3	0.8		—	—	0.3	—	—	4.6	—	100	Govt. Analyst, 1901
Sandstone, brown	Miller's Quarry, Helidon	90.9	0.5	3.3	—	tr	nil	—	—	5.4	—	100.1	Govt. Analyst, 1911
Sandstone ..	Murphy's Ck. ..	89.2	5.9		—	tr	0.9	—	—	4.0	—	100	Govt. Analyst, 1901
Sandstone ..	Highfields ..	80.50	14.00		—	0.25	1.79			3.56		100	Govt. Analyst, 1887
Sandstone ..	Yan Gan ..	93.5	3.1		—	tr	0.4			3.0	—	100	Govt. Analyst, 1901

TABLE SHOWING RESULTS OF TESTS ON QUEENSLAND SANDSTONES.

Stone.	Quarry.	Colour.	Specific Gravity.	Weight in lbs. per cubic ft.	Absorption in per cent. of dry weight.	Resistance to Crushing. Size of specimen in inches.	Cracking pressure in lbs.	Crushing pressure in lbs.	Crushing resistance in tons per sq. foot.	Crushing resistance in pounds per sq. inch.	Reference authority.	Remarks as to object of Tests and Character.
Helidon Sandstone ..	Wright	Brown	2.42	151	4.33	6x3x3	—	43,700	305.42	4751	Rly. Dept.	Crushed dry and on bed, 26.4.01
Helidon Sandstone ..	Wright	Brown	2.42	151	4.39	3x3x3	—	38,970	299.10	4537	Rly. Dept.	Crushed dry and on bed, 26.4.01
Helidon Sandstone ..	Wright	Brown	2.42	151	4.70	3x3x3	39,000	46,750	330.40	5140	Rly. Dept.	Crushed dry on edge, 26.4.01
Helidon Sandstone ..	Wright	Brown	2.28	143	4.00	3x3x3	—	48,160	344.00	5350	Rly. Dept.	4.4.99
Helidon Sandstone ..	Wright	Brown	2.42	151	4.80	4x4x4	—	36,000	144.60	2250	P.W.D.†	Executive Building tests, 1901
Helidon Sandstone ..	Wright	Brown	2.42	151	4.80	4x4x4	36,000	39,590	159.10	2475	P.W.D.	Executive Building tests, 1901
Helidon Sandstone ..	Wright	Brown	2.42	151	4.80	4x4x4	42,500	49,690	201.20	3130	P.W.D.	Executive Building tests, 1901
Helidon Sandstone ..	Wright	Brown	2.34	146	4.41	—	—	—	324.00	5040	P.W.D.	Govt. Printing Office tests, 1911
Helidon Sandstone ..	Wright	Brown	2.34	146	4.41	—	—	—	344.25	5355	P.W.D.	Govt. Printing Office tests, 1911
Helidon Sandstone ..	Wright	Brown	2.26	141		4x4x4	—	81,900	326.00	5076	P.W.D.	Cent. Tech. Col., 1911, cr. dry on b'd
Helidon Sandstone ..	Wright	Brown	2.26	141	2.8	4x4x4	—	58,940	233.00	3634	P.W.D.	Cent. Tech. Col., 1911, cr. wet bed
Helidon Sandstone ..	Wright	Brown	2.30	143	—	3x3x3	—	54,720	385.71	6000	Rly. Dept.	Crushed dry on bed, C.R.S.,* 1900
Helidon Sandstone ..	Wright	Brown	2.30	143	—	3x3x3	—	61,550	439.66	6700	Rly. Dept.	Crushed dry on edge, C.R.S., 1900
Helidon Sandstone ..	Wright	Brown	2.30	143	—	6x3x3	—	43,680	310.13	4824	Rly. Dept.	Crushed dry on bed, C.R.S., 1900
Helidon Sandstone ..	Wright	Brown	2.30	143	3.55	6x3x3	—	33,720	238.55	3710	Rly. Dept.	Crushed wet on bed, C.R.S., 1900
Helidon Sandstone ..	Wright	Brown	2.37	148	—	3x3x3	—	71,780	509.48	7925	Rly. Dept.	Crushed dry on bed, C.R.S., 1900
Helidon Sandstone ..	Wright	Brown	2.37	148	—	3x3x3	—	75,610	538.81	8381	Rly. Dept.	Crushed dry on edge, C.R.S., 1900
Helidon Sandstone ..	Wright	Brown	2.37	148	—	6x3x3	—	60,640	432.70	6731	Rly. Dept.	Crushed dry on bed, C.R.S., 1900
Helidon Sandstone ..	Wright	Brown	2.37	148	2.86	6x3x3	—	36,760	260.05	4045	Rly. Dept.	Crushed wet on bed, C.R.S., 1900
Helidon Sandstone ..	Wright	Brown		153		4x4x4	49,950	56,480	—	3528	P.W.D.	Govt. Savings Bank tests, 1915
Helidon Sandstone ..	Wright	Brown		153	—	4x4x4	69,000	69,000	—	4312	P.W.D.	Govt. Savings Bank tests, 1915
Helidon Sandstone ..	Wright	Brown		153	—	4x4x4	67,200	77,800	—	4765	P.W.D.	Govt. Savings Bank tests, 1915
Helidon Sandstone ..	Miller ..	Brown	2.31	144	4.36	—	—	—	328.50	5110	P.W.D.	Govt. Printing Office tests, 1911
Helidon Sandstone ..	Miller ..	Brown		148	—	4x4x4	42,560	51,744	—	3234	P.W.D.	Govt. Savings Bank tests, 1915
Helidon Sandstone ..	Miller ..	Brown		148	—	4x4x4	41,440	41,440	—	2590	P.W.D.	Govt. Savings Bank tests, 1915
Helidon Sandstone ..	Miller ..	Brown		148	—	4x4x4	47,488	47,488	—	2968	P.W.D.	Govt. Savings Bank tests, 1915

* P.W.D.—Public Works Department. * C.R.S.—Central Railway Station.

TABLE SHOWING RESULTS OF TESTS ON QUEENSLAND SANDSTONES—(*continued*).

Stone.	Quarry.	Colour.	Specific Gravity.	Weight in lbs. per cubic ft.	Absorption in per cent. of dry weight.	Resistance to Crushing. Size of specimen in inches.	Cracking pressure in lbs.	Crushing pressure in lbs.	Crushing resistance in tons per sq. foot.	Crushing resistance in pounds per sq. inch.	Reference authority.	Remarks as to object of Tests and Character.
Helidon Sandstone ..	Pearson	White	2.30	144	6.2	4x4x4	—	36,710	152.00	2295	P.W.D.	Executive Building tests, 1901
Helidon Sandstone ..	Pearson	White	2.30	144	6.2	4x4x4	29,250	34,100	136.90	2130	P.W.D.	Executive Building tests, 1901
Helidon Sandstone ..	Pearson	White	2.30	144	6.2	4x4x4	27,900	32,570	130.80	2035	P.W.D.	Executive Building tests, 1901
Helidon Sandstone ..	Pearson	White	2.32	139	3.5	3x3x3	—	40,320	288	4480	Rly. Dept.	1899.
Helidon Sandstone ..	Pearson	Brown	2.27	142	3.5	3x3x3	—	35,840	256	3950	Rly. Dept.	1899.
Helidon Sandstone ..	Pearson	Pink ..	2.33	146	2.7	3x3x3	—	40,320	288	4480	Rly. Dept.	1899.
Helidon Sandstone ..	Pearson	Purple	2.38	149	2.7	3x3x3	—	60,240	416	6700	Rly. Dept.	1899.
Helidon Sandstone ..	Pearson	Brown	2.20	138	2.3	3x3x3	—	30,120	208	3350	Rly. Dept	1899.
Helidon Sandstone ..	Pearson	White	2.21	138	—	3x3x3	—	51,340	365.5	5685	Rly Dept	Crushed dry on bed
Helidon Sandstone ..	Pearson	White	2.21	138	—	3x3x3	—	65,380	468.5	7287	Rly Dept.	Crushed dry on edge
Helidon Sandstone ..	Pearson	White	2.21	138	—	6x3x3	—	53,570	388.7	6047	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	White	2.21	138	3.66	6x3x3	—	37,470	268.5	4176	Rly. Dept.	Crushed wet on bed
Helidon Sandstone ..	Pearson	White	2.24	139	—	3x3x3	—	39,180	278.5	4333	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	White	2.24	139	—	3x3x3	—	55,650	397	6175	Rly. Dept.	Crushed dry on edge
Helidon Sandstone ..	Pearson	White	2.24	139	—	6x3x3	—	46,200	329	5122	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	White	2.24	139	3.44	6x3x3	—	29,870	214	3329	Rly. Dept.	Crushed wet on bed
Helidon Sandstone ..	Pearson	Pink ..	2.26	141	—	3x3x3	—	53,580	386.4	6011	Rly Dept	Crushed dry on bed
Helidon Sandstone ..	Pearson	Pink ..	2.26	141	—	3x3x3	—	65,280	467	7334	Rly Dept.	Crushed dry on edge
Helidon Sandstone ..	Pearson	Pink	2.26	141	—	6x3x3	—	56,100	406.4	6322	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	Pink ..	2.26	141	3.98	6x3x3	—	46,980	341.5	5312	Rly. Dept.	Crushed wet on bed
Helidon Sandstone ..	Pearson	Pink ..	2.37	148	—	3x3x3	—	80,970	571.1	8884	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	Pink ..	2.37	148	—	3x3x3	—	79,180	560.2	8714	Rly. Dept.	Crushed dry on edge
Helidon Sandstone ..	Pearson	Pink ..	2.37	148	—	6x3x3	—	79,050	558.1	8682	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	Pink ..	2.37	148	3.35	6x3x3	—	63,480	450.4	7007	Rly. Dept.	Crushed wet on bed
Helidon Sandstone ..	Pearson	Brown	2.26	141	—	3x3x3	—	43,030	304.9	4743	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	Brown	2.26	141	—	3x3x3	—	52,570	373.7	5814	Rly. Dept.	Crushed dry on edge
Helidon Sandstone ..	Pearson	Brown	2.26	141	—	6x3x3	—	46,760	332.2	5168	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Pearson	Brown	2.26	141	4.20	6x3x3	—	27,210	197.7	2997	Rly. Dept.	Crushed wet on bed

Central Railway Station Tests, 1900.

Stone.	Quarry.	Colour.	Specific Gravity.	Weight in lbs. per cubic ft.	Absorption in per cent. of dry weight.	Resistance to Crushing. Size of specimen in inches.	Cracking pressure in lbs.	Crushing pressure in lbs.	Crushing resistance in tons per sq. foot.	Crushing resistance in pounds per sq. inch.	Reference authority.	Remarks as to object of Tests and Character.
Helidon Sandstone ..	Phippard	White	2.33	145	—	3x3x3	—	57,680	409.5	6371	Rly. Dept.	Crushed dry on bed } Central R'l-way Station Tests, 1900.
Helidon Sandstone ..	Phippard	White	2.33	145	—	3x3x3	—	49,370	352.5	5484	Rly. Dept.	Crushed dry on edge
Helidon Sandstone ..	Phippard	White	2.33	145	—	6x3x3	—	50,760	360.7	5612	Rly. Dept.	Crushed dry on bed
Helidon Sandstone ..	Phippard	White	2.33	145	2.73	6x3x3	—	32,780	231.8	3606	Rly. Dept.	Crushed wet on bed
Yan Gan Sandstone ..	Midson	Brown	2.18	136	—	4x4x4	—	40,560	163	2535	P.W.D.	Executive Building tests, 1901
Yan Gan Sandstone ..	Midson	Brown	2.18	136	8.7	4x4x4	—	43,120	173.2	2695	P.W.D.	Executive Building tests, 1901
Yan Gan Sandstone ..	Midson	Brown	2.18	136	—	4x4x4	—	50,610	203.3	3163	P.W.D.	Executive Building tests, 1901
Murphy's Ck. Sandstone	—	Brown	2.41	150	—	4x4x4	—	52,470	210.9	3280	P.W.D.	Executive Building tests, 1901
Murphy's Ck. Sandstone	—	Brown	2.41	150	—	4x4x4	—	57,670	231.8	3605	P.W.D.	Executive Building tests, 1901
Murphy's Ck. Sandstone	—	Brown	2.41	150	5.0	4x4x4	—	59,400	238.7	3712	P.W.D.	Executive Building tests, 1901
Calvert Sandstone ..	Downs	Brown	—	—	—	3x3x3	—	45,760	327.3	5085	R. Ferguson	Tests conducted at Syd. Tech. Coll.
Calvert Sandstone ..	Downs	Brown	—	—	—	3x3x3	—	45,510	325.1	5057	R. Ferguson	Tests conducted at Syd. Tech. Coll.
Calvert Sandstone ..	Downs	Brown	—	—	—	3x3x3	—	32,890	234.8	3654	R. Ferguson	Tests conducted at Syd. Tech. Coll.
Calvert Sandstone ..	Beatty & Walsh	Brown	2.39	149	4.47	—	—	—	240.6	3733	Rly. Dept.	Bremer Bridge test, 1896
Calvert Sandstone ..	Beatty & Walsh	Brown	—	—	—	—	—	—	288.3	4485	Rly. Dept.	Bremer Bridge test, 1896
Murphy's Ck. Sandstone	—	White	2.18	136	5.1	—	—	—	—	—	Rly. Dept.	Brisbane Dry Dock tests, 1875
Murphy's Ck. Sandstone	—	White	2.30	144	3.7	—	—	—	—	—	Rly. Dept.	Brisbane Dry Dock tests, 1875
Highfields Sandstone ..	—	White	—	—	4.8	—	—	—	—	—	W. Hamlet	Treasury Building tests, 1888
Highfields Sandstone ..	—	White	—	—	7.0	—	—	—	—	—	W. H. Dixon	1886.
Moggill Sandstone ..	Lyons ..	—	2.40	150	3.04	—	—	—	—	—	Rly. Dept.	Brisbane Dry Dock tests, 1875.
Moggill Sandstone ..	Lyons ..	—	2.39	149.4	3.0	—	—	—	—	—	—	Brisbane Dry Dock tests, 1875.
Moggill Sandstone ..	Lyons ..	—	2.30	143.75	3.8	—	—	—	—	—	—	Brisbane Dry Dock tests, 1875.
Moggill Sandstone ..	Lyons ..	—	2.48	153 75	2.07	—	—	—	—	—	—	Brisbane Dry Dock tests, 1875.
Lockyer Ck. Sandstone	—	—	2.45	153	3.7	—	—	—	—	—	Rly. Dept.	Brisbane Dry Dock tests, 1875.
Brisbane Tuff	Spring Hill	—	2.16	135	7.2	—	—	—	—	—	—	Brisbane Dry Dock tests, 1875.

General Remarks.

The difference in character of stones obtainable from the same quarry is not always appreciated. Igneous rocks such as granites, trachytes, etc., are rather homogeneous and there is little variation in the character of the stone as a rule, provided it is fresh and unweathered. Sedimentary rocks such as sandstones and limestones show great variation and adjacent beds in the same quarry frequently vary to a considerable extent. This is easily understood when one realises the mode of origin of these rocks ; also the same bed might easily change in character for better or for worse as it is worked. The inspection of sedimentary stones should, therefore, be very strict and each stone before being used should be passed by a duly-qualified person as being up to standard ; with igneous stones after careful selection of the quarry the inspection need not be quite so strict.

A perusal of the Table of Crushing Strengths, etc., shows how variable the results may be for stone from the same quarry.

It is generally agreed that in correlating results of Crushing Tests, little heed can be paid to the results obtained on different machines by different operators over a lengthy period. The manner in which the specimen is shaped and mounted, the size of the cube and the condition of the jaws, whether greased or lined with paper, cardboard, zinc, etc., affect the results obtained.

The selection of the specimens to be tested is of course an all-important matter, as a great variation exists in the results obtained from the same stone when crushed wet and dry. If a stone is taken from a quarry, dressed straight away and crushed with the sap water still in it, lower results will be obtained than by the selection of a piece of stone from the same bed, but which has been allowed to dry thoroughly before dressing and crushing.

The cracking pressure, the crushing pressure, the nature of the report on crushing, the shapes and number of the fragments, the sharpness of the edges and the amount of powder, should all be noted. The sharper the report, the keener the edges of the fragments and the smaller the amount of powder, the better the stone. In any case the average of a number of specimens crushed under the same conditions should be obtained if a reliable indication is required.

The values for specific gravity, in the case of porous stones like sandstones, require to be carefully accepted, as considerable difficulty is attached to the correct determination of the specific gravity of a porous stone.

In several places in Brisbane the practice of cementing the bar posts of iron fencing on top of stone by means of pouring in molten sulphur and letting it solidify has been adopted. This is fraught with much risk and very frequently results in the splitting open of the stone just as is done by the "plug and feathers" method of splitting. This is well seen on the fence wall along the river side of William Street opposite the Treasury building.

Sulphur is used on account of its cheapness and great chemical stability but the use of lead is preferable. The splitting of stone resulting from the use of sulphur instead of lead is a common feature in Melbourne in the basalt fence bases so that it is not restricted to Brisbane or to sandstones. Sulphur changes its crystalline form and becomes more dense after its initial cooling in the hole, but it is difficult to see how this could cause the pressure—it should have the reverse effect. Differences in the rates of expansion and contraction of the iron, sulphur and stone may bring about the cracking.

Summary and Conclusions.

The great advisability of closely considering the available supplies of suitable building stones in Queensland has been pointed out and the necessity of insisting on only sound weathering material being used has been urged. A systematic treatment of the physical, chemical and mineralogical characters of the stones which have been used and those likely to be used has been given. Queensland is well off for suitable granites in many places, and as far as Brisbane is concerned, a good dark "granite" from the Mt. Crosby district is worthy of further development. The defects of the Enoggera granite have been shown, but further prospecting of the granite mass in search of material free from pyrites is suggested. At present the grey granite from Greymare, near Warwick, is the most suitable granite available in Brisbane, but no regular quarries have yet been worked in it.

With respect to rhyolites and trachytes, the material from the Glass House Mts. has been dealt with and immense quantities of a very good, serviceable stone are readily available and in fairly close proximity to Brisbane. At Esk, a handsome brown rhyolite occurs in immense quantities and in a most advantageous position for working and handling. In considering the stones for use in the proposed Town Hall it is hoped these stones receive full consideration as they are much more serviceable than sandstones.

The various sandstones which have been used have been considered, but in many cases the quarries have been worked out. Good stone has been obtained from Goodna, Murphy's Creek, Helidon, and in the Warwick district at Yan Gan and Mount Sturt.

The Goodna stone from Jeay's quarry has lasted especially well, but that quarry is not available for working, and if the good beds could be found elsewhere and worked the stone would surely find a market.

The Murphy's Creek stone has been worked out and has given good results.

The Helidon stone has been largely used and is a very serviceable stone. It will probably be the chief sandstone used for some time; large quantities are still available.

In the Warwick district the best stone is at Yan Gan and it is probably the best sandstone at present available in the State. Large quantities exist, and the quarry is well opened up and thick beds are available for working. This stone will probably be used a great deal, but the distance from Brisbane is an item of cost which makes the stone rather expensive.

The Stanwell sandstone in the Rockhampton district has been considered. Large quantities are available and it may be regarded as a very fair serviceable sandstone.

The Brisbane tuff or "Porphyry" has been dealt with, and the necessity of careful selection pointed out. This stone is distinctly valuable for many purposes and a great acquisition to Brisbane.

A somewhat cursory treatment of the marbles, limestones and serpentines has been given, but Central Queensland possesses fine deposits of commercially valuable marbles which should be opened up and developed. The white marble deposit at Ulam is at present being opened up and promises well.

A list of the important stone structures in the State has been drawn up, the sources of the stones being given and the dates of erection whenever possible.

A table showing the chemical analysis of seven igneous rocks and six sandstones is given; also one to show the specific gravity, weight per cubic foot, absorption and resistance to crushing of the more important stones which have been used.

A few general remarks have been made on several matters of importance.

Several microphotographs are shown in Plates viii-x; these show the microstructure of the several rocks and are very useful in indicating the amount of cementing material in the sandstones.

Queensland may regard herself as fortunate in being subject to a very kindly climate as far as building stones are concerned, and also in having large quantities of granites, rhyolites, trachytes and easy-working sandstones of good appearance and reasonable weathering properties readily available.

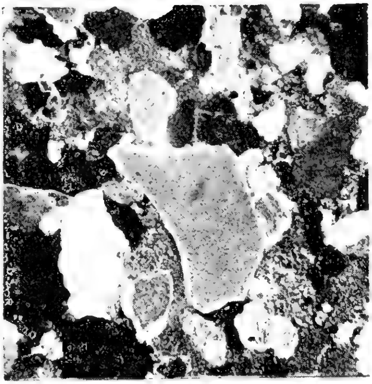
MICROPHOTOGRAPHS.

All the microphotographs have been taken with crossed nicols, and are magnified 22 diameters.

PLATE VIII.

1. Sandstone from Wright's Quarry, Helidon, showing the angular nature of many of the quartz grains and the abundant cement.
2. Sandstone from Montgomery's Quarry, Murphy's Creek, showing the uneven size of the grains and abundant cement.
3. Sandstone from Yan Gan, showing the fine, even-grained character in comparison with the other sandstones except the Calvert stone.
4. Sandstone from Calvert, showing its fine, even-grained character and similarity to Yan Gan sandstone.
5. Sandstone from Jeay's Quarry, Goodna, showing the uneven size of the grains and the relative abundance of cement.
6. Sandstone from Stanwell, 20 miles from Rockhampton. The uneven grain-size and amount of cement are well shown.

1



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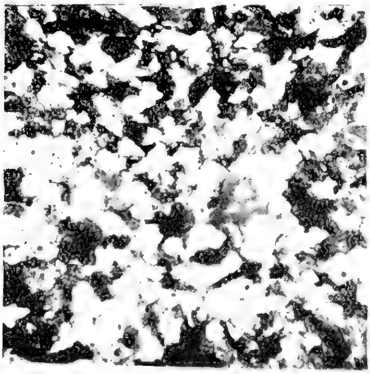

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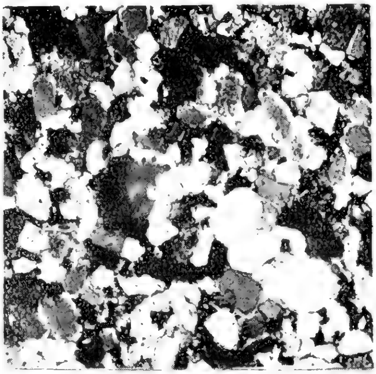

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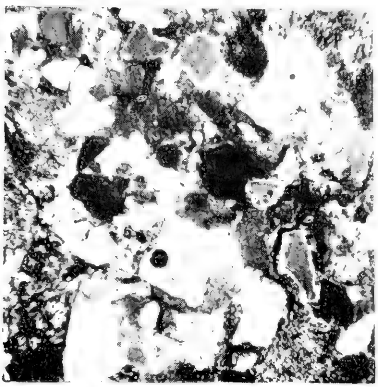

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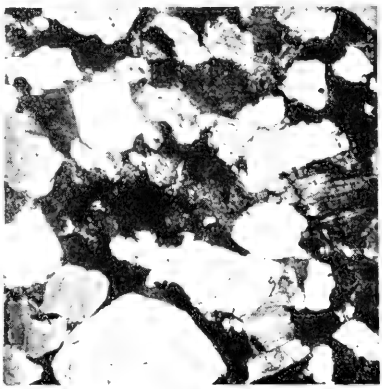

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PLATE IX.

7. Olivine Basalt from Municipal Quarry, Toowoomba. The lath-shaped crystals of plagioclase felspar and the rounded granules of olivine are clearly seen.

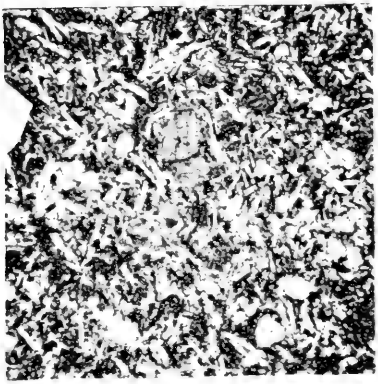
8. Rhyolite Tuff from Leichhardt Street Quarry, Spring Hill, Brisbane. The fine-grained nature of the stone, the curved particles of devitrified glass and the phenocrysts of quartz and felspar are seen.

9. Rhyolite from Council Quarry, Glen Rock, Esk, showing the fine, even-grained nature of the small crystals of quartz and felspar.

10. "Trachyte" from Mt. Ngun Ngun, Glass House Mountains. The lath-shaped crystals of sanidine felspar and the dark crystals of soda-rich augite are seen clearly.

11. "Trachyte" from Mt. Tibrogargan, Glass House Mountains, showing a phenocryst of sanidine felspar set in a very fine-grained groundmass of sanidine and soda-rich augite crystals; the latter are arranged in lines and patches.

12. Sandstone from Petrie's Breakfast Creek Quarry, Albion. The coarse nature of the sand grains and the abundant cement are seen.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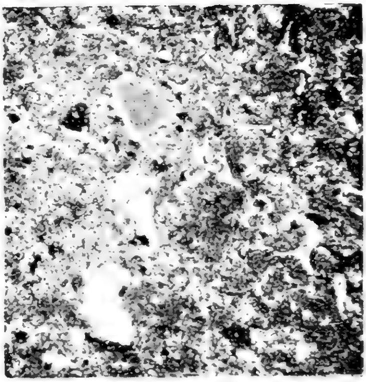
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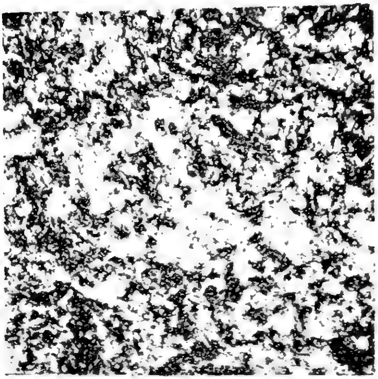
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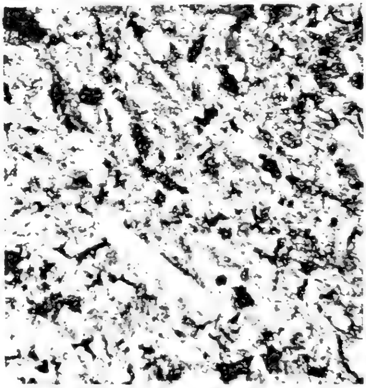
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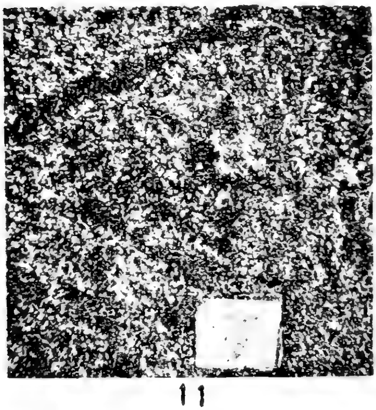
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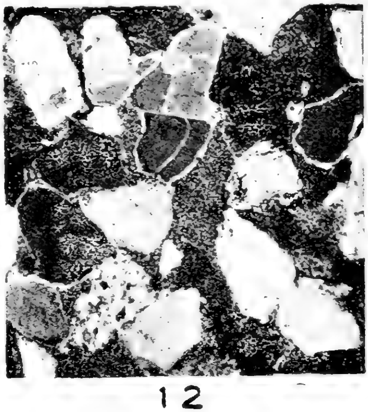
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PLATE X.

13. Granodiorite from Quarry at the Gap, Enoggera. The intergrowth of quartz and felspar is well shown; also the presence of biotite in the right-hand corner.

14. Quartz Diorite, from Bendley's selection, Mt. Crosby. The dark mineral is augite, while the grey and white minerals are plagioclase, and to a small extent, quartz.

15. Granodiorite from Greymare, showing clear quartz, cloudy plagioclase (zoned) and black mica.

16. Sandstone from Mitchell's Hong Kong Quarry, Warwick. The coarse and uneven nature of the stone is shown.

17. Sandstone from Quarry at Highfields, showing the fine-grained character of the stone and the very abundant cement.

18. Sandstone from Sydney. This is shown for comparison with the other sandstones.

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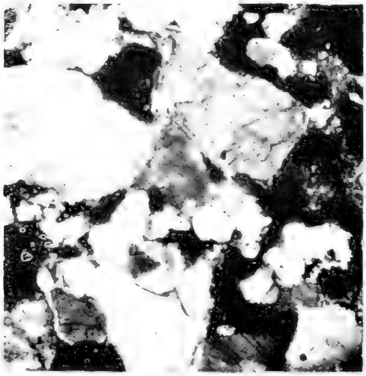

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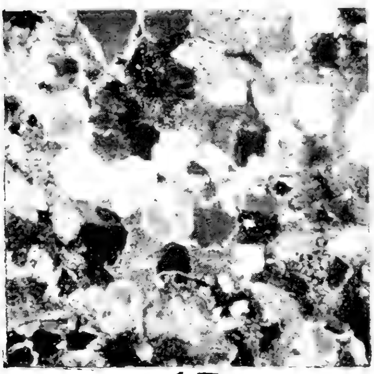

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ON THE OCCURRENCE OF PACINIAN CORPUSCLES IN THE PANCREAS OF THE DOMESTIC CAT.

By

C. D. Gillies, M.Sc., and O. W. Tiegs.

Biology Department, University of Queensland.

(With Text Figure 21).

(*Read before the Royal Society of Queensland, 30th September, 1918*).

Amongst the most interesting of the various nerve endings are the Pacinian or Vater-Pacinian corpuscles, which were discovered by Vater in 1741. Typically a Pacinian corpuscle is an ovoid body situated at the extremity of a medullated nerve fibre, the axon of which passes up the major axis of the structure and terminates within the latter as an arborescence. At the base of the corpuscle the perineurium or sheath of Henle of the nerve fibre is continuous with a considerable number of concentric tunics or coats of connective tissue (*t*, fig. 21), which are lined internally by endothelial cells (*n*, fig. 21)—in transverse and longitudinal sections the cells of the latter are prominent structures. The endoneurium, neurilemma or sheath of Schwann and the medullary sheath pass into the corpuscle for some distance with the axon, retaining their characteristic features, but eventually the endoneurium becomes modified to form a core (*c*, fig. 21) surrounding the axon, while the neurilemma and the medullary sheath are lost. Rauber* described an interesting variation in which three corpuscles

*Zool. Anz., iii, 1880, p. 635.

MUTATION IN A PROTEACEOUS TREE.

By H. A. Longman and C. T. White.

(With Text-Figure 22.)

(*Read before the Royal Society of Queensland, 30th September*, 1918).

A number of specimens of the handsome Proteaceous tree, *Buckinghamia celsissima* F. v. M., have been introduced from North Queensland and are thriving in Brisbane gardens. In the normal flower there is at the base of the style "a single semiannular truncate and crenulate gland."* (*Glandula hypogyna solitaria*, fere semiannulata)"†. Certain trees, however, present a striking divergence from the typical form. Several hundreds of flowers obtained from a tree at Wooloowin during February and March, 1918, were closely observed by us. In practically every flower the hypogynous gland is divided into four or five segments (usually five), and two of these are much elongated into supplementary style-like processes. These are about two thirds the length of the true style and terminate in small clavate discs which simulate stigmas, even as to colour. These supplementary style-like processes are very noticeable in the showy racemes. The length varies with development. In the earlier stages these processes are partly curved upon themselves inside the perianth tube and at no time do they reach the revolute limb which encloses the stamens. As the flower matures they are set

*Bentham, Flora Australiensis, v., p. 532.

†F. v. Mueller, Fragm., Phytogr., vi, 247; italics Mueller's.

free and stand erect, usually one on each side of the central style, which may still be looped in. In still later stages they tend to shrivel and are easily misplaced. In no case was any enlargement to be detected at the base. The differences between the normal and abnormal flowers are illustrated in text-figure 22.

The flowers of our Proteaceæ are typically protandrous, and the remarkable mechanism which ensures cross fertilisation—the immature style when detached from the anthers being a temporary depot for pollen grains—has been described by Delpino, Bentham and a number of subsequent authors. As long ago as 1882, W. Trelease made interesting comments on the various views held*.

In *Buckinghamia celsissima* the central style may have a number of pollen grains adhering to it when first set free. Pollen grains also adhered readily to the supplementary style-like processes when artificially supplied, but no grains were actually detected upon them in a state of nature. It is, however, conceivable that these processes may be of value as pollen carriers through grains falling upon them, and a still further development would increase their utility. On the other hand, this variation may be of use from the decorative standpoint to the tree, which attracts large numbers of insects, principally Hymenoptera.

Upon inquiry we found that the tree examined had been brought as a seedling from another specimen at Enoggera. Many racemes from the parent tree were then observed and also a single raceme from a young one close by. Without exception, each flower showed a pair of supplementary style-like processes developed similarly to those on the first tree.

Searching also revealed one or two flowers with elongate processes in each of many racemes examined from trees in the Brisbane Botanic Gardens. In each raceme from another tree at Indooroopilly a few flowers were found with two elongate processes and a number with only one elongate process, the great majority being normal.

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*Proc. Boston Socy. Nat. Hist., xxi, 1882, p. 419.

The first three trees demonstrate a race with well-developed supplementary style-like processes. There is no evidence of a graduated change from the tiny segments of the hypogynous gland, and it is, therefore, thought that this marked modification is better expressed as a mutation than as a variation. With the occasional exception in *Hakea digyna* Ewart and Davies* (through fusion of pedicels), a one-celled ovary seems to be the prevailing condition in Proteaceæ, and we do not know sufficient of their ancestry to warrant an interpretation of these structures as instancing a primitive tri-locular form. It has been suggested that the gynaecium of Proteaceæ is bi-carpellary because bidented or bifurcated style-ends are found in the genera *Agastachys* and *Adenanthos*, but Bentham expressed his opinion that these genera "are essentially monocarpellary."†

The hypogynous gland or glands usually possess fairly constant generic characters, and their value in classification was noted by Robert Brown.‡ He also recorded their resemblance to stamina and their function as secreting organs (*loc. cit.*, p. 133).

Instances of twin styles in Proteaceæ have been noted by Cheel (*Grevillea punicea* R. Br.)†† and Fletcher (*Grevillea buxifolia* R. Br.),‡‡ as well as in *Hakea digyna* Ewart and Davies.**

A normal raceme of *Buckinghamia celsissima* is well illustrated in Bailey's Queensland Flora (Vol. iv, p. 1352, pl. lx).

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*Flora of the Northern Territory, 1917, p. 85

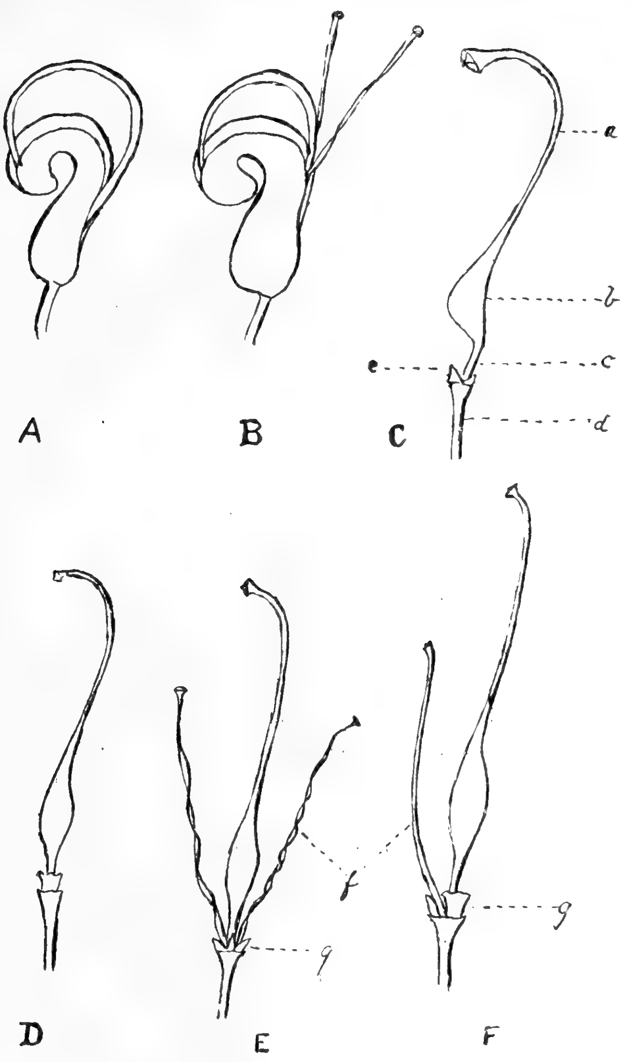
†Journ. Linn. Socy., Bot., xiii, 1873, p. 63.

‡Miscel. Bot. Works, Ray. Socy., ii, 1867, p. 17.

††Proc Linn. Soc. N.S.W., xxxvi, 1911, p. 158.

‡‡Proc. Linn. Soc. N.S.W., xlii, 1917, p. 247.

**Flora of the Northern Territory, 1917, p. 85.



Text-Figure 22. A—Flower bud (normal); B—flower bud showing position of the style-like processes; C—pistil (normal), side view: *a* style, *b* ovary, *c* stipes, *d* pedicel, *e* hypogynous gland; D—same, front view; E—pistil, front view; *f* elongate process; *g* the three small lobes of the hypogynous gland; F—pistil showing only one elongated process of the hypogynous gland. All enlarged.

AN ABNORMAL VERTEBRAL COLUMN IN *HYLA CÆRULEA* WHITE.

By C. D. Gillies, M.Sc., and Beatrice B. Taylor,
Biology Department, University, Brisbane.

(With Text-Figure 23).

(*Read before the Royal Society of Queensland, 30th September*, 1918).

During the course of an osteological examination of a number of specimens of *Hyla cœrulea* White that had been used for class purposes in the Biology Laboratory of the University of Queensland, one was observed to possess a vertebral column which deviated from the normal condition to a very marked degree. Instead of the vertebrae forming the characteristic linear series a pronounced curvature was seen on viewing the column dorsally and ventrally, the abnormality being more apparent from the ventral aspect, while on examining the vertebrae laterally it was observed that the column was directed dorsally from the fourth vertebra to the atlas. Viewing the specimen ventrally, the lateral curvature became apparent in the third vertebra and proceeding posteriorly to the junction of the fourth and the fifth, the deflection was to the left, but in the fifth and sixth the curvature was to the right bringing the longitudinal axis back to the characteristic linear condition in the remaining posterior components of the column. The atlas and second vertebra were also normal in this respect.

On account of the number of abnormalities present it was thought advisable to consider the individual components of the column separately.

Atlas. Ventrally the vertebra conformed to the typical condition, but from the dorsal surface it was abnormal in regard to the position of the neural crest, which was situated to the left of the longitudinal mid-line of the lamina, thus causing the left slope of the latter to be much steeper than the right. In addition, the left post-zygapophysis was rudimentary and the posterior border of the lamina ran antero-laterally to the left.

Second vertebra. The neural crest was similarly situated to that of the atlas, and anteriorly its spine bore a well-developed articular surface, which came into relationship with the atlas. The pre-zygapophyses were unequal in size, the right being the larger. From the ventral surface the posterior portion of the centrum was displaced to the right, and the diapophyses cut the horizontal at an angle of about 25°, the process on the left sloping anteriorly and that on the right posteriorly. The latter diapophysis came into close relationship with the corresponding transverse process of the third vertebra.

Third vertebra. The malformation of this was considerable as it was composed of distinct right and left divisions, each contributing to the formation of the centrum and the neural arch. Examined dorsally, the neural crest was borne by the right component, the diapophysis of which formed a greater angle with the horizontal than the corresponding process on the left, and furthermore was dilated into a rectangular expansion. This transverse process was broader and shorter than that on the left, which was typical. From the ventral surface the two portions of the centrum were separated by an oblique fissure running antero-laterally to the left. The most remarkable feature of this region was the articulation with the second vertebra, the centrum of which came into relationship with only the right component.

Fourth vertebra. The left portion of this vertebra, viewed dorsally, was strangely modified causing a reduction of the neural arch on the left. The right post-zygapophysis was normal but the left bore the articular surface on the *dorsal* aspect causing it to be overlapped by the associated prezygapophysis. Ventrally it was seen that the centrum was displaced to the right. The diapophysis of this side was very reduced and was undoubtedly the smallest transverse process of the entire series, though probably it was slightly damaged. The diapophysis of the left side was typical but for the fact that it approached the horizontal rather closer than is usually the case.

Fifth vertebra. Viewed dorsally, it was seen that the zygapophyses of the right side were better developed than those of the left; furthermore the prezygapophysis of the latter was abnormal in bearing the articular surface on its *ventral* aspect. The left disapophysis was dilated distally, and was stouter and somewhat longer than the one on the right.

Sixth vertebra. This vertebra was almost normal. The centrum, when viewed from the ventral surface, was curved to the left to a slight extent and the left diapophysis was more slender than the right, which was directed anteriorly instead of being more or less horizontal.

Seventh vertebra. The right diapophysis (vertebra viewed dorsally) was stouter than the process on the left.

Eighth vertebra. The neural arch was remarkable owing to the absence of a right posterior zygapophysis, but the one on the left was normal. Viewed dorsally the diapophysis of the right was dilated in the manner characteristic of a normal ninth vertebra, hence on this side forward homœsis was exhibited. The left transverse process was normal but instead of making a greater angle with the horizontal than the corresponding process of the seventh the angle present was actually less.

Sacral vertebra and urostyle. The last component of the vertebral column was compound and evidently formed by the fusion of the ninth or sacral with the urostyle, the union being so complete that it was impossible to determine the line of demarcation between them. The typical dilatation of the diapophyses was only apparent on the right transverse process (dorsal view), but the latter was slightly smaller than the abnormally dilated diapophysis of the eighth. The undilated diapophysis was only slightly more than half the length of the latter and was directed posteriorly at an angle of about 45° to the longitudinal axis. The foramina of the ninth spinal nerves were situated at the junction of the diapophyses with the urostylar region, the foramen associated with the dilated diapophysis being the larger and more elongated of the two.

The dilated transverse process of the eighth and the fused ninth and urostyle together formed the sacrum. In the specimen described in this paper the left diapophysis of the eighth and the right of the fused ninth were dilated, but Gillies and Peberdy* recorded a variation in which the right of the eighth and the left of the ninth were dilated, also viewed from the ventral surface. Again, in the latter the processes were approximately equal in size, but in our specimen the diapophysis of the eighth was the larger of the two.

Though possibly the malformation of the second, third and fourth vertebræ may have been the result of an accident, this can hardly be said of eighth and the fused ninth urostyle, neither of which exhibited traces of injury, so we infer that the specimen examined owed some of its most striking abnormalities to variation.

*Proc. Roy. Soc. Q'land, xxix, 1917, p. 53.

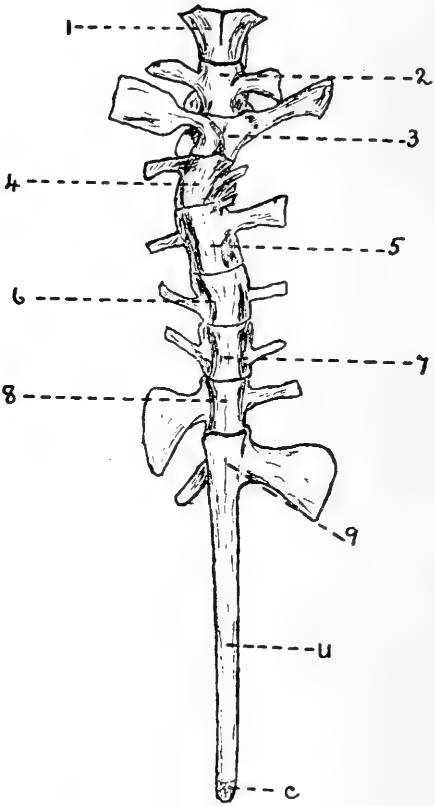


Figure 23. Ventral view of the vertebral column (x2).

1 Atlas; 2. Second vertebra; 3. Third vertebra showing right and left components; 4. Fourth vertebra; 5. Fifth vertebra; 6. Sixth vertebra; 7. Seventh vertebra; 8. Eighth vertebra with dilated left diapophysis; 9. Region of ninth vertebra; u. Urostylar portion of the fused sacral vertebra and urostyle: c. cartilage.

NOTES ON A NEW ROTIFER. *MELICERTA COLONIENSIS.*

By W. R. Colledge.

(With plate XI).

(*Read before the Royal Society of Queensland, 30th September,* 1918).

The present note is a description of what seems to be an entirely new species of colonial rotifer of the family Melicertadae, order Rhizota. They occur as circular masses of tough yellow gelatinous matter, a quarter of an inch or more in diameter. Occasionally they encrust the stems of water plants but oftener are found on submerged pieces of loose bark. In the latter case the form is hemispherical. Two hundred individuals were counted in one colony, not quite a quarter of an inch in diameter. Like most colonial rotifers, the feet of each individual are placed at the centre, and the bodies radiate on all sides. The head, or trochal disc, is very large and shaped like a four-leaved shamrock. During narcotization, at first, muscular control relaxes, and the organ becomes circular like the flower of the pansy. This phase passes, and the ordinary melicertan outline appears.

Occasionally, an additional contraction is seen, and a fifth smaller petal forms, frequently at the top, but occasionally on the lower edge of the disc. In fixing the animal for preservation, the outline becomes much squarer than it is in a natural state. A line of strong cilia borders the disc forming the principal wreath. Lying within this is the secondary wreath, formed of much shorter and finer cilia. Between these is sunk a deep gutter extending all round the disc. The action of the cilia drives a strong current of water through this channel. Protozoa and floating vegetable spores are thus carried on to the buccal funnel. This, densely lined with cilia, hurries the food down to the mouth, or chamber where the mastax or jaws are situated. On either side there appears to be a channel for carrying off the surplus water. The neck is bent, so that the trochal disc lies parallel to the long axis of the body, but can easily be placed in any direction. The creature is very sensitive, and quickly shrinks within the gelatinous cover when alarmed ; when this occurs the trochal disc, though three times the diameter of the body, is folded together and disappears, part of the neck is also invaginated, a series of parallel curves pointing to the place of disappearance.

A remarkable feature, which distinguishes it from *M. ringens*, is the possession of a pair of brilliant red eyes. These are connected together by a broad band of red pigment. A living colony seen under the microscope, the trochal discs extending like a bouquet of flowers around the periphery, and each adorned with a pair of brilliant ruby eyes, forms a most interesting sight.

The antennae, so conspicuous in *M. ringens*, are absent ; a small pimple near the ovary may represent them, but no tactile hairs are traceable on it.

Immediately below the jaws is a large oval mass, bearing two small lobes on its upper surface. The oesophageal tube is narrow, lined with cilia, and runs obliquely for some distance before reaching the stomach. On either side of this organ are two pear-shaped gastric glands. The stomach is long, opening into a broad intestine and the anus distinctly projects from the body. The foecal pellets are oval and projected with some force from the body, so as to be thrown beyond the attraction of the currents caused by the cilia on the trochal disc. The space behind the alimentary canal is occupied by the yolk gland, which largely fills the tube.

From this part the body gradually tapers to form a long slender tubular foot. It varies in length in different individuals, being adapted to the thickness of the matrix of the colony. The extreme section of the tube is of stiffer material, inflexible and adheres to the gelatinous matrix with some degree of firmness ; but the rest of the foot and body slides loosely within its own special cavity in the colony. In contraction the lower portion especially shrinks into a close series of concentric folds. The principal body muscles arise a short distance from the extreme end of the tube to which they are affixed. They are six in number, and proceed as separate strands upwards to near the anus, where they divide into twelve branches, some of which are inserted into the alimentary and reproductive glands, while others pass on to the corona and are the means by which it is invaginated. A number of glands are scattered along the interior of the foot similar to the mucous glands found in other rotifers of the same family. The mastax is a large elongated organ, built on the melicertan type, but differing from *M. ringens* and others in the details of its structure.

It lies across the centre of the face of the trochal disc and is twice as long as it is high. It is hinged in the centre, each side falling and rising about fifty times in a minute. The central portion or incus of each jaw is broadly triangular, and is destitute of the fine parallel teeth usually shown in the jaws of *Melicerta* and *Lacinularia*. At each corner of the base of the triangle is a blunt tooth, the sides are united by a bifurcating rod. Three thin, wide arches form the exterior frame of each jaw. A rod from each arch passes onward, and below the incus is broadened into a spatulate form, and lie with their flat sides parallel to each other, thus forming three large broad teeth at right angles to the side of the incus.

From the inner edge of the base of the incus, a rod extends to form the fulcrum, this instead of terminating in a point as in *M. ringens*, broadens out into a wide base for muscular attachment. The manubrium consists of the three circular arches just mentioned. These are strengthened by two rods and a transverse bar. They afford a wide attachment for the muscles, and furnish a strong leverage for them in the fulfilment of their work.

The male of this Melicertan was observed. It is small and similar in shape to others of the type. The body is long, narrow, terminating in a short foot. The head is truncated, surrounded by stout cilia, has two eyes placed wide apart ; a large nerve ganglion fills the head sending threads towards the foot. In the chest is a large clear space, one third the length of the body. Close to this arises a large dark testicular gland filled with spermatozoa, and reaching nearly to the foot. In the foot two large mucous glands lie side by side.

The eggs are oval, and filled with granular matter, and colonies die down at the approach of winter.

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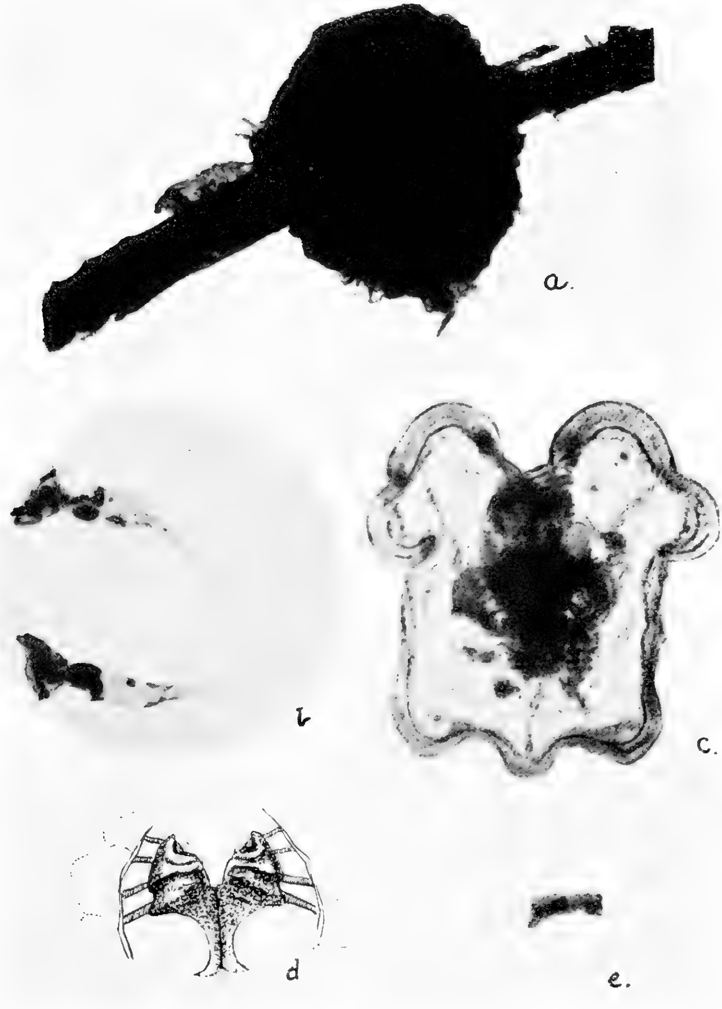
" " H. P. Gosse, *ibid.*
" " Bedwell, *ibid.*, 1878, p. 176.



Melicerta coloniensis Colledge.

a. Colony on stem; *b*. Two rotifers; *c*. Trochal disc; *d*. Mastax; *e*. Male.

THE VOCABULARY OF THE MT. SPENCER BLACKS.

By F. Bennett, B.Sc.

(*Read before the Royal Society of Queensland*, 30*th September*, 1918).

A few years ago, on the Middle Dawson, my brother pointed out to me a very old blackfellow, the last of the Lower Dee blacks. He came from the Mt. Spencer area, which lies about 50 miles south-west of Rockhampton. As I was aware (1) that the blacks on the Lower Dee River differed somewhat in their dialect from those of the Middle Dawson, 50 miles further to the south-west; (2) that this black was the last who might be able to throw any light on the matter; and (3) that this black and I might never meet again, or that he might soon die, I determined to get what information I could before it was too late.

There are, however, several difficulties in dealing with blacks, thus: (*a*) You wish to obtain the name of a stream: you point to the water and say "what name that pfeller?" The blackfellow sees with keen eye an eel *in* the water, and, as anything edible is important to *him*, he naturally supposes that you have seen the eel (though you have not) and it is, to him, perfectly natural that you should inquire about *it*. He therefore says "go'yooh," and you enter this as the name for "stream," when it is really the name for "eel." (*b*) It is almost impossible for a white man successfully to imitate the sound of the blacks' words. Often the utterance is preceded by a kind of nasal "gluck" (similar to that used by the "n" tribes in Africa when saying n'yanza, n'yassa, n'gami, etc.) The utterance seems to be suddenly cut off by the tongue and forced up the nose, producing an explosive sound like the noise of a "water-hammer" in the tap of a water pipe when a sister tap in the same pipe is suddenly turned off. Try as I would, I could not tell whether their word for bowels was "malcoo" or "walcoo." The sound seemed intermediate between the two. Then when I tried to say the same word the old fellow became convulsed with laughter. It was evident I had committed some awful solecism in his tongue, but what it was he would not tell me. He simply roared afresh. It was as if one had called a German maiden "bengel" for "engel."

Forewarned was forearmed, and I secured, moreover, the help of my brother, who has known for years every surviving blackfellow in this locality and enjoyed the confidence of all.

I asked as many questions at one sitting as I thought fair to the patience of the old man (for it is a tedious business if you have set your heart on being absolutely correct), and intended to procure another "yabber" (talk) later on.

However, he was called elsewhere, and, before my next visit, died. It is therefore no longer possible to complete the vocabulary of this tribe, but the list given may be useful for purposes of comparison. Thus these blacks call water "camoo," while 50 miles west, we have in "coomoo (bolaroo)" the same word.

On the Middle Dawson River we have "mil" for "eye," as in "mil-bookum" and "gooninny-mil."

Right away in the West Moreton District, 300 miles south, we have "mil-bong" *i.e.*, eye dead, eye gone or missing, eye poked out, blind in one eye; and "mil" extends far, far south. Yet, at Mt. Spencer, only 50 miles to the north-east, "eye" is "tee'parry". On the Middle Dawson and far to the southward, "foot" is "man-do-ee," but with the Mt. Spencer blacks it is "tid-nah."

On the Walsh River in the far north of Queensland many of the common words are identical with those used on the Paroo River in the remote south-west. Yet, here, tribes only 50 miles apart use different words for the most common objects. There was evidently some natural boundary between the two tribes, but what it could be I do not know as there is no large range or river to the south of Mt. Spencer. The tribe was, I fancy, a small one and restricted to a small area, whereas the powerful and savage blacks of the Upper Dawson, after the notorious Goongarry massacre, fled to the Flagstaff ranges, 72 miles away, and the Comet River blacks, after the Cullin-la-ringo slaughter, fled to a great distance.

The explanation may lie in the fact that the ranges in the south-west of the Leichhardt district abound in deep gorges almost inaccessible to enemies, and tribes using the refuge amalgamated into one powerful tribe, whereas this "City of Refuge" was too far distant for the Dee River blacks to attempt.

Partial Vocabulary.

(*a*) *Common objects.*
Water=cam'oo
Springwater=tee'nang camoo
River=buboo'rah
(*cf* Biboo'hra near Cairns)
Mountain=bar'ree
Sun=kar'roo
Moon=kak kal
Stars=gat till
Thunder=kar'ree
Lightning=par'ee-war'ree
(Note the similarity in barree, karee, paree-warree)

(*b*) *Common animals* (edible or otherwise).
Eel=go'yooh, or boog'-so-lah
Turtle=nay' pur'-rah
Scrub turkey=coo'-coo-bee
Plain turkey=wurk'-er
Alligator=tee'-nah
(Note that thee'nah=sole of the foot. Tid'-na=foot).
Porcupine=mont'-coo
Carpet-snake=boon'-gi
Tiger snake=coo-yun'-garra
Emu=goon-doo-'oo or goo'-roo-man
Kangaroo=woorah
Wallaby=woy-yah
Opossum=koolan (*cf* Kolan R.)
Native bear=ko-o-lah (*cf* ko-a-la)
Whip-tail wallaby=wal-lum-bul
Black iguana=mo'-nal (*cf* Mo-nal township)
Yellow iguana=mon-gull

(*c*) *Trees* (used for weapons, and as scrubs for refuge and for hunting).
Scrub=mon-gay
Brigalow=cab-bal-lah (*cf* Cabar-lah, near Toowoomba)
Bottle tree=boffine
Bauhinia=moo-kine
Ironbark=boon-garrah
Moreton Bay ash=kal-koo-rah'-ee
Coolibah=wee-coo'-loo
Npunyah=mund-jah

(*d*) *Relationships,* etc.

Father=yah-poo

Daughter=nap-oo

Mother=yung-ah

Sweetheart= yung-un-ay, or bee-coo'-nah, or bee-coo

Wife=tem-bar-goo

Brother=at-tun'nah

Sister=goo-tang

Son= teed-yee-nah, or be-coo-nay (contrast be-coo-nah)

Boy=gan-doo

Girl=ky-een

Little girl=bee-jin'-a-nan

Old man=wat-yoo-ur'ren

(*e*) *Parts of the body.*

Head=cutlah (not, as elsewhere, kob'berrah)

Hair=too-root

Beard=mn'-kah or um'-kah (the mn a nasal grunt as in *mw*alcoo)

Eye=tee-par-ree

Ear=wal-loo

Mouth=moo-noo

Teeth=yee-rah

Nose=wooh-tah

Breasts=nah-moon

Arm=moo-lah or mul-lah (The vowel sound lies between oo and u)

Palm of hand=mah

Bowels=malcoo or walcoo (The first consonant intermediate between m and w, like mw al'coo)

Testicles=moon'-moor-ah (*cf* Moon-mera a township.)

Anus=moo-lah (*cf* arm)

Thigh=wah-cah

Leg=tar-rah

Shin=too-moo

Foot=tid-nah

Sole of foot=thee-nah

Excrement=good-nah (as the township in the Moreton district)

(*f*) *Common actions.*

Cut=bahm-boong'ee

Kill=gundan'gi or goon-dab-bah

Die=my-in'dee

Swim=unt-al-lim bar'rah

Dive=my-oon-o-bo

Throw=bar-ree (Mountain also=bar-ree)

Corrobboree=wap-pee

(*g*) *Common adjectives.*

Hungry=cop-per-rah

White=moo-rah

(*h*) *Places.*

Cemetery=nah-wee-dah

Philologists must be careful not to conclude that a similar or identical word in another part of Queensland is really the same, unless the meaning is also the same. As in English, "box" has many meanings so "barree" in the Mt. Spencer area has at least two different meanings.

"Yerra" on the Burnett River may have no connection with the Mt. Spencer "yeera." Wallumbilla in the Roma area has nothing to do with the Mt. Spencer "wallumbul" any more than "breede" in Dutch has to do with "breeder" in English.

THE VOLCANIC ROCKS OF SPRINGSURE, CENTRAL QUEENSLAND.

By H. C. Richards, D.Sc., Lecturer in Geology, The University of Queensland.

(With 1 Plate and 6 Text-figures).

(*Read before the Royal Society of Queensland, 28th October, 1918.*)

Introduction.

In August, 1917, the writer visited Springsure for the purpose of examining the reported occurrence of alunogen on Vandyke Holding, sixteen miles south-west of Springsure, and also the volcanic rocks in the area, some of which were reputed to be alkaline trachytes.

The result of investigation of the alunogen deposit is given elsewhere in these Proceedings while the treatment of the volcanic rocks in particular is dealt with in this paper.

The area has been spoken of for some time past as containing representatives of the Cainozoic alkaline trachytes and as far as the author knows these rocks have not been examined and described hitherto.

The Agricultural Chemist (Mr. J. C. Brunnich, F.I.C.) kindly arranged for one of his assistants, Mr. G. R. Patten, to carry out three complete rock analyses of the three main types of volcanic rocks from the area, and a much more accurate knowledge of the rocks is gained thereby.

The similarity of the volcanic rocks in their lithological characters and in their arrangement with the volcanic rocks of south-eastern Queensland is very marked, as there is a three-fold development, with the alkaline trachytic rocks forming the middle representatives while basalts constitute the lower and upper divisions of the volcanic effusions.

Dr. Jensen and others have referred to the area as one containing alkaline trachytes and the area is regarded as being near the northern termination of a fairly definite line through Eastern Australia which connects the developments of Cainozoic alkaline trachytes*.

Previous Literature.

In 1894, in the Annual Progress Report of the Geological Survey Dr. R. L. Jack gives a general account of the geology of the Springsure district. Among other things he states on page 9 : " The village of Springsure is very picturesquely situated in the centre of a volcanic region built up of successive beds of lava, sometimes trachytic, but for the most part consisting of basic rocks, varying from ordinary basalt (sometimes glassy) to highly augitic andesite." . . . " Both the basic and acidic rocks contain, on joints and faces and in cavities, immense quantities of hyalite and chalcedony." Dr. Jack also refers to the opal-bearing trachyte on a ridge just to the south of the town.

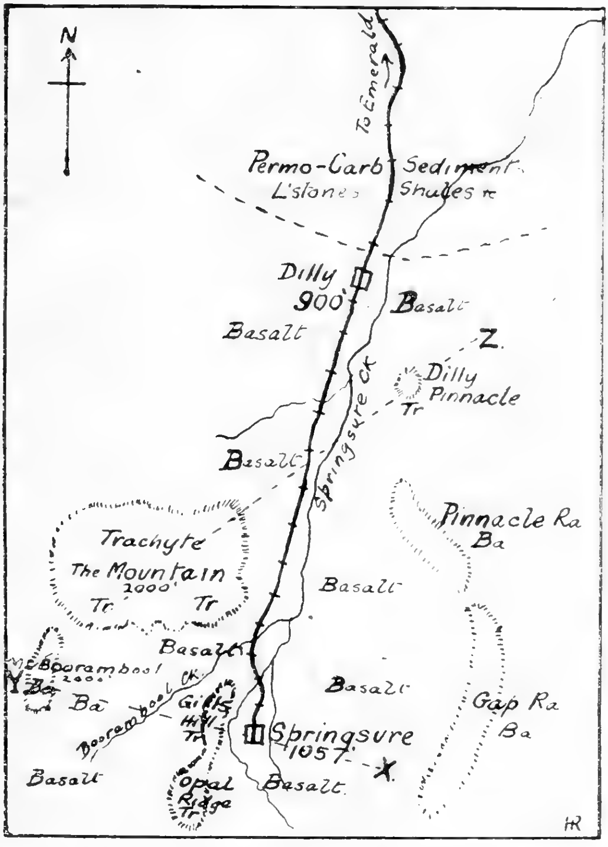
Mr. C. F. V. Jackson, in publication 177 of the Geological Survey of Queensland, gives an excellent account of the interesting development of opal in the trachyte, near Springsure. He writes : " The trachyte contains in many places large numbers of vesicular cavities, small thin veins and cracks, etc., filled with different varieties of opal which have been formed by infiltration of siliceous waters from the rock mass. The common forms are very plentiful, but occasionally the opal in the cavities is of the precious or noble variety, and gems so found are said to exhibit very brilliant colouring."

*Jensen, H.I., Proc. Linn. Soc., N.S.W., xxxiii, 1908, p. 585, text-fig. 10.

Physical Features.

Springsure is situated at the termination of a branch line 40 miles long, running south from Emerald which is 166 miles west of Rockhampton.

The basal rocks of the area are sediments of late Palæozoic age and piled on these are accumulations of volcanic rocks. These have been weathered down and very much dissected but they act as a divide between the Comet River on the east and the Nogoa River on the west which join further to the north to form the MacKenzie River.



Text-Fig. 24.—Sketch-Map of Springsure to show the location of the volcanic masses west and north-west of the town. XY and YZ are the lines along which the sketch-sections in Figs. 25 and 26 were taken. *Scale*: 2 miles to one inch.

In the immediate vicinity of Springsure the volcanic series of rocks have not been denuded through to the underlying Palæozoic sediments. These sediments are believed by the Geological Survey* to be of Lower Bowen age and to be part of a belt about 10 miles wide which extends from the south of Springsure in a northerly direction a little to the west of Emerald and east of Clermont. To the west of this belt the Star Series outcrops and the alunogen deposit at Vandyke, 16 miles south-west from Springsure, is in sandstones belonging to that series. To the east of the belt the Upper Bowen Series outcrops.

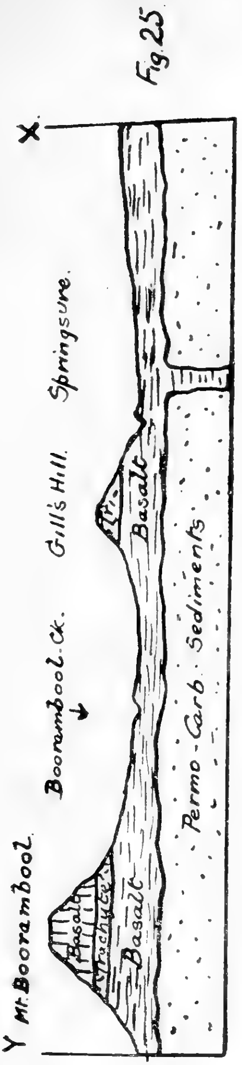
Springsure railway station is 1,057 feet above sea-level and the height of the volcanic accumulations reaches approximately 2,000 feet in the case of Mt. Boorambool which is about two miles west of the town.

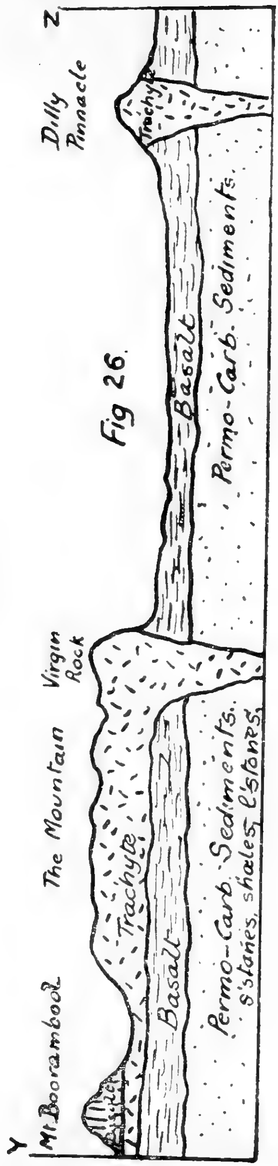
The immediate approach to Springsure by rail is along the valley of the Springsure Creek which runs north between the ridges of volcanic rocks. Boorambool Creek which joins Springsure Creek a little to the north of Springsure flows between Gill's Hill and Mt. Boorambool and around the southern flank of the Mountain. These creeks have denuded through the upper and middle series of volcanic rocks but have not cut through the basal volcanic series of basalts and basaltic agglomerates.

The investigations of the author were restricted almost entirely to the volcanic masses to the west and north-west of the town and these are the Opal Ridge running north to Gill's Hill, Mt. Boorambool or Ward's Hill and the Mountain. Mt. Zamia is the name given by some people to the Mountain and by others to Gill's Hill. In order to avoid confusion the term Mt. Zamia will not be used throughout this paper. Mr. McCahon, of Springsure, writes on this point: "After very full enquiries from some of the oldest residents and from several born and still living here I am inclined to think that Mt. Zamia has been given on maps, plans, etc. to the wrong mass. Many are positive that the correct name for what you have called the "Mountain" is Mount Zamia and the hill named Mt. Zamia on the maps is Gill's Hill."

The Pinnacle Range to the north-east and Gap Range to the east were not visited by the author but appear to be

*Verbal communication from Mr. B. Dunstan, Chief Govt. Geologist.





Text-Fig. 25.—Geological Sketch-Section from east to west, from Springsure to Mount Boorambool.

Text-Fig. 26.—Geological Sketch-Section from Mt. Boorambool to Dilly Pinnacle.

Hor. Scale : 1 mile to an inch. *Vert. Scale* : 2,000 feet to an inch accumulations of volcanic rocks. The Opal Ridge and Gill's Hill consist of trachyte and trachytic tuff rising to a height of 1,260 feet above sea level on Gill's Hill, *i.e.*, approximately 200 feet above the railway station level.

Mt. Boorambool further west from the town than Gill's Hill is about 2,000 feet above sea level and has a level top several hundred yards long and in width from 20 to 100 yards. The length of the ridge is along a north and south line. Mt. Boorambool is very steep and this is due to the hard protecting cap of olivine basalt which weathers less readily than the underlying volcanic rocks (*see* Text-Fig 27).

Photo. H. C. R.

Text-Fig. 27.—Mt. Boorambool from the Tambo road near the Opal Patch. The level surface of the basalt capping is well seen.

Further to the west a ridge on a more extensive scale but with a similar mesa-like character occurs. Several isolated mesas with basalt cappings occur to the south and south-west. The question arises as to whether these points were all connected at one time and subsequent denudation has left them as residuals or whether they are the residuals of several flows in different valleys. The latter view is the more probable.

The Mountain which rises to 2,000 feet above sea level is a mass of trachyte resting on basaltic agglomerate and basalt. Its sides are very precipitous and it is a matter of considerable difficulty to ascend the mass. The height of the Mountain above the surrounding country is about 1,000 feet and the upper 600 feet are of trachyte. The top of the Mountain, which occupies several hundred acres has a very uneven surface and great gorges up to 300 feet in depth have been carved out of the solid trachyte, the streams in them falling over on to the lower surrounding country by waterfalls several hundred feet high. The southern and eastern sides of the Mountain are precipitous and so the mass stands out in bold relief (*see* Text-Fig. 28).

Text-Fig. 28.—View looking north across the Springsure Township over the lower basaltic rocks to the Mountain, which is composed of trachyte. The steep sides of the Mountain are well seen.

(*Blo k lent by Government Tourist Bureau.*)

The Virgin Rock is the name given to one of the more prominent peaks on the eastern edge of the Mountain.

Palæozoic Sediments.

These form the basal rocks of the area and have been intruded by the volcanic rocks. They consist of sandstones, gravels and shales where met with seven or eight miles to the south-west of Springsure, near the homestead on Rainworth Station. In the immediate neighbourhood of Springsure they do not outcrop at all as the basal rock showing in the vicinity of the town is the basaltic agglomerate which underlies the trachytic rock.

Dr. Jack* recorded the occurrence, between Dilly Station and Crystal Creek, of a blue limestone containing

*Ann. Progress Report, Q'ld. Geol. Surv., 1894, p. 9.

numerous fossils, including a large *Aviculopecten, Productus subquadratus, Stenopora ovata, Protoretepora* and encrinite stems. This outcrop is about seven to eight miles north from Springsure township and a few miles less from the alkaline trachytic rocks. The occurrence of this limestone in the sedimentary series of rocks intersected by the volcanic rocks is noteworthy in connection with the origin of alkaline rocks as postulated by Daly and others.

Dr. Jack recorded another patch of limestone with similar remains three miles west of the patch above mentioned, and he speaks of the limestone as belonging to the Gympie division of the Permo-Carboniferous rocks. Mr.

Photo H. C. R.

Text-Fig. 29.—View of the eastern edge of the Mountain from the Virgin Rock. The precipitous nature of the cliff face is well seen.

B. Dunstan, the Chief Government Geologist, regards these rocks as belonging to the Lower Bowen Series.

Petrography of the Volcanic Rocks.

The volcanic rocks which have a total thickness of about 1 000 feet are naturally developed into three divisions.

Lower Volcanic Rocks.

These consist of basaltic agglomerate and basaltic flows which extend from a height of about 1,050 feet above sea level to a maximum height of 1,400 feet on Mount Boorambool, and a minimum height of 1,160 feet on Gill's Hill, before they are succeeded by the trachyte tuffs and trachytic flows which, in their turn, have been succeeded by a series of basaltic flows. This basal agglomeratic material is very well developed in the southern portion of the town where it is shown in the streamcourse under the road bridge. The agglomerate is made up of fragments of scoria which range in size from that of a walnut to that of a large apple. The fragmental material is bright in appearance and shows a marked contrast in colour to the grey-blue lava with which it is associated. Chalcedony is very abundant all through the weathered flows and scoria, and the junction line between the lava and agglomerate is the most favourable spot for its development.

Evidently from the presence of agglomerate here, there must have been a centre of explosive activity in the immediate vicinity. Similar agglomerate is met with on the southern slope of the Mountain which is a huge trachytic mass situated north-east of the town.

Scattered about on the weathered surface of the lower basaltic rocks are abundant pieces of chalcedony which at one time occupied the vesicles, etc. in these rocks. Many of these fragments show opaline characters and occasionally closely approach precious opal.

The flows exhibit a marked platy character and this is due mainly to movement of flow during the consolidation period as microscopic investigation shows the augite well drawn out and with the lath-shaped plagioclase crystals all through it.

Specimen 278*, from a well sunk in the yard of Scott's Hotel, Springsure, is a dense fine-grained, greenish-black plagioclase basalt. It has a density of 2.822 which is high and, no doubt, largely due to the great amount of augite and iron ores which the rock contains. Occasional amygdules of chalcedony occur.

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*This number and others subsequent refer to the numbers in the collection in the University of Queensland.

A microscopic examination (*see* Plate xii, Fig. 6) shows the rock to be holocrystalline and to be made up of lath-shaped plagioclase crystals set in allotriomorphic, drawn-out crystals of deeply violet-tinted augite. Granules and rods of the iron ores (magnetite and ilmenite) occur very abundantly throughout the section. The felspar crystals have an average length of about 0.5 mm. while the drawn-out augite crystals which are optically continuous but much dissected by the plagioclase crystals, range up to 1.0 mm. in length and 0.5 mm. in width. The chemical analysis of the rock shows the high percentage of 4.04 for titania which corresponds with the deep violet tint of the augite. Patches of a dark-green chloritic product occur occasionally through the section and this material is probably derived from the augite. The plagioclase obviously ceased crystallising before the augite, and the allotriomorphic drawn-out crystals of the latter with idiomorphic plagioclase crystals sticking through them indicate movement in the flow after the plagioclase had crystallised and before the augite has ceased crystallising.

The plagioclase could not be determined optically. There is a marked absence of olivine in this rock which is in strong contrast with the olivine-rich basalt of the flows forming the uppermost series of volcanic rocks in the area.

A chemical analysis carried out by Mr. G. R. Patten, of the Agricultural Chemist's Laboratory, Brisbane, is shown on Table I. A comparison of the analysis with that of the olivine basalt from Mt. Boorambool shows how closely allied the two rocks are chemically; this is still further emphasised by comparing the norms.

Specimen 279, from the Opal Ridge about three-quarters of a mile south-west of Springsure, is a very finely scoriaceous, glassy basalt. It forms the uppermost portion of the lowest division of volcanic rocks and immediately underlies a trachytic tuff which in its turn is succeeded by trachytic pitchstone and trachyte. The material is somewhat agglomeratic and in colour it is a dark bluish-grey. The material has been met with at the bottom of the shaft which was sunk on the opal patch through the trachyte and trachyte tuff. It outcrops over the lower portions of the ridge, having been exposed by the weathering of the covering material.

The microscopic section (*see* Plate xii, Fig. 4) shows the rock to be a finely scoriaceous black glass through which there are minute microlites of felspar. The cavities are lined with very fine rounded granules which have a refractive index lower than Canada balsam and are probably tridymite.

Middle Volcanic Rocks.

These consist of trachytic tuffs and flows.

Trachytic Tuff. This occurs at the base of the series and is several feet thick. It is made up for the most part of trachytic material but in the lower parts it contains abundant fragments of the underlying scoriaceous basalt. These particles are usually about the size of filberts. The best development of tuff occurs along the Tambo road and on the sides of the ridges in the neighbourhood of the opal patch. Its extension in a south-westerly direction could be traced for some distance, also in a northerly direction around the flanks of Gill's Hill. On the southern slope of the Mountain, at the base of the steep cliffs of trachtye, a trachytic agglomerate was met with at one point. It is much weathered and occurs on top of the basic representatives of the lower division of volcanic rocks. Certain bands in the tuff contain abundant rounded grains of sand.

Trachyte. This occurs outcropping on the surface of the Opal Ridge, Gill's Hill and the Mountain, while on the flanks of Mt. Boorambool it is found outcropping between the lower basaltic and upper basaltic series. It is a very fine-grained, pink rock, showing a very definite fluxion structure. It rests on top of the tuff and in some cases, as on the upper ridge, near Gill's Hill, it has cooled so quickly as to form pitchstone. The pitchstone, in some cases, occurs as a dense black glass and bears a marked resemblance to the Mount Lindsay pitchstone*; it differs, however, in being almost entirely free from felspar phenocrysts. In other cases it shows a very good fluxion banding and some blocks of this have been brought to the surface

*Richards H. C., Proc. Roy. Soc. Q'ld., xxvii (2), 1916, p. 138.

from the shaft sunk in the opal patch. This material bears a remarkable similarity to the pitchstone on the Springbrook Plateau*, near MacPherson's Range, in south-east Queensland, and occurs in a similar manner as a glassy selvage at the base of the flow of trachyte. On Gill's Hill and Mt. Boorambool, the trachyte flows are about 100 feet thick while on the Mountain the accumulated thicknesses are at least 600 feet.

On the Opal Ridge the trachyte is rather more weathered than elsewhere and is spherulitic for the most part. Sections of the more compact material show this very clearly. The material, however, has been altered into kaolin and chalcedony which occurs abundantly through it.

The precious opal was found in this weathered trachytic material and, as noted by Jackson†, its occurrence in this respect differs from that of the opal deposits in south-western Queensland, north-western New South Wales and Central Australia, which occur in the Cretaceous sedimentary rock. Jackson speaks of opal occurring in a similar manner to this deposit near Rocky Bridge Creek in New South Wales, while the writer has seen a specimen of precious opal obtained from the O'Connell Town quarry in the Brisbane Tuff.

The main mass of trachyte on the Mountain is rather uniform in character and while the prevailing colour is pink, in places it is a greyish-white. As great gorges, in places 300 feet deep, have been carved through the trachyte and as it is almost devoid of soil an excellent opportunity of examining the material is afforded. The rock is very platy as a result of the fluxion structure and thin flakes of the material when knocked together give forth a pronounced metallic clinking sound. The stone well merits the term "Clinkstone," and it is very interesting to find that it is really a phonolite in the strict petrological sense.

Specimen 277, obtained from the Virgin Rock on the Mountain, is representative of the main mass. It is a very fine-grained pink rock with occasional phenocrysts of anorthoclase which range up to 1mm. in length. Under the

*Richards, H. C., Proc. Roy. Soc. Q'ld., xxvii (2), 1916, p. 137.

†Jackson, C. F. V., Geol. Surv. Q'ld., Pub. 177, 1902, p. 33.

microscope (*see* Plate xii, figs. 1, 2) the section shows a holocrystalline texture although the groundmass is very fine. Phenocrysts of anorthoclase, sanidine and nosean occur. The sanidine crystals range up to 0.5 mm. in length and are idiomorphic, whereas those of anorthoclase are allotriomorphic and up to 1 mm. long, while the nosean crystals are allotriomorphic to hypidiomorphic and the rounded granules range up to 0.25 mm. in diameter. The fluxion structure can be seen in a general way in the section in the ground mass which is composed of felspar, nosean, very fine light-brown augite granules and magnetite. The nosean is rather abundant and the granules are transparent and isotropic with rough cracks through them. The refractive index is much lower than that of Canada balsam. When altered, the granules become reddish brown and this brown staining can be seen developing along the cracks. The nosean was determined by etching with strong hydrochloric acid for 30 minutes and then staining the gelatinous silica produced thereby with fuchsine. Some of the granules showed a weak double refraction but the dust like inclusions, so generally characteristic of nosean, were absent.

The alteration into brown limonite and a kaolin-like aggregation is, according to Iddings*, one of the characteristic weatherings of nosean and this, together with the very low lime content of the rock, inclines one to nosean rather than hauyne. The analysis of this rock, as shown on Table I, shows the very alkaline character, with 10.61 per cent. of alkalies and less than one per cent. of lime. Although the silica percentage is 67.32 the rock is regarded as a phonolite. The specific gravity is 2.519.

Specimen 283, is from the Opal Ridge and is also characteristic of the material on Gill's Hill and on Mt. Boorambool. The material is somewhat weathered and veins of chalcedony along the fluxion lines and through the cracks are prevalent. The rock is very fine-grained and in colour is pinkish-brown. It is reported that this is the type of material in which the precious opal was found. Under the microscope the texture is hypohyaline and the

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*Rock Minerals, 1911 Edtn, p. 257.

whole rock is microspherulitic with very well defined perlitic cracks through it (*see* Plate xii, fig. 3). There were no traces of nosean crystals in this section. The specimen was obtained from near the base of the flow and is evidently a more glassy form of the phonolite.

At Dilly, which is about five miles north of Springsure, there is a pinnacle standing about 700 or 800 feet above the surrounding basaltic country. The writer did not investigate it but from the railway line it appears to be similar material to the phonolite on the Mountain and local inhabitants state that it is of a similar nature.

Dr. Jack* refers to a series of centres of eruptions or "necks" standing about 300 to 600 feet above the level of the old telegraph road between Springsure and Minerva Creek. He mentions Mt. Zamia, the Pigeon House, Saint Peter and Little Saint Peter. He regards these necks as composed of trachyte for the most part but some of them, *e.g.* Red Hill, are partly filled up with a coarse angular agglomerate in which basaltic fragments are mixed up with the trachyte. Unfortunately, owing to limited time, the author was unable to visit these points.

Upper Volcanic Series.

This consists of basaltic flows and just near Springsure they are best developed on Mt. Boorambool. The flows are horizontally disposed and there is a total thickness of about 600 feet. The thickness of individual flows ranges from six to ten feet.

Mt. Boorambool has a very well defined "table-top" appearance and to the west and south, similarly-shaped, flat-topped mesas may be seen.

The weathering of the upper series of basaltic rocks has resulted in several of these mesas being left where the rocks have been more resistant; the sharp breaking across and comparatively steep sides of the ridges gives the table-top effect.

At Mount Boorambool there are several layers of rock especially rich in hyalite which occurs in large masses. Some of the flows are particularly rich in fayalite which on ex-

*Annual Prog. Report, 1894, p. 9.

posure to weather alters to ferric oxide and silica* and this is probably the source of the hyalite so commonly developed in the flows in vughs, cracks, etc. A rough columnar structure is developed in the flows at the north end of Mt. Boorambool.

Specimen 280, from the top flow of Mt. Boorambool is typical of the series and in the hand specimen it is a fine-grained, grey, scoriaceous rock. It has a density of 2.747. Under the microscope (*see* Plate xii, fig. 5) the section is seen to be that of a fayalite basalt made up of plagioclase, fayalite, augite and the iron ores, set in a partly-glassy groundmass. The rock shows a rough fluxion structure. The plagioclase is a basic andesine corresponding to Ab_{55} An_{45} and ranges in length up to 0.6 mm. The augite is strongly violet-tinted and is titaniferous, and is much disconnected by the interlacing felspar laths. The drawn-out augite crystals occur up to 1 mm. in length. The fayalite occurs in rounded grains and averages 0.25 mm. in diameter. Limonite occurs as a secondary product from the alteration of the fayalite while serpentine does not occur at all.

Chemical Characters of the Volcanic Rocks.

The chemical analysis of the phonolite shows a very high percentage of alkalies with the soda and potash in approximately equal amounts. The lime content is very low as is also the magnesia. Sulphuric trioxide occurs to a slight extent and occurs probably in the nosean. In the norm the alkaline character of the rock is very well indicated as orthoclase and albite together total over 75 per cent. of the rock while anorthite totals less than 2 per cent.

The chemical analyses of the two basalts are very close to one another, the most marked difference being in the lime content. A comparison with the average composition of the basalts of the world shows they are nearly normal in their compositions, except in the titania content which is very high indeed in both cases. Both rocks are rich in augite which, from its violet colour, appears titaniferous, but, in addition, a considerable portion of the iron ore must be ilmenite.

*Iddings. Rock Minerals, 1911 Edtn., p. 381.

TABLE I.—*Chemical Analyses of Volcanic Rocks and their Norms.*

A. Phonolite. Virgin Rock, The Mountain, Springsure.
B. Basalt. Scott's Well, Springsure.
C. Fayalite Basalt. Mount Boorambool, Springsure.
D. Average composition of Basalts of World*.

	A.	B.	C.	D
SiO_2	67.32	46.41	47.20	48.78
Al_2O_3	15.10	16.61	15.25	15.85
Fe_2O_3	2.70	3.85	4.61	5.37
FeO	1.57	8.69	8.43	6.34
MgO	0.41	5.41	5.72	6.03
CaO	0.70	6.24	8.14	8.91
Na_2O	5.32	3.41	3.45	3.18
K_2O	5.29	1.36	1.57	1.63
H_2O+	0.35	0.50	1.54	1.76
H_2O-	0.55	2.86	0.50	
TiO_2	0.32	4.04	3.25	1.39
P_2O_5	0.08	0.62	0.55	0.47
MnO	tr	0.14	0.16	0.29
SO_3	0.07	0.03	0.07	
Total	99.78	100.17	100.44	100.00
Spec. Grav.	2.519	2.822	2.747	

NORMS.

	A.	B.	C.	D.
Quartz	14.94	—	—	
Orthoclase	31.14	8.34	9.45	
Albite	44.54	28.82	28.82	
Anorthite	1.95	25.85	21.68	
Diopside	0.65	1.11	12.30	
Hypersthene	0.70	14.59	4.42	
Olivine	—	3.53	7.55	
Magnetite	3.94	5.57	6.73	
Ilmenite	0.61	7.60	6.23	
Pyrites	0.06	—	0.06	
Apatite	0.34	1.34	1.34	
Water	0.90	3.36	2.04	
Total	99.77	100.11	100.62	
Classification	I.4.1.3. *Liparose*	II.5.3.4. *Andose*	III (II).5.3.4. *Camptonose*	

*Daly. Igneous Rocks and their Origin, p. 27.

There is a marked difference in the *modes* of the two rocks although they are so close chemically and that is with respect to the mineral fayalite. The basalt from Scott's Well does not contain any fayalite or olivine as seen in the microsection, while the Mt. Boorambool basalt is very rich indeed in the mineral.

Relationships and Origin of the Volcanic Rocks.

The close association in this field of normal sub-alkaline or calcic basalts and alkaline trachyte rocks causes one to speculate as to the cause of the variation. The phonolitic magma has been extruded after calcic basaltic magma was effused and in its turn it was followed by a succession of outpourings of basaltic flows.

The analyses of typical samples of both the upper and lower series of basaltic flows show them to be very similar and to be closely comparable with the average composition of the basalts of the world.

The several outpourings seem to have followed one another at frequent intervals as there is no evidence of any period of time having elapsed between successive outpourings. The lower series of basalts were extruded in the immediate vicinity of Springsure, as evidenced by the agglomeratic character of much of this series; also the middle series was effused from a focus in the same vicinity, as shown by the occurrence of trachytic tuffs and agglomerate and by the character of the main mass of the trachytic rock.

There is no evidence as to whether the upper series was effused from the same centre of activity or not. The fact that the flows on the disconnected mesas "line up" rather suggests a different centre of effusion as the upper series is of greater thickness and on a far more extensive scale of development than the lower and middle series.

There are, however, many points of resemblance between the lithological and chemical characters of the two basaltic series and a somewhat common origin may be assumed for them.

The phonolitic material is interbedded between these two series of basic calcic rocks and the interesting question of accounting for this association arises.

The basaltic rocks both above and below may represent outpourings of a comparatively undifferentiated primary basaltic magma and on chemical evidence this view is supported. Gravitative differentiation may have gone on to some extent as the lower series is olivine free, while the upper series is rich in olivine (fayalite). This arrangement is the reverse of that cited by Daly*, as found by Lewis and Du Toit in certain areas in New Jersey and East Griqualand respectively. If the magma had been affected by the olivine crystals separating out and owing to their higher gravity settling at the bottom the material in the upper part of the magma if extruded first would tend to be olivine free, while the material at the bottom of the reservoir and extruded last would be olivine rich. How has the phonolitic material resulted ? Has it been formed from the basic calcic magma by fractional gravitative differentiation as advocated by Bowen, by the absorption of foreign material as advocated by Daly, by the action of gases or mineralisers as advocated by Smyth, or by any other means ? In answering this, a consideration of the nature of the intruded terrane is of importance. The underlying rocks are sandstones, shales and limestones as far as can be ascertained. These sediments† outcrop just to the north of the area covered by the volcanic rocks.

The intruded terrane almost certainly contains limestone, and the solution of this material to a small extent would be regarded by Daly as sufficient to result in the production of the phonolitic material from the calcic basaltic magma.

The writer, in dealing with the origin of the volcanic rocks of south-eastern Queensland, regarded them as being differentiates of a single original magma and owing to the almost entire absence of any known limestone in the intruded rocks rejected the sediment-syntectic hypothesis of Daly.

Daly‡ in the "Genesis of Alkaline Rocks" points out that he does not regard limestone as necessarily a partner in a syntectic from which trachytes, etc. are differentiates,

*Daly, R. A., Igneous Rocks and their Origin, p. 316.

†Ann. Prog. Rept., Q'ld. Geol. Survey. 1894, Pub. 103, p. 9.

‡Jour. Geol., xxvi, 1918, p. 108.

and he has "indicated the grounds for regarding shales and other sub-siliceous, hydrous sediments as more influential in the generation of trachytic and syenitic magmas generally." On these grounds of course the alkaline rocks in south-eastern Queensland and in the Springsure area may be accounted for, but it is difficult to explain why the outpourings from the same eruptive centre should be at one time calcic and at another time alkalic when the same series of sediments are being intruded. A further matter to account for is the reason for the middle series only of volcanic rocks being alkaline.

All through the south-eastern Queensland area the alkaline rocks are restricted to the middle series of the three-fold development of volcanic effusions and the same holds good in this area.

Even if Daly's origin of the phonolitic material be accepted, it is difficult to account for the regular mode of occurrence in south-eastern Queensland and at Springsure, of the material in between the two developments of calcic basic to sub-basic volcanic rocks.

It is perhaps easier to reconcile such a regular occurrence with a gravitative differentiation scheme as postulated by Bowen, or even with some modification of Harker's hypothesis of crustal dislocation by radial movements. With respect to Harker's hypothesis the writer has not any evidence at all as to crustal movements or otherwise in this particular area.

Age of Volcanic Rocks.

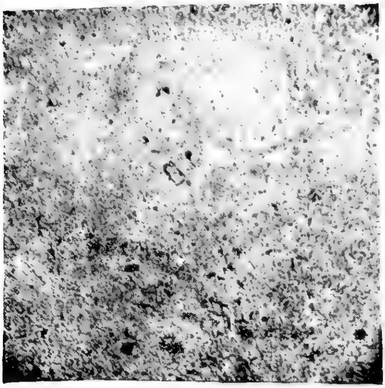
With respect to the age of the volcanic rocks there is no stratigraphical evidence except that they are later than the Upper Bowen Series (Permo-Carboniferous). On lithological and chemical grounds, however, there seems to be no reason for regarding them other than part of the Caino-zoic development of volcanic effusions so abundantly developed in eastern Australia.

A close parallel can be drawn with the volcanic rocks in south-eastern Queensland in sequence, on physiographic grounds, and in lithological, mineralogical and chemical characters. As these volcanic rocks are almost certainly of Cainozoic age, a similar age might with confidence be assigned to the volcanic rocks of the Springsure district.

PLATE XII.

Figures 1-6 magnified 22 diameters.

1. *Phonolite* from Virgin Rock, the Mountain, Springsure. The granule of nosean in the centre of the field and crystals of anorthoclase are seen set in a groundmass of felspar and nosean.
2. Same section as above but under crossed nicols. The isotropic character of the nosean is well shown.
3. *Trachyte* from Opal Ridge, under crossed nicols. It shows perlitic cracks in one portion and the edge of a large spherulite in the other portion.
4. *Glassy Basalt* from Opal Ridge, under crossed nicols. The scoriaceous character is well shown, also the glassy nature of the base. The tridymite lining the cavities is not observable in the microsection.
5. *Fayalite Basalt* from upper flow, Mt. Boorambool. Composed of plagioclase, fayalite, augite and iron ores. The rounded granules with the dark borders are fayalite crystals.
6. *Basalt* from Scott's Well, Springsure, composed of plagioclase, augite and the iron ores.



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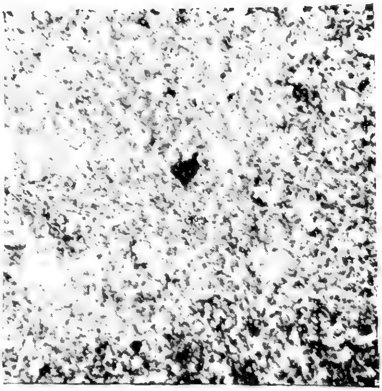

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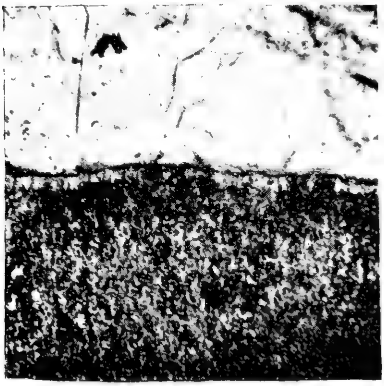

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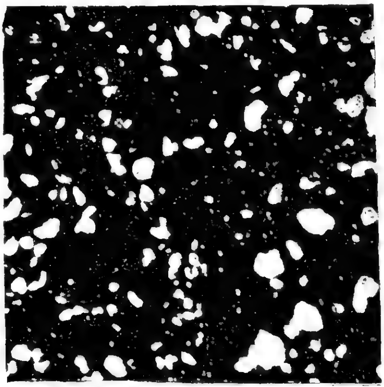

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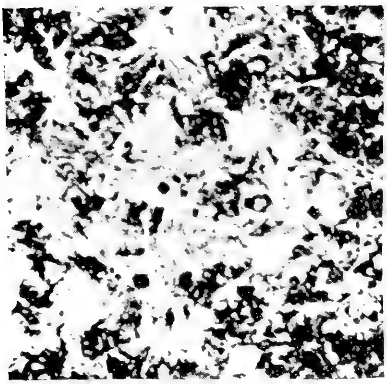

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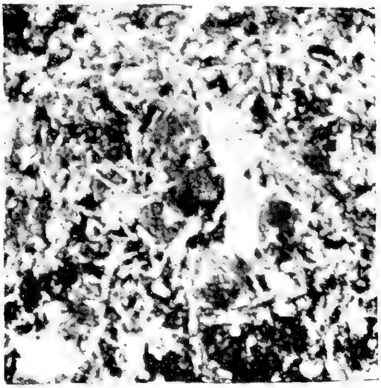

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THE NATURE, OCCURRENCE, AND ORIGIN OF ALUNOGEN AT VANDYKE, NEAR SPRINGSURE, CENTRAL QUEENSLAND.

By H. C. Richards, D.Sc., Lecturer in Geology, University of Queensland.

(With two Text-figures).

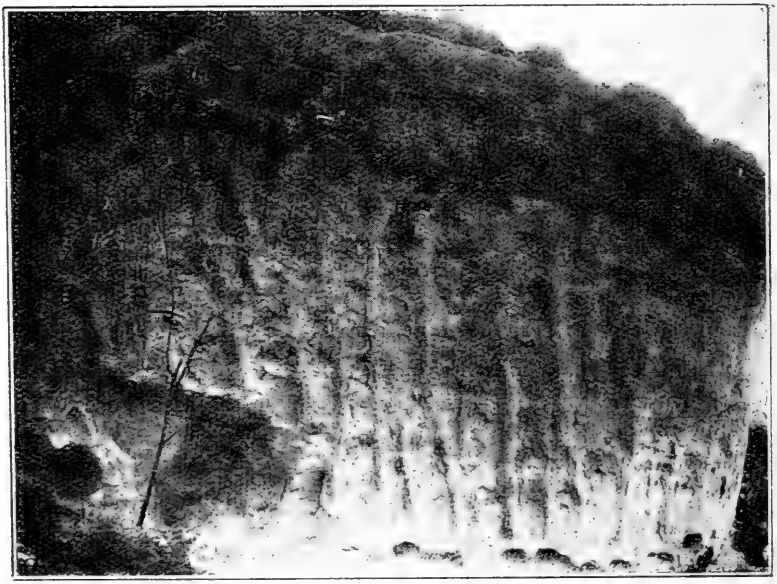
(*Read before the Royal Society of Queensland, 28th October, 1918.*)

In the October number of the Queensland Government Mining Journal for 1916, Mr. B. Dunstan, F.G.S., while dealing with aluminium referred to a deposit of alunogen or basic aluminium sulphate which occurs at Vandyke, some 16 miles south-east of Springsure. A brief account of the nature and occurrence of the deposit was given, also an analysis which had been carried out in the Agricultural Chemist's Laboratory.

It has been known for some time that in the neighbourhood of Springsure there are alkaline trachytic rocks rich in potash-felspar. While potash-felspar rocks are not usually utilised as a source of potash it sometimes happens, as at Bulladelah, in New South Wales, that potassium aluminium sulphate deposits (alunite) occur in the form of veins through the rock owing, it is believed, to the attack of vapours such as sulphurous acid.

Queensland like many other places has, since the advent of the war, suffered a potash famine and the fruit-growing industry in particular has been much affected. Consequently the writer felt that with potash-rich volcanic rocks in the Springsure district and also an aluminium sulphate deposit the conditions for the occurrence of alunite might be favourable. As alunite by the simple process of roasting under certain conditions is converted into a valuable potash fertiliser the importance of finding a reasonably high grade and extensive deposit is obvious.

As the Vandyke alunogen deposit had not been geologically examined and the origin of the aluminium sulphate was not known, the opportunity afforded the writer in August, 1917, of visiting and examining the deposit was gladly availed of. The deposit is in portion 9, parish of Osmondthorpe, at Vandyke holding, the property of Kavanagh Bros. Mr. Michael Kavanagh guided me to the deposit which is about 16 miles south-east of Springsure.



Text-Fig. 30—View of the sandstone cliff, showing the incrustation of alunogen. The top layer, from two to three feet thick, is formed of conglomerate and is free from any alunogen incrustation.

The alunogen is known to occur at three distinct hillocks in the same locality and each one is about one half-mile distant from the other two. The deposit visited was the main one and the occurrence of all three deposits is similar according to Mr. M. Kavanagh. The alunogen occurs as an incrustation on the surface of a fine-grained white sandstone which is horizontally bedded and which outcrops all round a hill about 100 feet above the surrounding country. The sandstone is capped by a bed of conglomerate containing abundant quartz pebbles about the size of a walnut. The conglomerate is quite free from any alunogen incrustation while the sandstone immediately below it is thickly coated (*see* text-figure 30).

In the most recent geological map* the sandstones are mapped as belonging to the Star Series (Carboniferous). The sandstone bed is not exposed for any great depth but the main incrustation occurs on a cliff face about 16 feet high and in a cave in the sandstone. The cave, which is some 30 feet long and 10 feet wide, has its walls and roof thickly coated with the incrustation. In some cases this is four inches thick and shows a crusted banding, while here and there through the material there are small specks of limonite. The incrustation is much thicker on the walls and roof of the cave than anywhere else. The beds have a slight downward warp in the neighbourhood of the cave and this may result in an increased percolation of water through the sandstone here and consequently a thicker incrustation.

The forms taken on by the incrustation are varied, and where it is thin the usual one is distinctly crenulate. In the cave, however, where the deposit is thick one gets blanket-like forms as in limestone caves, also structures resembling giant rose blooms (*see* text-figure 31).

All round the hill the sandstone which is rather soft has been scalloped out and small amphitheatres formed by the action of wind and solution. Wherever there is a protective covering by means of a ledge over these small amphitheatres, a deposit of the alum incrustation is invariably found. In the cave, hornet nests built on the walls have become coated with the incrustation.

As the surface of the sandstone wherever slightly protected from the weather invariably shows traces of alunogen and the conglomerate bed above is quite free from it, the source of the material seems to be within the sandstone. Some of the sandstone in the cliff face had been scraped to remove the incrustation six weeks previous to my visit,

*Queensland Mineral Index, Plate 11.

and there were very evident signs of recoating in the form of wart-like incrustations, some of which were a half inch in length and rounded. About nine months previous to my visit some sandstone five feet in from the incrustation had been picked out and thrown in a heap at the foot of the cliff and exposed to the weather. The lumps of sandstone were coated with a spongy coat of the alum material $1\frac{1}{2}$ inches thick in places and the lumps were firmly held together by the incrustation.

It is quite clear from the above that exposure to the weather of the freshly-broken sandstone results in the formation of the incrustation and that the sulphate is present in the sandstone.

Text-Fig.31—View of the incrustation of alunogen on the roof of the cave, showing the concentric arrangement of the layers.

Scattered through the sandstone there are small rounded nodules of limonite-stained material which resist weathering much better than the normal sandstone. These range in size from quite small pellets up to some which are nearly one inch in diameter. Also throughout the sandstone there are small specks of limonite.

The sandstone is believed by the writer to have originally contained iron pyrites which in decomposing has caused ferric sulphate and sulphuric acid to be formed and through subsequent attack on the aluminous cementing material, basic aluminium sulphate has resulted while the ferric sulphate has been reduced to ferric oxide and hydrated to form limonite.

The sandstone is a friable, white sedimentary rock with quartz grains rounded to subangular and averaging about .2 mm. in diameter. The cementing medium is very abundant and clayey in nature and when the stone is moistened the characteristic clay odour is given off.

The occurrence of alunogen as a decomposition product from iron pyrites in the presence of aluminous shales is recorded by G. P. Merrill* so that its development under the above conditions can be readily understood. The aluminium sulphate would be gradually leached out to the surface of the stone and deposited there as an incrustation while the iron sesquioxide would stain the sandstone in the immediate vicinity of its point of origin. In those places where the pyrites crystals were large we may have the nodules formed and where only small grains of pyrites existed we have the specks of brown limonite. The aluminium sulphate, being soluble, would be washed off the surface of the stone by the rain unless protected from the weather, so that one can understand the occurrence of the material in the cave on the cliff face and in the back of the small amphitheatres scooped out of the sandstone.

In the cave the best protection has been afforded, also probably the leaching effect has been more pronounced there owing to the downward warp of the bed above it giving more drainage in that direction, so that the greatest thickness of the incrustation therein is not unexpected.

In order to ascertain the extent to which the sandstone some distance from the surface was impregnated with sulphate material. a specimen of sandstone was obtained two feet in from the surface for analysis. This sandstone was analysed in duplicate by Mr. R. Graff, B.Sc., and the folowing results were obtained :

*Non Metallic Minerals. New York, 1910 Ed., pp. 352, 358.

ANALYSIS OF SANDSTONE, TWO FEET IN FROM THE CLIFF FACE.

	I.	II.
Moisture and combined water	3.22	3.21
Insoluble	95.10	95.24
Alumina (Al_2O_3) and Iron sesquioxide (Fe_2O_3) ..	1.60	1.40
Sulphuric anhydride (SO_3)	0.68	0.69
	100.60	100.54

It will be noted that the SO_3 content percentage averages 0.685, which corresponds to approximately 2 per cent. of $Al_2(SO_4)_3.18H_2O$ in the sandstone.

The solid incrustation was also analysed in duplicate by Mr. Graff. His results are set out below under I. and II. along with those obtained in the Agricultural Chemist's Laboratory under III, and recorded in the Queensland Government Mining Journal, 1916, p. 427.

ANALYSIS OF THE SOLID INCRUSTATION.

	I.	II.	Mean of I & II.	III.
Moisture and combined water	32.40	33.10	32.75	17.3
Insoluble..	26.35	26.53	26.44	36.5
Al_2O_3 and Fe_2O_3	13.37	13.78	13.57	16.1
SO_3	28.00	27.30	27.65	29.9
K_2O	—	—	—	tr.
	100.12	100.71	100.41	99.8

The sample whose analysis is shown under III. was dried at 100°C. before analysis.

Taking the mean of I and II and assuming that the insoluble material is made up of sand grains and recalculating to 100 per cent. we get the following results (A) which can be compared with the theoretical alunogen analysis (B).

	A.	B.
Water (H_2O)	44.30	48.7
Sulphuric acid anhydride (SO_3)	37.33	36.0
Alumina (Al_2O_3)	18.37	15.3
	100.00	100.0

The similarity is thus seen to be very close and, although in water percentage it is lower, chemically the material may be regarded as alunogen. The incrustation is soluble in water and has an alum taste in accordance with the properties of alunogen so that there is very little doubt about the nature of the material.

The alunogen deposit considered above is distant about 16 miles from the nearest potash-rich volcanic rocks, and this, coupled with the mode of origin put forward by the writer, renders the possibility of finding alunite in the area quite unfavourable. If the alunogen had occurred as a product of sublimation in a volcanic vent, as does sometimes happen, then the conditions might have been favourable.

The alkali-rich trachytes in the immediate vicinity of Springsure were examined by the author but nothing at all suggestive of an alunite deposit was noted.

There are undoubtedly many tons of the incrustation available but it is difficult to form any reliable estimate as to the quantity owing to the varying thickness of the deposit and the uneven surface of the cave and cliff. The formation of the material is still going on as evidenced by the recoating of scraped sandstone surfaces and the coating of the hornet nests in the cave.

The fact, that the broken up sandstone forms a coating of this material comparatively rapidly on exposure, suggests that after the main incrustation has been removed the sandstone could be broken down, crushed, and spread out evenly on trays. If the rain were kept off by some light covering and the crushed sandstone sprayed from time to time with a dilute solution of sulphuric acid no doubt the development of the incrustation would be accelerated. If the surface of the sandstone were smooth the coating might be scraped off, the sandstone raked up thoroughly and treated again until exhausted sufficiently when the sandstone could be renewed.

The question of whether it would pay to treat the sandstone in some such manner depends of course on the amount of aluminium sulphate in the sandstone and the cost of treatment, which would be mainly that of labour. The quantity of sandstone available is very large and, if necessary, sufficient material is available to be worked on a large scale. The sandstone would probably become less and less rich as one receded from the face in a horizontal direction, and what would happen on descending vertically is very difficult to conjecture.

The incrustation which has formed at present is easily removed and as the large flakes are broken away shrinkage cracks are very evident indicating that the deposit gradually becomes less hydrated: this is borne out by the analysis in comparison with the theoretical alunogen analysis.

The amount of impurity in the incrustation is something over twenty-six per cent. and in order to remove as much as possible of this the syndicate which has been experimenting with the material adopted the following method. The incrustation is crushed and treated with water. Owing to hydrolysis, a flocculent gelatinous mass of aluminium hydrate is formed and the clay and sand impurities are thrown out on the bottom of the containing vessel. The whole is treated with hot water and the aluminium sulphate leached out as completely as possible; the solution is then evaporated down in a large boiler and the crystalline aluminium sulphate obtained.

For such purposes as paper-making, water-clarification, tanning and dyeing, this material has a good commercial value, so that it is of economic importance.

Owing to its soluble nature, alunogen does not usually occur except in arid areas and as these generally have poor means of communication the material is not a regular commercial article.

Other Queensland Alum Occurrences.

Three occurrences are noted in the Mineral Index*; in the old workings of the Golden Gate mine, four miles N.W. of Croydon; on clay at the Blair Athol Coal Mines, near Clermont, and in caves of sandstone at Glen Haughton, 35 miles N.W. of Taroom. Another record of considerable interest is found in the evidence tendered by the Hon. A. C. Gregory to the Parliamentary Select Committee to report on the Sandstone Quarries of the Southern District 1888†. Speaking of the Highfields sandstone which was used in the first wing of the Treasury Building, Brisbane, the witness said :—" One peculiarity of this stone at this place is that it stands better if it is thoroughly washed by rain than when it is practically covered. The fact is that

*Q'ld Geol. Surv. Pub. 241, p.9.

†Votes and Proc., 1888, iii, p. 1037.

the pyrites and felspar in admixture form a description of alum which by its crystallisation causes the face of the stone to slip off, just as frost does. When the rain can wash over the face this alum is carried away rapidly and does not do the same amount of mischief."

In all the above occurrences the material seems to be associated with sedimentary rocks.

The occurrence of "alum" in association with trachytic breccia has been noted by Dr. Jensen at Mt. Flinders, near Ipswich*

He writes :—"On the south side of the mountain, fibrous Alum fills the joint cracks, and occurs as an excrescence on the rock. This is probably because the rock (breccia) is rich in sulphur, which by some process is being oxidised, and is reacting with the products of decomposition of the felspar."

Through the courtesy of the Minister for Mines (Hon. A. Jones, M.L.C.) and the Chief Government Geologist (Mr. B. Dunstan) I have been enabled to examine this deposit and to make use of the accompanying analysis.

The deposit occurs on portions of the floors of fairly extensive caves in the trachyte breccia and in cracks and joints on the rock forming the walls of the caves. The deposit is very limited in size and some of the more coarsely crystalline and pure material yielded on analysis by the Agricultural Chemist the following results :—

	Percentage
Loss at 100°C.	13.04
Loss on ignition	22.63†
Alumina	13.95
Ferric oxide	tr
Lime	1.70
Magnesia	nil
Soda	4.07
Potash	3.44
Sulphur trioxide	41.45
	100.28

†The sulphur trioxide lost here was deducted.

This analysis gives a composition corresponding to $(Na_2,K_2)O.\ Al_2O_3.\ 5SO_3.\ 12H_2O$. This does not correspond with the analysis of any of the common alums recorded by Dana. Some of the material is exceedingly fibrous and

*Proc. Linn. Soc., N.S.W., xxxiv, p. 76.

portions of it on being viewed in a certain position by reflected light show a decided pink tinge. Most of the material is columnar, but some of it is mealy in character.

The alum probably originated from the attack of sulphur dioxide on the felspathic material in the trachyte breccia which plugged up the vent through which the magma was effused. Sulphur dioxide is a very common mineraliser gas associated with acid magmas. As the plug of the material has been weathered down, the sulphate has become more concentrated and where protected from the weather in the floor of the caves and along cracks it has crystallised out in the forms found to-day.

Quite recently Mr. E. C. Saint Smith* has reported on an occurrence of natural alum at Boonmoo Pinnacle, about 80 miles south-west from Cairns. The material occurs through the altered acid lava forming the upper portion of the pinnacle. Mr. Saint Smith states that the lava is composed essentially of quartz and felspar with fairly abundant iron pyrites, and that the felspars have been very largely kaolinised. It is distinctly probable therefore, that the alum results from the attack of the products of alteration of the pyrites upon the kaolin.

New South Wales Alum Occurrences.

In New South Wales† it is found as a deposit from a volcanic vent at Mt. Wingen, and as an efflorescence in caves and under sheltered ledges of the Coal Measure sandstone, usually with epsomite, at Dabee, Wallerawang and Mudgee Road, the mouth of the Shoalhaven River, and other places. It is also found in crevices in blue slate at Alum Creek and at Gibraltar Rock.

To Mr. R. Graff, B.Sc., my best thanks are due for carrying out the very useful analyses of the alunogen incrustation and the sandstone behind it.

*Q'land Govt. Min. Journal, xix, p. 56.

†Merrill, Non Metallic Minerals, 1910 Ed., p. 354.

NOTES ON MISCELLANEOUS ENDOPARASITES.

By
T. HARVEY JOHNSTON, M.A., D.Sc., F.L.S., Biology Dept., University, Brisbane.

(*Read before the Royal Society of Queensland, 25th November, 1918*).

CESTODA.

Acanthotaenia gallardi Johnston.

Last year this cestode was found infesting the mid-region of the intestine of a black snake, *Pseudechis porphyriacus*, killed by Mr. Munro Hull at Eumundi. In addition to this parasite, larval cestodes (*Sparganum* sp.) were found just under the peritoneum of the body cavity. In company with *A. gallardi* there were numerous isolated individuals of a strongyle, *Diaphanocephalus* (*Kalicephalus*) sp. distributed throughout the greater part of the intestine, while the œsophagus and stomach harboured many *Physaloptera*. No entozoa had been previously reported from this host in Queensland.

Moniezia trigonophora St. & Hass.

This tapeworm was found in January 1918, in numbers in a lamb at Eumundi. It had not been previously reported from Queensland.

Multiceps multiceps Leske.

Dr. Dodd (1918, p. 502) in a recent address on endoparasites of live stock referred to the parasite and made a statement that " the condition Gid is not common in N.S.W."

I have not been able to obtain any records of authentic cases of the occurrence of the gid bladder worm, generally known as *Cœnurus cerebralis*, in any part of Australia, all cases of so-called gid being traceable to other causes.

Since Dr. Dodd's remarks would seem to imply that the parasite occurs in N.S.W., I wrote asking for further information. In reply he stated that he had not personally met with a case of Gid in that State, but had been informed that it had been seen there and occasionally in Melbourne. He went on to say, though proof is necessary before the statement can be accepted as conclusive, that he is not prepared to state that Gid does not exist in N.S.W., because the causal parasite has not been demonstrated. He mentioned that he had examined large numbers of sheep all over that State without having encountered a case. In a later letter he agreed that it was quite possible that persons had confused other conditions and Gid, and believed that some of the cases mistaken for gid were probably due to the presence of *Echinococcus* hydatids in the cranial cavity.

In view of the evidence given by Dr. Dodd, as well as that which I have collected, we cannot at present affirm the occurrence of *Multiceps multiceps* in Australia. It must be struck off the list of entozoa actually known as occurring in this continent.*

Tænia hydatigena Pall.

The occasional presence of the bladder worm stage (*Cysticercus tenuicollis*) in pigs in south-eastern Queensland is now noted for the first time.

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*In the same paper (p. 506) Dr. Dodd refers to the presence of *Trichostrongylus axei* (*Strongylus gracilis*) and other stomach worms in Australian sheep and cattle. (See also Dodd, Ann. Rep. Dept. Agric. Q'land, 1909, p. 93-4, where he calls it *Str. gracilis*). Cobbold (Parasites, etc., 1879, p. 283) gave the name *Strongylus axei* to certain minute nematodes occurring in the mucous membrane of the stomach of donkeys. Railliet and Henry (C. R. Soc. Biol., 66, 1909, p. 87) placed *S. gracilis* McFad. and *S. extenuatus* Raill. as synonyms of *Tricho. axei* Cobbold. Ransom in his fine account of the nematodes occurring in the alimentary tract of sheep, cattle, etc. (Bull. 127, U.S. Dept. Agric., B.A.I., 1911, p. 94) referred to *S. gracilis* McF. as a synonym of Railliet's *Tricho. extenuatus*, making no mention of *Tr. axei* as a parasite of stock—apparently not accepting Railliet's views. Leiper (Jour. London Sch. Trop. Med., 1 (1), 1911, p. 25) in his check list, mentioned *Tr. axei* as a parasite of Equidæ and (*l.c.* 1 (2), 1912, p. 116) queried its presence in cattle. In my census of Queensland endoparasites (1916) I referred to Dodd's record of *Str. gracilis* as *Tr. extenuatus* Raill, following Ransom (1911) rather than Railliet (1909). In view of these remarks *Tr. axei* cannot yet be added to our known helminth fauna unless it be admitted that the two names *Str. axei* Cobbold and *S. gracilis* McFadyean (not Leuckt.) are synonymous.

Dipylidium caninum L.

As evidence of the rapidity with which some entozoa can reach maturity it may be of interest to mention that I found specimens of this cestode as well as the nematode *Toxascaris canis*, in full egg-bearing in a puppy only six weeks old (Sydney, September, 1909).

TREMATODA.

Bird Trematodes.

In some of my lists of parasites of Australian birds reference was made to the presence of certain trematodes under the broad generic names e.g. *Echinostomum*, *Monostomum*, etc. The flukes were submitted to my friend, Prof. S. J. Johnston, of Sydney University, who described them, along with others, in his paper on the Trematodes of Australian Birds (1916).

They are as follows :—

Host.	Locality.	Parasite.
Numenius cyanopus	Gladstone, Q.	*Echinostoma* J., 1912, 1916, = *Himasthla harrisoni* S.J.J.
Himantopus leucocephalus	South Australia	*Monostomum* J., 1910. 1912, = *Hæmatotrephus adelphus* S. J. J.
Charadrius dominicus	Sydney	*Echinostoma* J., 1910, = *Acanthoparyphium spinulosum* S. J. J.
Herodias timoriensis	Eidsvold, Q.	*Echinostoma* J., 1912 = *Echinoparyphium oxyurum* S .J. J. & *Patagifer fraternus* S. J. J.
Ibis molucca	Eidsvold, Q.	*Echinostoma* J., 1912 = *Patagifer acuminatus* S. J. J
Chenopsis atrata	Victoria	*Monostomum* J., 1910, 1912 = *Hyptiasmus magnus* S. J.J.
Micrœca fascinans	Eidsvold, Q.	*Echinostoma* J., 1912 = *Echinoparyphium harveyanum* S. J. J.

Dolichopera macalpini Nicoll.

This trematode was originally described (but not named) by Macalpine (1891, p. 40) from the copper-headed snake, *Denisonia superba* in Victoria. Nicoll included the species (which he named) in his genus *Dolichopera* (1914, p. 343), and in 1918 gave a description of the species mentioning as hosts, the tiger snake *Notechis scutatus* (Victoria), the copperheaded snake, *Denisonia superba* (Victoria) and an unnamed snake collected by Dr. J. B. Cleland* on Flinders Island (1918a). Quite recently he referred briefly to the parasite and published a figure illustrating its anatomy (1918b, p. 374).

I obtained *D. macalpini* from the œsophagus of *Denisonia superba* and the black snake *Pseudechis porphyriacus* in Sydney district, recording its presence under the name *Hemiurus* (*Apoblema*) sp. (1910a, 1911). This parasite of venomous snakes seems to be fairly widely distributed in Eastern Australia.

Echinochasmus tenuicollis S. J. Jnstn.

Recently described by S. J. Johnston, (1916, p. 206) from a cormorant, *Phalacrocorax melanoleucus*, Tuggerah, N.S.W. I have identified as belonging to this species a few trematodes collected from the same host species near Longreach, Thompson River, by Miss M. J. Bancroft (August, 1918). In my specimens the vitellaria extend further forwards, reaching the posterior edge of the ventral sucker, while the male and female glands are relatively more remote from the hinder end of the animal, being situated nearer the ventral sucker than shown in the original figure.

Schistosomum spp.

Some time ago reference was made to the likelihood of human blood flukes being introduced into Australia by returning troops from Egypt and neighbouring countries (Johnston, 1916, p. 37). In 1917 urine from returned soldiers in Queensland, submitted to me for examination, was found to contain *Bilharzia* ova. Most specimens possessed terminal spines (*S. haematobium* Bilh.) but occasional lateral-spined eggs (*S. mansoni* Sambon) were present in addition. Thus both species of human blood fluke are at present in this State. It is not unlikely that under certain conditions these may become endemic. One species, presumably *S. haematobium* on account of its South African origin, has become established in one locality in West Australia. Major Cherry gave an interesting summary in his article on Bilharziosis (1917).

*Dr. Cleland has informed me that the snake was *Notechis scutatus*.

Capt. Lawton recently published an account of the early clinical features of the serious disease caused by *S. mansoni* (1917, p. 21). He found lateral-spined ova in stools of a number of Australian soldiers in a Cairo Military Hospital. In addition to the ova, the fæces were found, in some cases, to contain other parasites such as *Entamoeba coli*, *Trichomonas intestinalis*, *Lamblia* and *Blastocystis hominis*. All these men were subsequently discharged to Australia.

NEMATODA.

Dictyocaulus arnfieldi Cobbold.

In 1893 in his report on Stock Diseases in Queensland, Dr. T. L. Bancroft recorded the occurrence of lung worms, *Strongylus micrurus* Mehlis, in sheep and horses. Perrie referred to their occurrence in horses in Sydney, using the same name.

The parasite is almost certainly *D. arnfieldi* from the horse (Sydney and Brisbane) and *D. filaria* from sheep (Queensland). *S. micrurus* (= *D. viviparus*) is the lung worm of calves.

Synthetocaulus capillaris Muller.

Dr. J. B. Cleland forwarded portion of a goat's lung parasitised by nematodes which have been provisionally identified as *S. capillaris* (Sydney District). Only an extremely brief account of the nematode is available to me. Lungworms had not been previously reported as occurring in goats in Australia.

Heligmosomum braziliense Travassos.

About a dozen specimens of this tiny strongyle were collected by Miss B. B. Taylor (Brisbane, May, 1918) from the intestine of a rat, kindly determined by Mr. H. A. Longman, Director of the Queensland Museum, as *Epimys rattus*. This is the only occasion on which *H. braziliense* has been reported from *E. rattus*. I have recorded its presence in *E. norvegicus* in Brisbane and Sydney (1918, p. 56).

Capillaria retusa Raill.

From the walls of the alimentary canal of the domestic fowl in Brisbane—not previously recorded from Queensland though known to occur in Sydney and Melbourne.

Pneumonema tiliquæ Johnston.

This worm was collected recently from the lungs of *Tiliqua scincoides* on Facing Island (Port Curtis) and in the Brisbane District.

Oxyuris tetraptera Nitzsch.

Now recorded from Queensland for the first time, having been found in *Mus musculus* and in *Epimys norvegicus.* In the latter case only one worm, a mature female, was collected. This constitutes the first record of the presence of the nematode in the brown rat which is not mentioned by Dr. Hall (1916) as a host. The specimen (collected by Miss B. B. Taylor, Sept., 1918, Brisbane) agrees in all particulars with the account of the species given by Hall.

Cheilospirura nasuta Rud.

I am indebted to Miss G. Y. James, B.Sc. for specimens of this worm collected from the urodæum of a domestic fowl at West Burleigh, 1918—not previously recorded from this State.

Habronema muscæ Carter.

The occurrence of the adult stage of *H. muscæ* in Australian horses has not yet been recorded, though its presence could be inferred. since the larval stage has been reported to be present in certain flies in N.S.W. and Queensland (Johnston, 1912). The life history has been carefully followed by Ransom (1913).

Bull recently published an interesting account of the occurrence of certain tumours or granulomata in horses, caused by larval *Habronema* in Victoria and South Australia (1916). He believed "swamp cancer" of horses in the Northern Territory to be another form of "habronemiasis." He did not know to which of the three species of *Habronema* infesting the horse these larvæ belonged.

I have re-examined my material labelled as "*Spiroptera microstoma*" and have found that although *Habronema microstoma* appears to be the commoner form in material collected in Sydney and Brisbane, *H. muscæ* was also present in small numbers. Specimens collected in Melbourne many years ago by Mr. A. S. Le Soeuf, on re-examination were all found to belong to *H. microstoma* as previously recorded by me.

H. muscæ must be added to the list of known entozoa occurring in N.S.W. and Queensland.*

Dr. J. B. Cleland† recorded the presence of *Spiroptera microstoma* in nodules or cavities in dense fibrous tissue in the stomach of horses in West Australia. Both of his records evidently refer to *H. megastoma*‡. Neither *H. muscæ* nor *H. microstoma* has, as far as I know, been noted as occurring in that State.

Gongylonema ingluvicola Ransom.

Last year, Dr. Cleland forwarded some small worm tumours from the walls of the crop and gizzard of a chicken (Sydney District). The causal parasites have been indentified as *G. ingluvicola*, which, as far as I know, has been recorded only from a locality in the United States (Ransom, 1904).

Acanthocephala.

Centrorhynchus asturinus Johnston.

This parasite, which infests the white hawk, *Astur novaehollandiae* Gm., in North Queensland, was described as a *Gigantorhynchus* but is now transferred to the genus *Centrorhynchus*, the chief characters of which have been summarised by Van Cleave (1916). The male has only three long tubular cement glands instead of several smaller ones as shown in my original figure (1913, pl. 17, fig. 41).

I have identified as belonging to the species a few specimens collected by Dr. J. B. Cleland from a crested hawk, *Baza subcristata* Gd., in December, 1916 at Mummulgum, near Casino, N.S.W., as well as a number in the collec-

*My attention has recently been drawn to a reference in the Scientific Australian (June 1918), where it stated that a paper by Mr. G. F. Hill, dealing with the life histories of *Habronema muscæ*, *H. microstoma* and *H. megastoma*, had been read before the May meeting (1918), of the Royal Society of Victoria.

†Cleland. Diseases of Animals, etc., Bull 33, Dept. Agric. West Australia, 1909, p. 3; Trypanosomiasis, etc. Bull. 34, 1909, p. 15.

‡Desmond (Journ. Agric. Ind. South Australia, 7, 1904, p. 569) referred to the presence of *Sclerostomum hypostomum* in tumours in the stomach of South Australian horses. The reference should be *H. megastoma*.

tion of the Australian Institute of Tropical Medicine, Townsville, obtained in North Queensland from the gray Goshawk, *Astur clarus* (*A. cinereus* Vieill). I desire to thank Dr. A. Brienl, the director of the Institute, for giving me the opportunity to examine his specimens.

The echinorhynch which was mentioned as having been found in *Ninox boobook* (collected by Dr. Bancroft in the Eidsvold District—T.H.J., 1912) is also a typical *Centrorhynchus* sp.

Echinorhynchus rotundocapitatus Johnston.

The presence of this parasite in *Pseudechis porphyriacus* in Queensland is now recorded for the first time; my specimens having been taken from the black snake already referred to as having been killed in the Eumundi district. It frequents the lower three quarters of the intestine though generally more abundant in the rectum.

Hormorhynchus hirundinaceus (*Gigantorhynchus gigas* Gœze).

This is met with occasionally in pigs in south-eastern Queensland—not previously reported from this State.

Linguatulida.

Porocephalus teretiusculus Baird.

A black snake *Pseudechis porphyriacus* from Eumundi —referred to earlier in this paper—was found to be parasitised by the above pentastome, the females being distributed in the lung, while the small males were found at the extremity of the organ. This constitutes the first record of the presence in Queensland of the entozoon, which is now known to infest the following Australian snakes—*Pseudechis porphyriacus*, *Denisonia superba*, *Diemenia textilis* and *D. reticulata*. I have specimens taken from the tiger snake *Notechis scutatus* (Blue Mountains, N.S.W.). Its known range extends from Western Australia to Southern Queensland and to the islands of Bass Strait.

Linguatula serrata Frol.

The larval stage, generally known as *Pentastomum denticulatum*, is now definitely recorded as occurring in the mesenteric glands of cattle in Queensland, specimens being occasionally found in animals killed in the Brisbane abattoirs.

ACARIDA.

Cytodites nudus Viz.

This mite is found occasionally in the Brisbane district in the air sacs of the domestic fowl.

Notœdres muris Mégnin.

Though mange mites are not true entozoa, I take the opportunity to record the presence of *Notœdres muris* (*Sarcoptes muris, S. alepis* Raill.) in Brisbane and Melbourne on *Epimys rattus* and *E. norvegicus*; in Launceston and Sydney on *E. rattus*; and in Adelaide on "rats" (collected by Dr. J. B. Cleland.*)

I have already referred to its occurrence in *E. norvegicus* in N.S.W. and *E. alexandrinus* in Perth, West Australia. The parasite sets up a warty condition of the tail, ears and sometimes other parts of the head.

Knemidocoptes mutans Rob. causes "scaly-leg" in the domestic fowl in Brisbane.

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A TICK-RESISTANT CONDITION IN CATTLE *

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Contents.

Introductory.

For about a quarter of a century Queensland has had to suffer from the presence of the cattle tick, variously known in Australian literature as *Boophilus australis*, *Rhipicephalus australis*, *Margaropus australis*, and as a variety *australis* or *microplus* of *Boophilus annulatus*. In this paper we intend to use the name *Boophilus australis* Fuller. A constant feature readily distinguishing *B*

*The Council of the Royal Society of Queensland desires to acknowledge the financial assistance rendered towards the publication of this paper by the University of Queensland from the Walter and Eliza Hall Fellowship fund.

australis and *B. annulatus* was pointed out by Fuller (1899) in his original account, and by Crawley (in Cowley and Pound, 1913). Neumann, Patton and Cragg, and others refer to our cattle tick as *Margaropus annulatus* var. *australis*.

Its introduction from the East Indies and its spread from the Northern Territory into this State have been traced by Pound (1895, 1897), Dodd (1908), Gilruth (1912), Lewis (1913), Stewart and others (1906, 1917). The onward progress of the tick eastward and then southward can be followed by referring to the reports of the Inter-Colonial Stock Conference (R.I.S.C., 1896) and of the various Royal Commissions on the tick pest (R.S.C., 1899).

As early as 1899, Tidswell (p. 13) expressed his opinion that ticks would eventually infect New South Wales in spite of all the precautions. The extension into that State has been slow owing, at least in part, to vigorous quarantine regulations and to vigilant border inspection (Stewart, Symons and Cowley's reports in Jamieson, 1912).

Effects Due to Ticks.

The losses caused directly and indirectly by the cattle tick in this continent have been enormous and still are very heavy. In the bulletin on "The Cattle Tick in Australia" (Stewart and others, 1917) an attempt has been made to give the Australian public some idea of the detrimental effects of the presence of the parasite. The losses are there divided into those caused by tick fever and those due to tick infestation ; both sets of losses being subdivided into those caused by (*a*) mortality, (*b*) the loss of condition involving meat supply, (*c*) diminution of milk yield* and consequent influence on calf-raising, pig-rearing, bacon industry, butter and cheese-making, etc. In addition to these, mention is made of the great deterioration in the value of hides as a result of tick infestation.

*" The cattle tick has a decidedly injurious effect upon supposedly immune dairy cattle, the extent being largely dependent on the degree of infestation. The effect is more pronounced on milk production than upon the body weights when a sufficient supply of food is given." Woodward and Turner. The effect of the cattle tick upon the milk production of dairy cows. U.S.D.A., B.A.I., Bull. 147, 1915, p. 16.

These facts are stated in order to emphasise the seriousness of the tick problem in such an important beef and butter-producing State as Queensland.

Tick infestation may lead to one or both of the following complaints: *Tick fever* or *Piroplasmosis* (often termed Babesiasis, Texas fever, or redwater) and *Tick worry*, often called tick poverty or tick anaemia.

TICK FEVER.

The term "immunity" is commonly used in Queensland in connection with the tick but it is not strictly correct*. We speak of cattle becoming rendered naturally or artificially "immune" to tick fever, whereas this so-called "immune" condition is now known to remain usually for a comparatively short time—one or two years (Dodd, 1909, p. 84) though a case of 12 or even 13 years persistence is known (Schroeder, 1905, p. 71; Wallace, 1908, p. 320)—unless maintained by subsequent re-inoculation of the animal† (Smith and Kilborne, Hunt, Tidswell, Pound, Wallace, 1908, p. 320). This occurs naturally in tick-infested districts through the agency of larval ticks that are infected with the micro-organism *Babesia bovis* (*Piroplasma bigeminum*) which causes the tick fever. Such larvae are born infected through some of the organisms in the parent reaching its ovary and thus infecting the eggs from which larvæ ultimately develop.‡ The condition can also be brought about by inoculating the cattle with ox

*"The condition is termed 'immunity' simply for want of a better and more descriptive name. It is in fact a very mild chronic form of Texas fever, positively associated with the infectious agent of the affection." (Schroeder and Cotton, 1905, p. 76). "It is merely a tolerance for the infectious organism." (Schroeder, 1905, p. 62). Lignières has also discussed the question as to whether the condition is an immunity or only a tolerance.

†Nuttall, G., in his lecture on Piroplasmosis (Herter Lectures, iii., John Hopkins Hosp. Bull., 24, 1913), has stated that recovered or salted animals are not susceptible to reinfection. This is contrary to Australian experience. He has pointed out (p. 309) that animals which have recovered from cattle tick fever caused by *Piroplasma divergens* are susceptible to Texas fever (due to *P. bigeminum*).

‡Crawley. Jour. Parasitol., 2, 1916, p. 87.

blood containing the piroplasm*. Animals which have passed through one attack of tick fever may pass through a second or even a third attack, especially if the vitality of the cattle becomes lowered by adverse conditions, *e.g.*, if they be over-driven, roughly handled, more or less deprived of food and water, etc. Dodd (1908, p. 16) states that the power of the micro-parasite varies a great deal in different regions and the immunity which may be sufficient in one district may not be enough to protect the cattle if moved to another district. He goes on to say that it is a well-known fact both in Queensland and South Africa that cattle which are immune in one district have contracted tick fever again when removed to another. Cory (1916, p. 80) stated that it had been frequently noticed that toleration broke down when cattle were removed to another tick infested district although they were apparently immune against pathogenic ticks before removal†.

Protective inoculation is widely practised in Queensland, especially in the case of stock imported from tick-free districts into ticky country. This operation does not really "protect" the animal from piroplasmosis but actually causes an attack of the disease which, however, is generally less severe and usually minimises the danger from a subsequent attack. Such, however, may occur but they are as a rule quite mild. In Queensland, blood for inoculation is nearly always taken from a "recovered animal," that is, one which has apparently recovered from tick fever. Such "recovered blood" is injected with due precaution into the cattle which it is desired to protect. The method locally practised has been carefully described by various workers (Hunt, Pound, Dodd, Tidswell and others). The mortality from natural tick infection in the case of

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*Hunt and Collins (1896, p. 6-7) refer to a case in Washington, D.C., U.S.A., where blood taken from a cow which had been kept away from ticks and tick-infested districts for over six years, set up virulent (and sometimes fatal) tick fever on inoculation into susceptible cattle; and yet after careful examination of four thousand blood smears, only five infected corpuscles were found by Schroeder and Kilborne.

†A number of Queensland instances are quoted by the Editor, Queensland Agr. Journal, 20, 1908, pp. 325-7, in an article entitled "Tick fever—Is general immunity attainable?"

adult animals is generally high, being often from 50-90%*, whereas that resulting from protective inoculation is often under 2% (Dodd, 1908, p. 10). Many years earlier, Tidswell gave the percentages as 60-70% and 3-5% respectively (1899*a*). Pound (1899, p. 100) gave an even lower figure, viz. 1% on a total of over 30,000 head protectively inoculated. He also published a list of percentage losses (0.5-5%) experienced by a number of Queensland graziers. Dodd, several years later (1908), mentioned that during nine months of 1908 the average mortality in this State was 1.98% in the case of highly susceptible animals (that is, those from herds which had not contracted fever though in fevered districts), and 0.58 in the case of partially susceptible animals (*i.e.*, those from herds in which tick fever was known to have appeared), while the average total loss from inoculation amongst the animals of both classes was about 1.5%. In 1909 (Dodd, 1909, p. 85) he gave the average loss for 1908-9 as being only slightly over 1%†. Mortality is especially high in older animals, in bulls and in very fat or very thin cattle (Tidswell, 1899*a*).

The amount of resistance to tick fever displayed by cattle has been summarised thus by Pound (1897, p. 473): "When ticks first appear in a herd the first animals to succumb to tick fever are bulls, especially the old ones; next in order come breeding cattle (cows); then bullocks and spayed cows; but the least susceptible of all are the young animals, and practically speaking, there is little or no mortality from tick fever among yearlings or calves at foot."

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*Smith a d Kilborne (1893, p. 274) in their account of an outbreak in U.S.A., stated that natural immunity of cattle more than a year old in the cas of animals outside of tick-infested areas and which had not previously bee tick-fevered, was so slight that the mortality in many cases was nearly 100%. Still, however, there were animals which had more or less immunity though they had never been previously exposed to the disease. Salmon (1899, p. 221), mentioned that 75-90% of adult cattle in fevered districts died of Texas fever in hot weather in the early days of the outbreak. G. Tucker (in Ann. Rep. Dept. Agr. Qld., 1916-7 (1917), pp. 88-9) referred to recent heavy losses in Northern Queensland owing to tick infestation.

†See also Editorial articles "Inoculation for tick fever" Q.A.J., 2, 1898, p. 517, *re* slight losses experienced.

In some cases extremely heavy losses have been experienced owing to the use of an unsuitable "bleeder" (as the animal from which the inoculating blood is periodically drawn, is termed) ; to conditions exciting the cattle just before or after inoculation ; to carelessness which brings about contamination of inoculating blood ; and to low condition of the inoculated cattle.

Tidswell (1900, p. 13) found that the amount of resistance to tick fever did not depend on controllable factors since "in certain animals the resistance was equally perfect though inoculation treatment had been different in each case ; and on the other hand in certain other animals the resistance exhibited was very different although the inoculation treatment was the same in each case." His observations did not reveal correspondence between any special feature of inoculation and the amount of resistance obtained, the issue appearing to depend more on the individual peculiarities of the animals than upon anything under human control. He went on to say that "It is known that the infectivity of the blood of inoculated animals does not depend on controllable factors. The duration of infectivity does not depend necessarily upon the source of inoculating blood nor on the amount used at one time nor on the total amount used on several occasions nor on the number of inoculations, nor the severity of the reaction, nor the kind of blood used (whether "recovered blood" or "virulent blood," *i.e.*, blood taken from an animal during the height of the fever). Loss of infectivity does not imply loss of protection and the protection of the mother does not imply protection of the offspring. . . From these various observations it appeared that the retention or loss of infectivity had no dependence upon any of the controllable factors of inoculation. One is forced to conclude that this feature like the protection is a matter of idiosyncrasy." (Tidswell, 1900, p. 14, 15).

The same ideas are expressed by Stewart and others (1917, pp. 12-13) who state that the infectivity of recovered blood varies both in degree and duration in individual beasts ; and that the protection produced is not absolute but is more of the nature of a tolerance than of an immunity, its duration and degree being subject to variation and apparently largely depending on the idiosyncrasy of the animal. Hunt (1898, p. 452) stated that probably individual animals differ somewhat in natural susceptibility to tick fever and perhaps various breeds of animals differ also, just as individuals and races of men differ in natural susceptibility to any given disease or noxious influence; but that he was not aware that constitution, breed or colour had been proved to have any protective influence or that there was any special protective virtue in one class of country over another except in so far as it might be unfavourable or otherwise to the life of the cattle tick. Cattle from all classes of country were attacked alike, when removed to places where the ticks were fever carriers.

As already mentioned, resistance to tick fever is known to be most satisfactorily attained during early life. Young calves have great powers of resistance and may pass through an attack so mild in form as to be unnoticed by an ordinary observer. Dodd (1908, p. 6) suggests that this may be partly due to the great activity of young animals in producing blood cells counterbalancing the destruction of erythrocytes by the piroplasm.

Practically all cattle in permanently tick-infested districts of Queensland are now "immune" (Pound, 1899, p. 99; Dodd, 1904) and the losses that are occasionally reported are generally due to the break-down of "immunity" by some means such as over-driving, injury, starvation, rough handling, want of water, etc., or the introduction of susceptible animals (Dodd, 1908, p.1, p. 6).

Pound (1899, p. 103) has given an instance of the occurrence of what he terms hereditary immunity, but the context shows that he really means to state that calves are occasionally born "immune," that is, that they have actually suffered from an attack of tick fever while in utero, due to the passage of piroplasms through the maternal placenta.

To sum up: There exists in many cattle a "resistance" more or less marked, to tick fever, such resistance depending on age, sex, sexual development, food supply, contentment, general health and apparently on some individual characteristic.

Tick Worry.

In addition to tick fever, ticks may cause tick worry. The two conditions may occur independently but they are generally associated in the tick-fevered districts in this State. As already stated, tick fever may be produced without the agency of ticks, *e.g.*, by inoculation of cattle with ox-blood containing the parasite. The other condition is the result of tick infestation apart from the presence of *Babesia*.

The names tick poverty and tick anæmia are often applied to it, particularly to the more serious stages. As one would expect, ticks set up a local irritation which may cause marked uneasiness according to the degree and site of the infestation and according to the individual animal affected. The attacked areas may become infected by pus-producing organisms and thus tick sores arise. Sometimes these latter are extensive and are reported to become sometimes flyblown (Hunt & Collins, 1896, p. 27 ; Stewart, 1906 ; Tidswell, 1898 : Stewart and others, 1917, p. 16).

Apart from lesions just referred to, there may be tick anæmia or poverty where the health of the infested animal becomes seriously affected, the vitality being lowered and condition lost, while the anæmia produced may lead to exhaustion and even death. As already mentioned, tick fever is usally co-existent though generally in a mild chronic form (the animals being in the so-called "immune" condition), but in the early days of the tick outbreak in Queensland Dr. Hunt was able to show that ticks in fever-free areas (*i.e.*, in areas where ticks were not pathogenic) caused cattle to lose condition and sometimes die, and that the blood of such animals when inoculated into healthy animals did not cause piroplasmosis, while those which survived the tick poverty were not protected against tick fever. The two complaints are distinct (Hunt, 1898*a* ; 1898, p. 449 ; 1898, p. 116-118 ; 1899*c*, p. 758 ; 1898*c* ; Gordon, 1899, p. 92; Thompson, 1899, p. 742 : Tidswell, 1899, p. 5 ; 1899*b*, p. 749 ; 1900, p. 112 ; Stewart, 1906, pp. 1155-1157). Pound has drawn attention to the fact that protective inoculation protects cattle against piroplasmosis and not against tick attacks, immune animals having been known to die of tick anæmia following gross infestation (1899, p. 107).

Habituation of Cattle to Tick Infestation.

Hunt says (1899, p. 118) that two things only appear to be effective against tick poverty—habituation and dipping. " By use and wont, cattle become to a great extent tick proof and by dipping they may be relieved from time to time till this tick proof condition is established. . . . The comparative immunity to tick irritation which comes of habituation, does not necessarily afford any protection against Texas fever." The same idea had already been expressed by him in 1898 (1898, p. 450). Pound (1899, p. 117) stated that some immunised cattle in grossly-infested districts were in no way inconvenienced by tick infestation while others became gradually inured to the irritation and annoyance caused by the ticks, more particularly in their larval stages. Though dips are of unquestionable value in combating the poverty from gross infestation, they are quite ineffective in protecting cattle from the fever (Hunt, 1898, p. 450).

" It is said that in time the cattle become habituated to ticks and do not suffer from the effect first described (tick worry and tick sores). I understand that their acquisition of this satisfactory state implies fatness or at least good condition. It is so far in keeping with this statement that the few animals in our herd which remained fairly fat suffered least. But I could not decide. . . . whether the animals did not suffer because they remained fat, or remained fat because they did not suffer. They appeared to harbour few ticks, and it is at least a plausible supposition that the maintenance of a healthy skin, with plenty of fat under it, and normal secretion of fatty sebaceous matter upon it, affords an undesirable and less tenable resting place for ticks than when the functions of the skin are less perfectly discharged owing to leanness and ill health." (Tidswell, 1900, p. 12).

Stewart (1906, p. 1156) has mentioned that cattle newly exposed to infestation not only suffer more from tick irritation than those accustomed to ticky pastures, but become more grossly infested, while those born and reared on infested pastures seem to acquire a certain tolerance to the tick.

Nuttall and Strickland* when referring to the toxic effects following the bites of *Argas persicus* which attacks man (and poultry), mentioned that strangers to tick-infested districts suffer more than others do, reminding one of the kind of immunity to mosquito bites experienced by many people—a form of habituation. This supported the view that ticks give off something of the nature of a posion when inflicting their bites.

It is a common report in Queensland that ticks, mosquitoes and even leeches will much more readily attack a townsman in preference to a " bushman " when the two are in company in a scrub—the explanation being almost certainly due to the existence of a greater or less degree of immunity, probably the result of previous attacks.

Tick Poison.

Tidswell (1899, p. 5) in commenting on the greater virulence of piroplasma infection by ticks over infection by inoculation, was led to suspect that ticks themselves might have some injurious effect apart from causing tick fever and that such effect was not a question of anæmia caused by the amount of blood lost, since that loss is comparatively slowly brought about and the time taken would permit regenerative activity of the host tissues. He suggested the possibility of some poison being injected by the tick and mentioned the well known effect often produced in dogs in this continent by the attack of ticks belonging to a certain species (*Ixodes holocyclus* Neum).

The possibility of the cattle tick injecting a poison and thus setting up a toxæmia was mentioned also by Hunt (1898, p. 448), by Thompson (1899, p. 742), and by Schroeder (1906, p. 59). In accounting for tick worry J. D. Stewart (1906, p. 1156) says, "In our present knowledge the mechanical irritation caused by the ticks in their attachment, the loss of blood extracted by them, and particularly by the maturing females, together with the effects of toxines absorbed from the sloughing wounds, might reasonably be accepted as sufficient to account for the condition. It is, however, possible that the tick injects a secretion when it attaches itself. . . . ."

*Nuttall and Strickland, Parasitol., 1, 1908, p. 302.

That some ticks do inject a toxic substance, is now well-known. Nuttall* in referring to the effects (which commonly include paralysis—" tick paralysis ") stated that they may prove to be due either to a toxin emanating from the tick or to a specific virus. He gave the name " tick bite fever " to the condition set up. A tick immunity becomes subsequently established. Tick bite fever is referred to by Brumpt† as occurring in man in South Africa, as a result of infestation by larvæ of *Margaropus* (*i.e.*, *Boophilus*) *decoloratus* and also by *Rhipicephalus simus*, immunity following.

There are many published references to the effects on man and domesticated animals resulting from tick bites in countries other than Australia‡.

The best known Australian example is *Ixodes holocyclus* Neum., commonly called in Eastern Australia the scrub tick or bottle tick. It frequently attacks man, sometimes with fatal results.** Dogs are especially liable to

*Nuttall, G. On symptoms following tick bites in man. Parasitology, 4, 1911, pp. 89-93 (*re Amblyomma* and *Boophilus*).

†Brumpt. Precis de Parasitologie. Paris, 1913, p. 581-2 (refers to work of various observers).

‡Nuttall, 1911, *l.c.*; Nuttall, Tick paralysis in man and animals, Parasitology, 7, 1914, pp. 95-104; Hadwen, On Tick paralysis in sheep and man following the bites of *Dermacentor venustulus*. Parasitol., 6, 1913, pp. 283-297; Nuttall and Hadwen, Experimental tick paralysis in the dog (from *Dermacentor venustulus*). Parasitol., 6, 1913, pp. 298-301; Nuttall, Biology of Ixodidæ, Parasitol., 6, 1913 (pp. 84-5 *re* bites of *Ixodes putus*); Sant Anna, On a disease in man following tick bites and occurring in Lourenco Marques, Parasitol., 4, 1911, p. 87-8; Nuttall and Strickland, On the presence of an anticoagulin in the salivary glands and intestine of *Argas persicus*. Parasitol., 1, 1908, pp. 302-10 (references to tick bites and toxic effects, p. 302); Nuttall, Warburton and others, Ticks, a Monogr. Ixodoidea, part I., 1908, pp. 85-8, 92-4 (*Argas*); pp. 98, 102-4 (*Ornithodorus*); part 2., p. 313, etc. (*Ixodes*); Todd, Tick paralysis. Jour. Parasit., 1, 1915, p. 55; McCaffrey, The effect of tick bites on man. Jour. Parasit., 2, 1916, p. 193-4 (*Dermacentor venustulus*); Herms, The Pajaroello tick (*Ornithodorus coriaceus* K.) Jour. Parasit., 2, 1916, pp. 137-142 (effects on man and various experimental animals).

**J. B. Cleland, Jour. Trop. Med. Hyg., 16, 1913, pp. 43-5; 188-9, and in Fantham, Stevens and Theobald, Animal Parasites of Man, 1916, p. 499; Injuries and diseases of man in Australia, attributable to animals. Austr. Med. Gaz., Sept., 1912; J. Bancroft. Queensland Ticks and Tick blindness, Aust. Med. Gaz., Nov., 1884; Anderson Stuart, P.R.S., N.S.W., 28, 1894 (pp. 10-11 *re* " poison of the Australian bush tick.")

its effects, paralysis and death being usual. Other animals are attacked, sometimes fatally, *e.g.*, cats, pigs, horses and cattle (especially while young), and even ducks.*

Having in mind certain resemblances between the effects produced in dogs by this tick and those caused by the fowl tick *Argus persicus* (*A. americana*) in domestic poultry through the introduction of *Spirochæta gallinarum* which causes fowl tick fever, Dr. Cleland and the senior author (while in Sydney in 1910) carefully examined blood from affected dogs, but failed to detect the presence of any spirochætes. Considerable experimental work relating to this tick was carried out by T. L. Bancroft.† The effects are almost certainly due to the injection of some poison. Immunity commonly follows recovery from bites. Mr. W. Davidson has kindly forwarded information (16th October, 1918), relating to the establishment of such a condition in dogs in his district (Tambourine Mountain): "So far as I have observed with regard to dogs and scrub ticks after an experience up here of over 23 years, it appears that if you extract the first scrub tick from a dog before it has been fixed more than about 24 hours, no bad results follow; if later you extract the second tick that becomes fixed, before it has been in, say, 48 hours no bad results follow; and if on the third occasion you extract the tick just as it begins to assume a rather greyish swollen abdomen (the first signs of incipient engorgement) no harmful results are produced, and you may safely assume that your dog is immune. If you have a valuable dog this is by far the best method to adopt to protect him, but it means looking over him carefully every day. . . . Wild animals appear to be immune to the attacks of scrub ticks, *e.g.*, dingoes, iguanas and carpet snakes are generally more or less infested and never seem to suffer. I have

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*T. L. Bancroft, Queenslander, 3rd Jan. 1891, Brit. Med. Jour., 16th May, 1191. . . . . . . also quoted in Neumann, Parasites, etc., of domesticated animals (Engl. transl. by Fleming), 1892, pp. 103-4. . . . ; H. Tryon, in Ann. Reports Dept. Agr. Q'land, 1911 (p. 80, fatal to calves); 1917 (p. 54, fatal to ducks); etc.; R.S.C., 1911, evidence by Pound (p. 23, dogs and fowls); and by Ramm (p. 2, foals, pigs, dogs, etc. ; 49, man, etc.); Editorial, Cure for tick poison, Q.A.J., 22, 1909, p. 105-6.

†T. L. Bancroft, l.c.

reason to assume that the latter would never be affected at any time or under any circumstances."

Tryon* mentioned that a large cattle tick, probably *Amblyomma* sp., was reported as killing cattle in North Queensland, even when very few of them were present on the animals.

It is known that an anticoagulin occurs in certain ticks. Sabbatini† in 1898 isolated such a substance from *Ixodes ricinus* and found that certain symptoms followed its injection into various animals, dogs being especially susceptible, cats less so, while sheep and cattle were relatively resistant. Nuttall and Strickland‡ referred to the presence of an anticoagulin in the salivary glands and intestine of *Argas* and *Ornithodorus*.

Christophers** reported that the coxal secretion of *Ornithodorus savignyi* possessed anticoagulative properties. Kunssberg†† found that the anticoagulin was produced by certain gland cells in the salivary glands of *Ixodes* and *Ornithodorus*. Cornwall and Patton ‡‡ followed up Sabbatini's work and asked the question as to whether the salivary anticoagulin was the substance which caused the irritation following the bite of a blood-sucking arthropod.

We have carried out a series of experiments with *Boophilus australis* along the lines of those published by Nuttall and Strickland, and have found that an anticoagulin exists in the salivary and Gene's gland but that its action on human blood is much less pronounced than that of *Argas*. This is to be expected, owing to the difference in the feeding habits of the two ticks.

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*Tryon, Ann. Rep. Dept. Agr. Q'land, 1915-6 (1916), p. 50.

†Sabbatini, Fermento anticoagulante dell *Ixodes ricinus*. Arch. Ital. biol. Turin, 31, 1899—abstract in Nuttall and Strickland, Parasitol. 1, 1908, pp. 303-4—also referred to by Cornwall and Patton, 1914.

‡Nuttall and Strickland, *l.c.*, 1908, pp. 302-310.

**Christophers, S. Anatomy and histology of ticks. Sci. Memoirs Med. San. Dept., India, No. 23, 1906, p. 45.

††Kunssberg, K. Eine Anticoagulindruse bei Zecken, Zool. Anz., 38, 1911, pp. 263-8.

‡‡Cornwall, J. and Patton, W. S. Some observations on the salivary secretion of the commoner blood-sucking insects and ticks. Ind. Jour. Med. Research, 2 (2), 1914, pp. 569-593. (Argas, p. 583-4).

The fact that immunity becomes established in the case of some ticks is evidence that some substance is injected by the tick. It is reasonable to suppose that the material acts as an antigen stimulating the production of an anti-body (anti-tick toxin) which can combine with the tick toxin and thus confer an immunity.

In many cases, a more or less marked eosinophilia is produced by the action of internal parasites*, and in the case of at least one of them (hydatids) the blood serum has become altered to such an extent that the precipitin reaction can be made use of to detect the presence of Echinococci in the patient†.

Zinsser‡ has given a list of the more important substances which, when on injection into the blood of an animal, lead to the formation of a specific antitoxin or toxin-neutralising body, one such substance being spider poison. It seems to us reasonable to expect that such reactions might be given by ticky cattle. It is proposed, with the assistance of Dr. H. B. Bradley, of the Bureau of Microbiology, Brisbane, to test the precipitin reaction, using the blood of cattle from non-infected districts (*e.g.*, N.S. Wales), from ordinary infested cattle and from strongly resistant animals. We must remember, however, that "the various antibodies are usually produced with more avidity by certain tissues than by others," and that "antibody formation may be of strictly local character depending upon the point where the antigen is injected."**

Should such a reaction be obtained from the blood, then one might consider the possibility of using an animal whose

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*Stitt, Practical Bacteriology, Blood work and Animal parasitology, 1918, p. 264; S. Hawden ("Natural Occurrence of eosinophilas," Journ. Parasitol, 4, 1918, p. 135-7) has shown that the injection below the skin of juices obtained from Hypoderma larvæ which nourish themselves in the subcutaneous tissues of suitable hosts, causes an eosinophilia, the eosinophils apparently playing an important part in neutralising toxins from parasites.

†Welsh and Chapman, Austr. Med. Gaz., 27, 1908, p. 1 (Human); Weinberg and Veillard, Sur le diagnostic de l'echinococcus chez le dromedaire, Bull. Soc. Med. Vet., 86, p. 50-1, Abstract in Jour. Trop. Vet. Sci., 4, 1909, p. 603 (Camel, sheep).

‡H. Zinsser, Infection and Resistance, 1918, pp. 86-7.

**C. Marshall, Microbiology, 1917, p. 699.

blood was strongly antitoxic to ticks, as a "bleeder" for providing blood to inoculate tick-infested stock and confer some degree of resistance—a passive immunity. The production of such antibody in the case of most ticky cattle is probably slow.

After mentioning that we may justly assume that natural resistance may be largely a matter of inheritance, Zinsser* goes on to say that natural immunity, unlike acquired immunity, cannot be passively transferred from one animal to another and implies therefore a fundamental cellular difference rather than a condition depending merely upon antibodies circulating in the blood.

Some graziers and dairy farmers maintain that if animals in fair condition be allowed to remain in ticky pastures without being treated in any way for tick infestation, such animals would become not merely habituated to ticks, but actually resistant. The cattle tick apparently reached Australia along with the Brahmin cattle introduced into the Northern Territory, and yet that particular breed is admitted to possess a marked resistance to *Boophilus*. Perhaps this resistance arose naturally in the manner just indicated. Marshall† points out that antibodies may be transferred from the mother to the young before birth, but only after fœtal circulation has become established, being carried from the maternal blood through the placenta into the offspring.

It does not seem to be an unreasonable suggestion that, as a result of continued light or moderate infection, animals which manage to maintain condition, may eventually develop more or less resistance to tick infestation. It may be urged that the tick is an ectoparasite and not an entozoon, but the distinction between it and a haematozoon in regard to food supply is really very slight, since the mouth parts of the tick are as truly bathed in plasma as is the absorptive surface of an internal blood parasite. If this point of view be correct then the use of dips to free cattle from tick infestation, though admittedly valuable as a temporary measure, really prevents the establishment of more or less

*H. Zinsser, Infection and Resistance, 1918, p. 56, 58.

†Marshall, *l.c.*, p. 699.

permanent resistance to tick attack.* However, when once such resistance is firmly established, it is hardly likely that dipping would destroy or suppress it (provided the animal's condition be maintained) unless the arsenic which—as stated later in this paper—becomes to some extent accumulated in the subcutaneous tissues, actually interferes with the action of, or destroys, the antitick substances.

Tick Resistance.

In speaking of natural resistance to bacterial invasion, Zinsser† referred to the very different results arising from invasion of different individuals by a given species of micro-organism whereas the same individual may be highly resistant to certain organisms but very susceptible to others; while "even in reactions with one and the same micro-organism, the susceptibility or resistance of the individual may be determined by variations in the physiological state, or by environmental conditions under which the two factors—invader and invaded—are brought together. . . Within the same race or species, an epidemic sweeping through a community will kill many individuals, and leave others unscathed. Such differences point to variations in the defensive mechanism since the invader in these cases is the same." There may be specific (*i.e.*, belonging to the species), racial and individual natural immunity. He points out‡ that in the case of human beings it is probable that individual differences in resistance are due, "not to any *fundamental* individual variations, but rather to such fortuitous factors as nutrition, metabolic fluctuations, temporary physical depression, fatigue, or chilling." These remarks would apply equally to tick invasion, since we have already shown that cattle may become habituated to tick and we know that in many herds there are to be found one or more individuals which are markedly resistant to tick infestation.

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*This statement must not be construed to mean that we advocate the abolition of dipping. We believe that, in the present state of our knowledge regarding tick control, systematic dipping, combined with a satisfactory rotation of paddocks, is the most efficient method of attacking, on a large scale, the problem of tick eradication.

†Zinsser, *l.c.*, p. 49, 50.

‡Zinsser, l.c., p. 59.

There has been considerable notice given in the public press of Queensland and elsewhere as well as in official publications, to the statements of Mr. G. W. Munro Hull, of Eumundi, who claims to possess a herd of tick-resisting cattle. In an article in the Queensland Agricultural Journal of September, 1912 (pp. 294-6) he called attention to the presence amongst his cows of a certain number of animals which he claimed remained free from ticks, whilst other animals were infested. He there stated that such a tick-resisting condition was produced by vaccinating the animals with a " particular organism "—" a tick destroying microbe" —contained in " lymph from tiny vesicles " which appeared periodically on the escutcheon and dewlap of the first resistant cow he had noticed in his herd. " While untreated stock shewed the ravages of ticks on their necks and flanks, the treated stock grew sleek and clean-coated and although many of them have not been sprayed or dipped for the past 18 months they shew no signs of tick " (p. 294). Any ticks that adhered to such vaccinated stock had a very short life, larval ticks dying and falling off in a few days after attachment. Rarely a tick might mature on such beasts and eggs might be laid but none had hatched. He drew attention to the peculiarity that these vesicles should be apparent only on the escutcheon and dewlap, two favourite habits of the tick itself. Vaccinated animals had been turned out by him into open country for a couple of months at a time but always maintained their freedom from ticks, while wandering stock were heavily infested and some had actually died of tick worry and tick poverty, even though there was abundance of fodder. He claimed that in two cases he had " immune calves from vaccinated cattle. One vaccinated cow, her daughter and granddaughter all clean," but admitted that these cases were not enough to enable him to state whether the condition was hereditarily transmitted.

A little later Mr. Hull's claims were widened. The following list of those made by him for the cows Clover and Tinkerbell is contained in Parliamentary papers, Queensland, 1914, Vol. 2, pp. 941-3 ; a report by Mr. C. J. Pound on these claims being also included in the publication (P.R. 1914) :

1. These cattle never mature more than a few odd female cattle ticks during the whole course of a year.

2. They never require any attention as regards the tick.

3. They never need dipping and may be turned out on any country for indefinite periods without suffering any ill effects from cattle ticks.

4. They are regularly and heavily infested (or attacked) by millions of larval ticks.

5. With the exceptions mentioned above (No. 1) these infesting ticks die when still very minute.

6. Probably in the pupa stage (*i.e.*, nymph stage).

7. The cattle remain at all times sleek and clean in appearance, without blemish of any description.

8. That this peculiarity is transmitted in every case to their progeny.

9. That this peculiarity does not develop in their progeny until after the first year of their life.

10. That this peculiarity is transmissible by contact, *i.e.*, by natural infection, and by vaccination.

11. That the source of infection and vaccination is not a state of dermatitis produced by excessive tick worry.

12. That the few odd ticks found to mature on these cattle are not " survivors " but are such as have developed on ordinary cattle, have become displaced without mutilation, and have re-attacked these special cattle.

13, 14, and 15. Of no importance.

16. That regular trials, extending without a break for three years, to hatch the eggs laid by the few odd mature females found on these cattle have invariably been failures.

17. That no difficulty was experienced in hatching control eggs from ordinary cattle.

18. That during the winter months these cattle will mature more female ticks than in summer when ticks are most active.

19. That temperature tests made in winter with a ground temperature of 53 degrees F., showed that these cattle invariably ranged from one degree to $2\frac{1}{2}$ degrees higher than the ordinary cattle tested at the same time.

20. That when the tests were made ticks were wholly absent from ordinary stock, but were found in small numbers on all the special cattle under test (minimum 3, maximum 7).

21. That I estimate the total possible crop of female ticks per cow for the year to be from 50-100 only.

22. That if all the stock on a farm or in the State were infected with this peculiarity the cattle tick would be exterminated in a single season.

23, 24, and 25. Of no importance.

Mr. C. J. Pound, Government Bacteriologist, Department of Agriculture, Queensland, who had two of Mr. Hull's cattle, Clover and Tinkerbell, under his control for some time, adversely reported on the claims in so far as they might be held to apply to these two animals specially selected by Mr. Hull as examples of tick resistant cattle.

Mr. Pound's findings were as follows :—

Claims, Nos 1, 5, 6, 21. The two cows were placed in a ticky paddock for 27 days and then removed to, and kept in, stalls for 25 days. During 23 days of the latter period 230 fully mature ticks were taken from Clover and 860 from Tinkerbell while large numbers dropped off and were found on the floors of the stalls, these not being included in the totals.

Nos. 2 and 3. As a result of 27 days exposure in a ticky paddock these two cows became so badly tick infested and so suffered from tick worry that dipping and spraying would certainly have been justified.

No. 4. The degree of infestation depends entirely on the conditions of environment.

No. 7. On each occasion that the two cows were exposed to ticky pastures they became covered with sores while portions of the skin were denuded of hair.

No. 8 and 9. Clover's calf (13 months old in August, 1914) has been more or less heavily tick-infested since it was a few weeks old.

No. 10. A number of cattle, young and old, and of either sex, running with these two cows have not acquired the so-called tick-killing property, nor had he been successful in transmitting the alleged immunity by vaccination.

No. 11. The skin lesions referred to by Mr. Hull and from which he obtained his alleged vaccine, are caused by ticks, since if the cattle be kept free from ticks then no such lesions will develop.

No. 12. In one experiment the cows were kept free from contact with any other animal and yet developed ticks. It is only on rare occasions and with the greatest difficulty that mature ticks, after removal, can be made to reattach themselves to the same or other animal while with partly or fully engorged females this is an impossibility.

Nos. 16 and 17. Eggs laid by ticks taken from the two cows hatch out as rapidly at all seasons of the year as eggs of ticks taken from other cattle.

Nos. 18 and 20. There is practically no difference between the nature of the infestation of the so-called proof cattle and that of ordinary cattle during either the winter or summer months.

No. 19. Hull's statements in regard to increase in temperature were not borne out by Pound's observations.

No. 21. See No. 1.

No. 22. The statement is refuted by the fact that ticks will readily mature on the so-called proof cattle, since 135 fully mature ticks were recently taken off Tinkerbell in one day.

Since we have not considered Mr. Hull's claims Nos. 13, 14, 15, 23, 24 and 25, as having any bearing on our subject we have not mentioned Mr. Pound's replies to them.

We recently asked Mr. Hull to inform us as to which of the "claims" above mentioned are still maintained by him. In reply (dated 17-10-18) he quotes Nos. 1, 2, 3, 4, 6, 7, 10, 11, 14, 15, 18, 23, 24, in their entirety; in regard to No. 5 the ticks do not necessarily die while "very minute" as some continue to live and grow, but the majority of these do not become engorged and as a consequence are not fertile; No. 8 is modified to the extent that he admits the possibility of some cases of apparently hereditary transmission being really due to "contact"; No. 9 needs amendment since in one case the exudate made its appearance in the first year of a calf's life (Tinkerbell III)—a tick free animal; in regard to No. 21 the estimate is excessive in many cases.

Our observations as well as our consideration of such evidence as we have been able to obtain from published and other sources, have led us to agree with Mr. Pound's criticisms in regard to Nos. 4, 8, 9, 10 (in part), 11 (in part), 12, (13, 14, 15, not considered in this paper though we agree with Mr. Pound in regard to them), 16, in part only, 19,—Nos. 23, 24, and 25 were not considered by us.

We can readily understand that most of the remainder of Mr. Pound's findings would be correct, if only *intense artificial infestation* be taken into account. We must emphasise the fact that Mr. Hull claims that his cattle do not *mature* ticks like other cattle under *ordinary natural infestation.*

We agree with Mr. Hull in regard to No. 1, 2, 3, provided condition of cattle be maintained ; 5, as subsequently modified ; 7, approximately correct ; 8 and 9, apparently true in many cases ; 21, approximately correct.

To sum up : Our observations have led us to the conclusion that the animals which Mr. Hull has designated as being resistant and which we have examined, do not mature more than a comparatively few ticks per season under conditions of natural infestation, and as a consequence do not require any treatment to prevent tick worry.

In subsequent official reports (1914, 1915, 1916) Pound made further reference to the claims, his remarks and observations being referred to later on in this paper when dealing with statements regarding various cows. (See under Clover, Tinkerbell and their calves). The 1914 Report is the most important. In it Mr. Pound states (p. 112) that the numerous experiments carried out at Yeerongpilly prove conclusively that Mr. Hull's claim that the tick-resisting peculiarity is transmitted by contact, heredity or vaccination, is without foundation.

Mr. Hull's dissatisfaction with the Departmental findings (Par. Rept. 1914 ; Pound, 1914) led to the appointment of a Select Committee of the Queensland Legislative Assembly, 1915, which examined amongst others, a number of persons who had had some experience with Mr. Hull's cattle. The evidence given proved conflicting and contradictory and this led the Select Committee to recommend the appointment of a small committee (consisting of Messrs. Tryon, Pound, Cory, Johnston, Steele and a nominee of Mr. Hull) to supervise and direct further investigations and experiments (R.S.C., 1915, p. iii).

In giving evidence, Mr. Hull restated his main claims, adding that he believed that the application of an arsenical dip or wash temporarily banished the condition of tick resistance (R.S.C., p. 8). One of us mentioned the more important claims in his evidence (R.S.C., p. 56-8).

The new committee, under the chairmanship of Mr. H. Tryon, and consisting of those above named (except Dr. Steele) formulated a scheme of work, but owing to circumstances which need not be referred to here, found itself unable to proceed. Its report was laid on the table of the House, 22nd December, 1916, but was not printed as a Parliamentary paper (Tryon, 1917, p. 53).

The senior author has been interested in Mr. Hull's claims for several years but has been able to give only intermittent attention to them owing to pressure of other duties. He has, however, been constantly in touch with Mr. Hull, and has paid frequent visits of inspection (1915-1917) to his farm at "Cudgeree," at Eumundi. The junior author was able to stay there for a prolonged period during the past tick season, January-February, 1918, and has made subsequent visits. Mr. Hull has afforded every possible assistance and has placed at our disposal all his records relating to the matter under discussion. The statements contained therein have been compared as far as could be done, with those contained in letters received from him since early in 1915, and with the observations made by both of us during our many visits.

The work outlined by one of us (Johnston, in R.S.C., p. 58-9) might be summarised thus :

(1) To ascertain whether the tick resisting condition actually existed, *i.e.*, whether his so-called resistant cattle when placed under conditions of natural infestation, would become tick infested and mature ticks to such a degree as to require dipping or other treatment to prevent tick worry.

(2) If tick resistance be present can it be transmitted ?

(3) To ascertain whether the exudation mentioned by Mr. Hull is or is not merely that from an ordinary tick sore; the relation, if any, of the exudation to tick infestation, climate, etc.; effect of dipping.

Does tick resistance actually occur?

We have already brought forward evidence, when dealing with tick worry, that a certain degree of resistance is by no means uncommonly met with amongst cattle.

We propose firstly to examine the evidence available in regard to Mr. Hull's animals, viz., that collected by Messrs. Hull, Pound, Corser, Walker, ourselves and others who have had actual experience with such cattle; secondly the experience of other Queensland farmers and dairymen in regard to tick resistance.

Tick resistance might be manifested by—

(*a*) A failure to develop ticks or a particular species of ticks—really a tick immunity;

(*b*) A tendency towards light infestation when ordinary controls become heavily infested;

(*c*) A failure of female ticks to become fully matured (*i.e.* engorged) in such numbers as on controls under the same conditions of climate;

(*d*) A failure of such engorged ticks either to lay a normal number of eggs or to lay eggs showing a normal percentage of hatchings.

(*a*) We know there are many ticks which have very limited host relationships, *e.g.*, the cattle tick, *Boophilus annulatus*, with its several varieties or related species, including the Queensland cattle tick, *B. australis*, which is occasionally found in horses and sheep. Certain others prefer a particular host species but are not uncommonly found on other hosts, *e.g.*, some species of *Argas*, *Ixodes*, etc; while certain others prefer a particular class of animals and occur only rarely outside that class, *e.g.*, *Aponomma* (on reptiles)—Still others seem to be indifferent as to the host, so long as it is an amniote vertebrate, e.*g.*, some of our Australian ticks, Some genera are practically restricted to certain classes of vertebrates, *e.g.*, many of those maturing on Cheiroptera, birds and reptiles (*Eschatocephalus*, *Ceratixodes*, *Aponomma*). Then again many require to leave their hosts during certain stages of their development and must regain a suitable host (which need not necessarily belong to even the same order as the former host) for further development. However, the matter is simplified in regard to *Boophilus* since it passes through all its stages on one host animal.

We know that larval ticks may temporarily infest a great number of different hosts, *e.g.*, the larvæ of *B. australis* may be thus transferred by man, horses, cattle, sheep, marsupials, birds (such as quails, ibis, Charadriiform birds, etc.) Infestation by larvæ is then not a satisfactory criterion by itself. We will therefore discard it and use the remaining items for comparison.

Mr. Hull's resistant cattle.

We have endeavoured to collect information regarding these animals so as to be able to pass judgment on Mr. Hull's claims. The majority of the cattle referred to in this report have been subjected to the closest scrutiny by one of us for many weeks during the tick season, while in regard to them as well as other cattle formerly in Mr. Hull's possession, a number of casual inspections were also made (1915-1918).

Peony. The first cow which Mr. Hull claims to have noted as a "tick-killer" was Peony, resistance being observed in 1908. The offspring include Tinkerbell and Poppy (*q.v.*).

Clover. A black and white cow was bought at Pinkenba in 1908. This was one of the original cows found by Mr. Hull to be tick resistant, and was selected by him as a suitable subject for experiment, being sold to the Queensland Government in December, 1912.

Tinkerbell. Brindle cow, born 1908, dam Peony, became clean by contact with the above (according to Mr. Hull) and was sold with Clover for experimental purposes. Mr. A. H. Cory, who was in charge of the Yeerongpilly Experimental Station in the absence of Mr. Pound, concluded the arrangements and as an initial experiment had the cows placed in a ticky paddock to test their resistance to natural infestation. About this time Mr. Pound returned from America and resumed charge.

On arrival at Yeerongpilly on December 19th, 1912, both cows were examined by officers of the Department and found " to be covered more or less all over their bodies with small sores, the result of the attacks of ticks. This condition was pronounced on the escutcheon, udder and dewlap." (Pound, 1914, p. 110). The cows with two controls were then placed in a tick-infested paddock, the property of Mr. Chambers, where they remained until January 21st, 1913. During this period of 33 days they were examined daily by Mr. Thorn and one of the assistants and on two occasions were seen by Mr. Cory who reported that " up to that period a few ticks which were developing, were found on the cows " (Cory, R.S.C., 1915, p. 51).

A letter dated March 29th, 1917, and signed by H. Chambers, Yeerongpilly, appeared in the Brisbane *Daily Mail*, and *Courier* in which the writer stated, ,' . . . . I would like to place before the public certain facts which came under my notice, with reference to two cows purchased by the Queensland Government from Mr. Munro Hull for the Experimental Farm at Yeerongpilly. These cows were sent to my paddock on December 18th (20th ?), 1912, and taken away on January 20th, (21st ?), 1913. During that time an officer from the Experimental Farm and myself examined them almost every day, and a very few small ticks were found. These disappeared in a day or so. On April 14th, 1913, one of the cows before mentioned was again sent to my paddock and the other on April 24th. No. 1 was taken away on May 12th and the other was taken away on July 17th, or four weeks and 12 weeks respectively. During that time only two very small ticks were found on one of the cows, which disappeared as they had done previously. The two cows were again sent to my paddock on May 12th, 1914, and taken away on June 8th, no ticks were found on them. My cattle were running with them while they were in my care and mine were badly infested, so much so that I was obliged most of the time to wash every three weeks. I hold no brief for Mr. Munro Hull, and my sole reason for writing this is that I am quite convinced, because I have had many years' experience with tick infested cattle, that Mr. Munro Hull has discovered a remedy which I believe would be the means of reducing the ravages of the tick to a minimum and be of inestimable value to farmers and others engaged in the cattle industry. In conclusion I would suggest that stock owners arrange with Mr. Munro Hull for, say, four head of cattle and have a thorough test by sending them to two districts where ticks are known to be most active and numerous."

On January 21st, 1913, the cows (*i.e.*, experimental animals and controls) were removed, examined and officially reported to have shewn evidence of tick worry and tick infestation. A number of fully-developed ticks were removed from the cows, presumably Clover and Tinkerbell. The fertility of these parasites and the vitality of their offspring was found to be normal. The cows were then re-infested artificially with larval ticks (Pound, 1914, p. 110) which matured and likewise showed unimpaired fertility.

On May 12th, 1913, Clover was placed in a ticky paddock at Oxley: on June 14th she had a calf. On July 19th both animals were found on examination to be tick infested. In August, 1913, both cows were sprayed (Thorn, R.S.C., 1915, p. 29).

In February, 1913, Mr. Swayne, as Secretary of the Parliamentary Farmers' Union, wrote to Mr. White—then Secretary for Agriculture—suggesting that the cows be sent to Mr. Walker, M.L.A., and Mr. Corser, M.L.A. to see whether Mr. Hull's claim, that the cows remain free from tick infestation, would be demonstrated by a second trial in another district and under different conditions. In September, 1913, this suggestion was carried out, Clover being sent to Wetheron and Tinkerbell to Traveston.

Clover. As the House was sitting Mr. Corser was away much of the time, but a local committee was formed consisting of members of the Wetheron Progress Association and one of the men on the place. This Committee was allowed to examine the cow at any time. Mr. Corser inspected her on every occasion he was home and at no time during the cow's stay at Wetheron was a developed tick found on her (Corser, R.S.C., 1915, p. 61). Larval ticks were observed but it was noticed that by the time they assumed the size of a pin's head a small sore would start to form at the point of attachment and the tick would dry away. Clover was in fairly low condition on arrival and although she was milking all the time and never dipped, picked or sprayed during the five months she was at Wetheron, she left in good condition. Mr. Corser's own herd with which Clover was running, became very heavily infested with ticks and would have been in extremely poor condition had they not been dipped at intervals.

On March 14th, 1914, Mr. Pound wrote *re* Clover: " I have the honour to report that Mr. Munro Hill's cow Clover was untrucked here yesterday from Wetheron where she had been under the care and observation of Mr. B. H. Corser, M.L.A., since September. Immediately on her arrival, in very good condition, she was run straight into the crush and examined, and as a result Mr. Thorn and myself found numbers of cattle ticks in various stages of development, some of them past the second moult which takes place on the fourteenth day after first attachment." (R.S.C., 1915, p 64). Later Mr. Pound wired to Mr. Corser asking him to visit Brisbane and stating there was one developed tick on the cow. Following Mr. Watson's investigations, Mr. Corser visited Yeerongpilly and saw a number of developed ticks on Clover as well as on Tinkerbell and other cattle. Mr. Corser also saw a calf of Clover's with fully developed ticks on it.

Tinkerbell. Mr. Walker had an independent committee formed consisting of five or seven local people who had authority to go into the farm at any time and examine her. They met every Sunday and discussed the matter and " during the whole period I do not think you could discover ticks on her." (Walker, R.S.C., 1915, p. 16). Mr. Pound (R.S.C., 1915, p. 14) admitted that three days before the cow was returned to Yeerongpilly he visited Traveston and after a half-hour's examination failed to find any ticks on Tinkerbell, but he was not, however, satisfied that the animal was free from them.

On arrival at Yeerongpilly she was put into the crush and examined by Inspector Carmody who stated that he could have picked off 500 ticks up to a fortnight old

(Carmody, R.S.C., 1915, p. 35). Three weeks later—on April 20th—she was examined by Messrs. Walker and Carmody and five small adult ticks were found on her (R.S.C., 1915, p. 15).

On May 12th, 1914, the cows Clover and Tinkerbell were again placed in a ticky paddock belonging to Mr. Chambers for 27 days (see Chamber's remarks quoted earlier). On June 8th they were brought into the stalls and subjected to daily examination. Mr. Walker was represented at these inspections by Mr. H. B. Watson who reported to him on the subject every week. Mr. Corser was unrepresented. During a period of 25 days Inspector Carmody and Mr. Watson made 30 examinations, 860 developed ticks being removed from Tinkerbell (Watson, R.S.C., 1915, p. 32) and 230 from Clover (Carmody, R.S.C., 1915, p. 38). During this period "both cows were so covered with sores of a vesicular and pustular character, caused by tick irritation, that under ordinary circumstances dipping or spraying would have been justified" (Pound, 1914, p. 110).

Inspector Carmody after having examined the cows at Eumundi, stated (R.S.C., 1915, p. 38) that "the vesicles on Clover had the form of variola or ordinary cow pox. The pus came out something like variola or cow pox."

On July, 1914, both cows were sprayed (Thorn, R.S.C., 1915, p. 29). In May, 1915, Clover and Tinkerbell were sent to Maryborough. In October, 1915, the Secretary of the Wide Bay and Burnett Pastoral and Agricultural Society reported to the Under Secretary as follows :—

"I have the honour to report that since their arrival here in May last the two cows, Clover and Tinkerbell, have been depasturing at Messrs. Butcher and Rex's, of Alford Dairy, Oakhurst, near Maryborough.

"They were placed among the dairy herd and treated in every respect, except dipping, in the same way as the herd, being regularly milked. Clover is in calf and now dry, whilst Tinkerbell is drying off. The former has developed a few odd matured ticks but Tinkerbell has never matured one, whilst the cattle they have been running with have been alive with ticks, and required constant dipping. The health of the cattle has been good and they are both in excellent condition."

On December 10th, 1915, these cows were inspected at Messrs. Butcher and Rex's farm by Mr. A. J. Jones, M.L.A., Mr. Dymock, Mr. Page, M.H.R., and Mr. H. A. Jones, Secretary of the Show Society of Maryborough. Mr. A. J. Jones (R.S.C., 1915, p. 69) reported that Tinkerbell was heavily infested with fully-matured ticks. Both Mr. Butcher and Mr. Rex stated the cows had not been dipped during the seven months they were under observation. Mr. Butcher is also reported to have said that Tinkerbell had not matured ticks until that week. Mr. Jones reported that "Clover was as clean as a table." He searched her very carefully and could find no ticks on her. He noticed that a yellow substance had been exuding from her skin. "Her skin was lovely. She was in good condition and clean." (Jones, R.S.C., 1915, p. 69).

There seems to have been some misunderstanding about the names of these cows. We have received the following note from Mr. Butcher *re* Clover :—"This cow we had from the Agricultural Department. She carried a few ticks while in good condition but she was an old cow and got fairly poor and became a living mass of ticks and died." This was during the 1915 drought.

Of Tinkerbell, Mr. Butcher wrote :—"Tinkerbell I failed to ever find a tick on, although we were milking her twice a day." We communicated again with Mr. Butcher pointing out this apparent contradiction. His reply was to the effect that he and Mr. Rex had confused the names and had given them to Mr. Jones wrongly, so that Clover must be substituted for Tinkerbell and *vice versa* in all his (Mr. Jones') statements.

Tinkerbell was subsequently returned to Yeerongpilly.

Two heifers, aged 2½ years and 6 months, the progeny of Clover and Tinkerbell respectively, were reported to be maturing ticks on artificial infestation (Thorn, R.S.C., 1915, p. 28). Clover's heifer was kept in a stall for observation and artificially infested (Pound, R.S.C., 1915, p.28).

The evidence given above is sufficient to justify the statement that under conditions of ordinary natural infestation, these cattle did not mature ticks in sufficient numbers to require any treatment to prevent tick worry.

Our examination of Mr. Hull's resistant stock:—During January and February of this year (1918) one of us, while enjoying the kind hospitality of Mr. and Mrs. Munro Hull, carefully collected all the engorged ticks to be seen on the resistant cows. The latter in most cases were examined both morning and afternoon, with the exception of a few non-milkers which were usually inspected only once daily.

The total numbers of engorged female ticks collected from January 16th to February 11th (inclusive) from the following cows were:—Baby, 0; Fairy, 3; Kittiwake, 3; Peewee, 2; Primrose, 0; Rainbow, 4; Rosie, 13; Sprite, 0; Squib, 30; Sunset, 18; Wallum, 0; Yellow, 1. Nine were taken from Dot in 12 days; and 64 from Spot (classed as non-resistant) in the total period. Dot, Rosie, Spot, and Squib, are young cows; Sunset is the least strongly resistant among the older animals; from the remaining nine cows only 13 fully-matured female ticks were removed during 26 days. One might object that these figures were evidence of the scarcity of ticks at "Cudgeree," but such was not the case since control cattle were fairly heavily infested at the same time.

In addition to the record of our observations made during that period we are including some made in March and June of this year (1918) and also some notes made over two years ago by one of us (in June, 1916), as well as information, (which we herein indicate) extracted from Mr. Hull's stock book.

Baby, born March, 1914; dam, Jessamine. An Ayrshire—Illawara cross; red roan with yellow skin. (Extensive exudate was first noticed in February, 1916; free from ticks in the following month. Stock book). June 24th, 1916: clean except for presence of a few small immature ticks; exudate* present.

From January 16th-31st, 1918, this cow was examined daily by one of us (except on 25th, 30th, and 31st), during which time no fully-matured female ticks were observed though a few males and nymphs were always to be found on close examination and one fair-sized female was taken

*For an account of this exudation, see later in this paper.

on January 16th Fresh exudate was seen on the 16th and 17th. On February 1st she calved and from this date to 11th was examined twice daily, but no matured females were seen. Fresh exudate appeared on 9th and 10th. From March 18th-24th she was examined five times, numerous larvæ being visible on the escutcheon but no fully developed ticks were seen. Extensive exudate appeared on 20th. On June 7th she was again examined when two fully-matured females were found, while males and nymphs were fairly numerous on the backs of the legs.

Beauty, bought from M. Bourke, Rosewood, 1911; clean, February, 1915; a few ticks present, May, 1915; clean, November, 1915; ticky and sprayed, January, 1916; vaccinated from Sweetbriar, 20th January, 1916; exudate present, March, 1916. Stock book).

June 24th, 1916: plenty of small ticks on escutcheon and axillae but none seen engorged though Mr. Hull stated that some do occasionally become engorged. Sold, 1917.

Betsy, bought at Gympie, 1913. June 24th, 1916: though referred to by Mr. Hull as a ticky animal, only a few small ticks were observed, also some tick sores. Sold, 1917.

Buttercup, born 1907; dam, Old Spot by Jersey Bull. Light yellow Jersey with yellow skin.

This cow had been running with a mob of milkers at Downey's in a rough and hilly paddock with poor grass since January, 1916. The cattle were poor and had been badly infested with ticks, they were dipped a week previous to examination. Buttercup had never been dipped and though only in fair condition had remained free from ticks. No ticks could be found on date of examination (at Downey's), February 3rd, 1918. June 7th, 1918, examined at "Cudgeree": small ticks were fairly numerous. Fresh exudate visible. Died, October, 1918.

Cherry, bought at Ripley, 1909.

June 24th, 1916. Examined immediately on her return from several months' stay in a neighbouring ticky paddock and found to be ticky. Sold 1917.

Dawn, born August, 1910, dam, Sunbeam,—sire, Peter Pan. A red Shorthorn-Jersey strain.

(Vaccinated from "Marty," 13/12/13; sprayed, December, 1915; infested, January, 1916 (condition low); sprayed, January, 1916; patch of ticks on escutcheon, March, 1916 (condition low); clean—no trace of ticks, 7/4/16; condition prime, slight exudate, 4/11/16: condition prime, no ticks, 9/1/17; condition prime, few mature females, 19/3/17; February 10th, 1917, applied larvæ from ticks from "Sunset"; February 19th, 1917, about 80 visible; February 20th, 1917, only 10 maturing ticks by natural infestation, excluding dead nymphs and males; May 4th, 1917, vaccinated on neck and rump with serum from Isis and Sprite: May 30th, 1917, ticks not attacking escutcheon, rest of body heavily infested and maturing in normal quantities; May 30th, 1917, vaccinated from "Kittiwake"; June 6th, 1917, body heavily infested, escutcheon clean; June 18th, 1917, free from ticks; December 11th, 1917, clean. Stock book).

Examined by one of us (24/6/1916) immediately on her return to Eumundi after several months' sojourn in an ordinary ticky paddock, and found to be apparently clean. Dawn had been running since December, 1917, with a heifer calf in Martin's paddock which previously carried ticky stock. Inspected 3rd February, 1918, only a few nymphs could be found. Calf also clean.

Dot, born October, 1914; dam, Starling; a black Jersey cow with fine short hair. (Slight exudate, October and November, 1916. Stock book).

June 24th, 1916: Several small ticks seen, none engorged. Examined twice daily from January 16th-25th, 1918: nymphs and males and half-bloated females seen on all occasions while nine fully-matured females were removed during that period. Fresh exudate appeared on January 24th.

Fairy, born September, 1911; dam, Vixen. A yellow Jersey, a very ticky animal until last season (1917). (Vaccinated from "Sweetbriar," 2/3/15; sprayed for last time, February, 1916; extensive exudate observed, 14/11/16. Stock book).

On 24/6/16 we found many small and a few engorged ticks, as well as numerous small tick sores resembling pinpricks. With the latter were associated ticks and a fluid resembling "exudate."

This cow was examined regularly twice daily from January 17th-February 11th (except on January 22nd and February 2nd), 1918. One fully-developed female tick was removed on each of the following dates: January 17th, Feb. 5th and 6th; larvæ, nymphs, males and a few unbloated females were observed on almost all occasions. Fresh exudate was seen on January 17th, 18th, 20th, 24th, February 1st, 3rd, 5th, 8th, and 9th. From March 18th-24th, Fairy was examined four times. Numerous males and nymphs as well as a few unbloated females, were noticed on the escutcheon while six matured but very small females were removed. Exudate had been breaking out all over escutcheon which was encrusted with thick yellow scales and hard black scabs. Calved April 1918. On June 7th she was again examined; males were numerous and a few fully-developed female ticks were removed. It was noteworthy that the escutcheon was free from scabs and ticks.

Greedy, born March, 1914; dam, Ladybird. Roan cow with yellow skin. (Tick infested, March, 1916; clean, shewing exudate, November, 1916. Stock book).

Clean, with a few typical exuding areas (24/6/16). Examined in paddock on six occasions from January 16th—February 11th, 1918.—Males and nymphs present but no mature females were observed. Fresh exudate was seen on January 16th and February 9th. March, 1918, very clean. Calved May, 1918. June 7th, much tickier than on previous examination, males and immature ticks numerous, few mature females. No trace of exudate.

Jockey, born 1915; dam, Old Spot. A red cow with yellow skin.

When 18 months old (24/6/16) she was examined and found to be clean except for the presence of some nymphs on the escutcheon.

This cow was running out in the paddocks and was examined on seven occasions between January 16th-

February 11th, 1918. A mature female tick was removed on 28th January and another on 9th February; extremely few ticks in any stage could be found. March 18th-24th, calved. No trace of ticks except a few larvæ. Exudate extensive. June 7th, still very clean but more immature ticks were noticed than in March and a few mature females were removed. This cow is very strongly resistant for such a young animal.

In October, 1911. ten heifers were purchased from M. Bourke, Rosewood, by Mr. Hull, who reported that they were all ticky on arrival at Eumundi and were turned into a small scrub paddock with Clover, Tinkerbell, Peony and other dry stock, for nine months. During this time they were not dipped or treated in any way for ticks. The results of this experiment were as follows :—

1. Rosewood .. died, 1912.
2. Mulga .. became resistant, 1913; died, 1915 (drought).
3. Cuckoo .. became resistant, 1914; sold, 1916.
4. Beauty .. became resistant, 1915; sold, 1917.
5. Misery .. remained ticky, died 1916,.
6. Starling .. became resistant, 1915; sold, 1915 (drought).
7. Stormbird .. became resistant, 1913.
8. Seagull .. became resistant, 1914.
9. Peewee .. became resistant, 1914.
10. Kittiwake .. became resistant, 1913.

For condition of progeny of these cows see genealogical tables.

The four last named are still in Mr. Hull's possession; of these Peewee and Kittiwake were milkers and were examined regularly by us during our stay early in 1918.

Kittiwake, bought from M. Bourke, Rosewood, 1911. A black Jersey with a very black greasy skin.

On 24/6/16 a few larvæ and nymphs seen; no engorged ticks present; yellowish crystal-like exudate; also tick sores associated with a number of which and partly buried in the lymph were ticks.

From January 16th-February 11th, 1918, this cow was examined twice daily (except on 27th-30th January, inclusive). Males, nymphs and larvæ were always more or less in evidence but only three fully-matured females were observed, one being removed January 16th and two on February 5th. Tick sores appeared from time to time;

while a typical exudation occurred on January 17th, 23rd and 24th. This cow shows tick blisters as well as the typical exudate. Calved on February 2nd. On March 21st and 22nd this cow was examined; the escutcheon was covered with larvæ and nymphs while three mature females were removed on 21st and 13 on 22nd. On June 7th, large tick sores were visible on escutcheon; small ticks numerous; fully-matured females fairly numerous. The tick resisting power of this animal apparently had undergone diminution.

Peewee, bought from M. Bourke, Rosewood, 1911. Black Jersey with white belly. (This cow was running with Finch's milkers (a ticky herd) from October, 1916-May, 1917, during which time she was never dipped and remained free from ticks. Stock book).

On 24/6/16 a few mature and immature ticks were seen on escutcheon; also some tick sores but no definite exudation; the body was free from ticks.

Although this cow was examined regularly from January 16th-February 11th, 1918, being a milker for the whole period, there is very little to report about her condition. She remained consistently clean throughout. Males and immature stages were occasionally seen, a few unbloated females were observed on the escutcheon on January 31st and February 1st, while a fully-matured female was removed on February 9th and another on 10th. There was no exudate visible during this period. March 19th - 24th: this cow was examined four times, males, nymphs and larvæ being found but no mature females. Fresh exudate was seen on 22nd and 24th. June 7th, examination disclosed a few unbloated females scattered over the body.

Primrose, born May, 1909; dam, Spot, by Jersey bull. A light yellow Jersey with yellow skin. (No ticks, 1914; condition low, few ticks, December, 1915; sprayed, January, 1916; clean, condition improved; exudate, February, 1916; tick sores, March, 1916; exudate, March, 1916; exudate pronounced, May and June, 1916; remained clean and in prime condition. Stock book).

On 24/6/16 free from ticks; exudate abundant on escutcheon. Examined daily from January 16th-February

11th, 1918. No ticks of any description were found on her. Fresh exudate appeared only once, on January 17th. Calved, January 26th. March 18th-24th : a few tick sores were visible on the escutcheon but the animal appeared perfectly free from ticks. June 7th : one mature female tick was removed and a few immature ticks were visible. No exudate present.

Rainbow, bought from Luke, Eumundi, 1912. Black Jersey with yellow skin. (Clean, 28th February, 1915 ; condition good, exudate evident, January, 1916 ; condition good, no exudate, February-May, 1916 ; condition good, exudate, November, 1916 ; condition good, slight exudate, May, 1917. Stock book.)

On 24/6/16 free from ticks ; exudation present. Examined, January 16th, 1918. Calved, January 20th. Examined twice daily from 21st January-11th February. During this period four fully-matured ticks were removed. Males, nymphs and larvæ were evident on many occasions. Fresh exudate was observed on February 8th. Sold March, 1918, to G. B. Wells, Eumundi.

Redwing, born, 1914 ; dam, Snailie.

On 24/6/16 a solitary engorged female and a few young ticks were seen—neither tick sores nor exudations were observed. Sold, 1917.

Rhinca, born, 1910 ; dam, Jessamine. A yellow Jersey with a white face ; yellow skin.

24/6/16 : Two engorged ticks found, a few immature parasites present.

January, 1918 : this cow had been running in a large paddock (Mr. Finch's) opposite "Cudgeree" with ordinary stock for almost twelve months. She was in good condition and not being milked during January and February, 1918. Four examinations were made. On one occasion one poorly developed female tick and several nymphs were found on the ear and shoulder ; while on the other occasions no ticks could be found. Fresh exudate was observed once ; the dry scales were seen on two other occasions. On 24th January, a number of Mr. Finch's milking stock were examined and found to be grossly infested with ticks ; Mr. Finch had been unable to dip for over three weeks owing to the continued heavy rain and as a result large numbers of ticks were maturing on the cattle. Two of his cows were noted as especially free from ticks. Sold March, 1918, to G. B. Wells, Eumundi, who reported (October, 1918), that neither this cow nor Rainbow had carried more than an occasional odd tick while in his possession, though both had not been dipped, sprayed or washed.

Rosie, born July, 1915 ; dam, Primrose, by Robbie —Jersey bull. A light red cow with yellow skin. (Clean, November, 1916 ; clean, February, 1917 ; exudate extensive, very ticky close to vulva, November, 1917 ; exudate slight, clean, December, 1917. Stock book).

24/6/16 : No mature ticks seen, exudate absent. Examined twice daily from January 16th-February 11th, 1918. Males, unbloated females, nymphs and larvæ were always present in small numbers. Thirteen fully-matured females were removed during this period. Exudate appeared on the 20th January and the 10th February. March 18th-24th : immature ticks abundant especially on the escutcheon ; a few mature females were removed each day and as many as 25 were collected on one occasion. June 7th : immature ticks fairly numerous, but condition as regards ticks had improved since March.

Seagull, bought from M. Bourke, Rosewood, 1911. A light brindle Jersey-Shorthorn strain, with a yellow skin.

24/6/16 : Quite clean—exudation present. Examined several times in paddock from January 16th-February 11th, 1918, but no ticks were observed. March, 1918 : in splendid condition, absolutely no trace of ticks. June 7th : condition unchanged in any way. Calved, September, 1918.

Stormbird, bought from M. Bourke, Rosewood, 1911. A dark brindle Jersey strain, with a dark yellow skin.

24/6/16 : Examined at "Cudgeree" immediately on arrival there after having been for several months in a ticky paddock some miles away. Found to be free from engorged ticks. Examined in the paddocks on several occasions from January 16th-February 11th, 1918, no ticks were found. March 19th-24th : one mature female was removed from the escutcheon, otherwise very clean. June 7th : perfectly clean. Calved, September, 1918.

Spot, born December, 1915 ; dam, Brownie. A little light yellow Jersey with a yellow skin.

This young cow was by far the tickiest subject on the place, with the exception of some of the yearling stock and control heifers. She was not milking but came up each day with the milkers and was examined regularly from January 16th-February 11th, 1918. Males, half-bloated females, nymphs and larvæ could always be found on her, while from 2-3 fully-matured females were removed each day, the total number being 64. During this time no trace of exudate was observed. March 19th-25th : five examinations were made and 18 mature females were removed, numerous immature ticks were observed. The escutcheon was coated with a dry yellow substance resembling exudate. June 7th : small ticks were still numerous and a few mature female specimens were secured.

Sprite, born November, 1911 ; dam, Tinkerbell. A brindle Jersey with a dark skin. (Allowed to run wild from birth as her calf has also been allowed to do ; neither have ever been treated for ticks, March, 1916. 1/2/16 : clean, —out on roads. No ticks found to date 23/1/18. Stock book).

June 24th, 1916 : Free from ticks—exudate present but somewhat blood-stained. During the January-February examinations, 1918, this cow was not a milker, being allowed to rear her calf, but was examined each day with a few exceptions. No ticks were observed on any occasion. Fresh exudate appeared on January 27th, 28th, February 5th and 10th. March 19th-24th : no mature ticks except two or three very poorly developed females were found. Larvæ were numerous on the escutcheon. On 22nd March, a clear yellow fluid was observed exuding from the part about some tick-sores on the escutcheon, while fresh exudate was also seen at the side of the escutcheon. June 7th : a few very small females were removed.

Squib, born May, 1915 ; dam, Rhinca. Ayrshire-Jersey strain : light red cow with white face, yellow skin. (Clean, November, 1916 ; clean, February, 1917 ; a few small ticks on escutcheon, April, 1917 ; few mature females, December, 1917. Calved, December, 1917. Stock book).

June 24th, 1916: A few engorged ticks present. This cow was examined daily from January 16th - February 11th, 1918. Males, half-bloated females, nymphs and larvæ were observed frequently . On the morning of January 18th, larvæ from tube II (hatched, 4/1/18) were applied to the escutcheon. The majority had disappeared on the following day. Mature females were removed from time to time making a total of 30, but from 8th-11th February when the artificial infestation might be supposed to be developing, only two fully-matured females were found. Fresh exudate was observed on 17th, 25th, 26th, 31st January, 8th, 9th and 10th February. March 19th-24th: Males and nymphs were very numerous and over 70 matured females were removed in five examinations; many of these were, however, extremely small. No fresh exudate was observed. June 7th: immature ticks fairly numerous, but infestation not so heavy as in March.

Snailie, bought at Tewantin 1913.

24/6/16: Tick-free, exudate present.

Sunset, bought from H. Bull, Tewantin, 1912. A red and white cow with rather long hair and white skin. (Very ticky,—inoculated from resistant animal. Clean 28/2/15; Condition good, clean, exudate, March, 1916. Stock book).

24/6/16: Examined immediately on return after several months stay in a neighbouring ticky paddock,—found to be free from ticks, exudate present. This cow was examined daily from January 16th - February 11th, 1918. Males, unbloated females and nymphs could always be discovered on close examination and fully-matured females were removed from time to time, making a total of 18 during that period. Fresh exudate was noticed on January 17th and February 9th. March 19th-22nd: traces of recent extensive exudation were observed on the escutcheon and several mature females were removed. Sold April, 1918, to H. Clem, Eumundi, who reported (October, 1918) that he had never dipped or sprayed this cow, since only a few small ticks had been noticed on her.

Sweetbriar, born June, 1910; dam, Bluebell, sire, Don (Jersey). A black and white cow, with yellow skin and short fine hair.

24/6/16 : No mature ticks found ; " tear-drop " type of exudation present. 1918 : This cow had been running with Mr. Fred Hull's milking herd at " Lonehand " for some months. Examined at " Lonehand " 25th January : only a few larvæ were visible. On 5th February, Mr. Fred Hull dipped his milkers with the exception of some five or six resistant animals of his own and five (including Sweetbriar), belonging to Mr. Munro Hull. No ticks were found on this animal and she was taken home and from 6th-11th February, 1918, was examined twice daily, but no ticks were detected on her. Fresh exudate was observed on 5th, 8th and 9th February. March 19th-24th : numerous larvæ were found attached to udder and escutcheon but no other stages were visible. Fresh exudate was observed on the 19th, 21st, and 24th. June 7th : Not examined carefully, but no ticks were apparent.

Wallum, born August, 1913 ; dam, Heatherbell. A dark brindle Jersey strain, with dark yellow skin. (Condition low and very ticky, December, 1915 ; perfectly clean, June, 1916 ; slight exudate, November, 1916,—clean ; slight exudate, May, 1917,—clean. Stock book).

24/6/16 : Examined on return from several months stay in a neighbouring ticky paddock—found to be free from ticks—dry exudate was present. This cow was examined daily from January 16th-February 11th, 1918, and no ticks of any age were discovered on her. Fresh exudate was frequently observed—on 16th, 30th January, 1st, 5th, 8th and 10th February. March 20th-24th : three examinations were made but no ticks were discovered ; fresh exudate seen on each occasion. Calved, April, 1918. June 7th : no fully-matured female ticks were observed but a fair number of immature ticks were noticed. No fresh exudate was seen.

Yellow II, born 1912 ; dam, Yellow I.

24/6/16 : A few engorged ticks as well as a number of immature and maturing ticks. Substance resembling exudate present. Sold, 1917.

Yellow III, born, December, 1915 ; dam, Yellow II. A light yellow Jersey with particularly short hair and a yellow skin. (Exudate ; condition prime, November, 1916, November, 1917. Stock book).

24/6/16 : Only a few immature ticks detected. This cow was examined regularly from January 18th-February 11th, 1918, but only one matured female was observed. A few immature ticks were noticed on several occasions. Fresh exudate was seen on 25th, 26th January, 3rd, 6th, and 8th February. March 19th-22nd : three examinations were made, only one mature female was discovered, fresh exudate was observed on 22nd. June 7th : a few immature ticks were seen but no mature females or exudate.

Zephyr, bought at Toowong, 1912 . Remained ticky after vaccination. 24/6/16 : Examined immediately on her return from several months' stay in a neighbouring ticky paddock,—found to be ticky. Sold, 1917.

Trampas II, born, October, 1915 ; dam, Stormbird, sire Trampas I. Blue roan bull, reared on "Cudgeree" and has never been treated in any way for ticks.

24/6/16 : Found to be free from engorged ticks. January 16th-February 11th, 1918 : examined at intervals and found to carry ticks in all stages including fully-developed females, but the infestation was light and mainly on the flanks. March, 1918 : in the same condition as previous month.

Young Stock.

Bramble, born, November, 1916 : dam, Sweetbriar. A young Jersey bull. Five examinations were made between January 16th-February 9th, 1918. A few mature female ticks (1-7) were removed on each occasion, while patches of immature ticks and males were present on the hind parts and scrotum. Two red-legged ticks (*Rhipicephalus sanguineus*) were removed from this animal. No exudate was noticed.

Lotus, born November, 1916 ; dam, Isis. A Jersey heifer ; this young heifer was examined several times from January 16th-February 9th, 1918, but very few matured females were discovered ; immature ticks were present, but the infestation was not very heavy. Dry yellow exudate was observed on two occasions, while it was seen in fresh condition on 9th February, 1918. In March, 1918, three examinations were made and several (2-5) matured females were removed on each occasion, while immature ticks, males and unbloated females were numerous on escutcheon, neck and ears. The escutcheon was encrusted with yellowish scales. On June 7th, 1918, she was again examined and a few ticks—mostly small, *i.e.*, immature—were present. The yellowish scales were again present on the escutcheon.

Nigger, born October, 1916; dam, Peewee. A black Jersey heifer. This heifer remained free from tick infestation throughout the January-February examinations. In March, 1918, she was noted as "fairly clean," carrying a light infestation of small ticks.

Sunrise, born August, 1916; dam, Sunset. A golden yellow Jersey heifer. This animal remained fairly free from ticks during the January-February examinations, only occasional mature females being removed from her. In March, 1918, she was still comparatively tick free. Sold, 1918.

Vixen, born July, 1916; dam, Fairy. A Jersey heifer. This animal was one of the tickiest under observation. Ten detailed examinations were made from January 17th-February 10th, 1918, and on each occasion males, half-bloated females and nymphs were abundant, especially on escutcheon, skirt and neck, whilst matured females were removed on each occasion, 26 being the greatest number found at one time. In March, 1918, Vixen was examined several times and 53 matured females were removed on 18th March, 1918. She calved a few days afterwards. Immature ticks and unbloated females were very numerous. On June 7th, matured ticks were less abundant, only a few fully-matured females being found though small ticks were present in fairly large numbers. It is thought that this heifer is becoming resistant as the proportion of fully developed ticks to the sickly yellow infertile variety is diminishing.

Donkey II, born December, 1916; dam, Donkey II. A brindle steer, in poor condition. Remained ticky throughout the January-February and March examinations (1918).

Bally, born March, 1917 ; dam, Rhinca. A red heifer with white face. This calf was running in a small paddock during January-February, 1918, and remained quite free from ticks. In March, having been turned out into the large paddocks, a few mature females were removed from her, but she was in no wise badly infested.

Bluebell III, born October, 1917 ; dam, Sweetbriar. A blue roan heifer. Remained quite free from ticks during the January-February and March examinations (1918). During the winter she became poor on account of lung worm and was heavily tick infested. Died, winter, 1918.

Brindle, born July, 1917 ; dam, Pride. A brindle heifer. This animal always carried a few ticks : unbloated females could be found on all parts of the body, especially on the escutcheon, whilst odd mature females were removed occasionally. Died from lung worm, winter, 1918.

Bunting, born March, 1917 ; dam, Baby. A red and white heifer. Several (1-5) mature females were removed on each examination during January-February, 1918. In March a few mature females were found, while the escutcheon was thickly encrusted with yellowish scabs.

Banksia, born June, 1917 ; dam, Wallum. A brindle heifer carrying very few ticks during the periods of our observations.

Briar, born December, 1917 ; dam, Rosie. A red and white steer. This little calf was noticed to have a big patch of maturing ticks on the dewlap and odd matured females were removed from time to time. The rest of the body was practically free from ticks (January-February, 1918). Still fairly tick free in March, 1918. Died from lung worm, winter, 1918.

Cracker, born December, 1917 ; dam, Squib. A red and white heifer. Infestation on this calf was very similar to preceding (1918).

Crescent, born March, 1917 ; dam, Rainbow. A red steer, carrying abundant ticks during the January-February examinations. Became so heavily infested that washing with kerosene and light oil was resorted to to relieve tick worry ; hence fairly clean when examined in March, 1918.

Curlew, born March, 1917 ; dam, Seagull. A light red steer. Very ticky during January-February, 1918. Numerous matured females were removed from time to time. Washing was resorted to as in preceding case, but the fluid was applied only to hind parts. When examined in March the neck and sides were heavily tick infested. Died from lung worm, winter, 1918.

Peter Pan II, born May, 1917 ; dam, Fairy. A Jersey steer, carrying numbers of ticks. Numerous matured females were removed from time to time during January-February. This steer was also washed in March, 1918, and appeared fairly clean on examination later in that month.

Petrel, born February, 1917 ; dam, Stormbird. A blue roan heifer. Remained practically tick free during January-February, 1918. In March, she was fairly clean, a few ticks being found. A mass of yellowish scales was present on the escutcheon. Calved, September, 1918.

Snowy, born July, 1917 ; dam, Brownie. A white steer, carrying a few ticks, mostly immature, but odd mature females were removed occasionally, (January-February, 1918). Died from worms, March, 1918.

Stormy, born August, 1917 ; dam, Spot. A red and white heifer, carrying a fair number of ticks including matured females (January-February, 1918). Sold, 1918.

Tewantin, born March, 1917 ; dam, Sunset. A yellow and white steer. Ticky during January-February examinations. Washed with Crescent, Curlew, etc., and appeared fairly clean in March, 1918.

Tinkerbell III, born March, 1917 ; dam, Sprite. A red brindle heifer, remained practically free from ticks during the whole period of examination (January-February, March and June, 1918). A few immature ticks could be found on close scrutiny and an occasional matured female was removed. On 28th January, 1918, and again on 10th February, some tiny dry patches of serum were found on the escutcheon. Mr. Hull had noticed exudate on this heifer previously, this being the youngest subject on which he has observed it.*

Rosewood heifers.

Six heifers were loaned by Mr. A. W. Johnston, Cowleigh, Thagoona, near Rosewood, as controls, their arrival at Eumundi being witnessed by one of us on October 18th, 1917. These animals ran in Mr. Hull's paddocks with the rest of his stock until June 17th, 1918, when they were returned to their owner.

One (Brand J.4.V.) died early in January. We found that the remaining five shewed varying degrees of infestation, becoming progressively cleaner in the following order :—

Brand	T.3.O. No. 1	red and white	ticky
,,	T.3.O. No. 2	red and black	
,,	R.O.8. No. 1	red	
,,	R.O.8. No. 2	red and white	comparatively clean
,,	J.4.V. No. 1	red	

These heifers were examined from time to time (on 11 occasions) from January 17th-February 11th, 1918. With the exception of J.4.V., it was impossible to examine any of them thoroughly, the two branded T.3.O. being especially wild. The fact that there was no crush or facilities for handling such animals, made it impossible to collect all the mature female ticks present at any one time.

The two branded T.3.O. were ticky throughout the January-February examinations, shewing big patches of fully-matured females on escutcheon, shoulders and in the ears. March 18th and 22nd : these two heifers were carrying a large number of mature ticks. On March 25th the number of mature females was considerably less. June 7th : mature females were less numerous.

*Mr. Hull reports (11th Nov., 1918) that of the young stock mentioned above, Squib, Bally, Bunting, Banksia and Bramble are now resistant.

Of the two branded R.O.8. one remained consistently freer from ticks than the other. On one occasion (February 5th), 26 fully-matured females were removed from the escutcheon alone of the latter, while many more could be seen along the belly, sides of body and neck. Fully-matured ticks were occasionally seen on the other heifer (R.O.8. No. 2) but never in any great number. Three examinations were made from March 18th-25th, when both heifers were carrying more ticks but in the same ratio as before. Thirty-seven fully-matured females were removed from R.O.8. No. 1 on 22nd, while the shoulders, escutcheon and dewlap were fairly encrusted with small ticks. The escutcheon of this heifer was covered with yellowish white scabs, while the butt of the tail was scurfy. R.O.8. No. 2—the relatively clean animal—was also carrying numerous small ticks and yellowish white scabs on the escutcheon but the latter were not as plentiful as on her mate. June 7th : Both these heifers were carrying ticks, the one being more heavily infested just as on former occasions. In both, the escutcheon was coated with the whitish scabs mentioned above.

J.4.V. This—the odd—heifer soon became very tame and could be examined with ease. She remained practically free from ticks during the January-February examinations. On February 9th, about six tiny spots of yellow exudate appeared on the escutcheon. March 18th-25th : Carried many more ticks than on previous examinations. The escutcheon was quite covered with small immature ticks while about 12 mature females were removed on one occasion and 5 on another. Dry yellow granules were apparent on escutcheon. The ticks were practically confined to this portion, the rest of the body being almost free. June 7th : a few immature ticks visible.

Prior to trucking on June 17th, all these heifers were hand-picked and sprayed to comply with Stock regulations, though ticks were not numerous on them. In response to our request as to their condition, the owner, Mr. A. W. Johnston, stated (October, 1918) that one of the heifers—R.O.8. No. 1—had a few ticks on arrival at Rosewood and was still shewing some, though she had been dipped. None of the others appeared to have ticks nor were any of the cattle with which these were now running, tick-infested. Particulars as to their condition during the coming tick season have been promised by Mr. Johnston.

Resistant cows at "Lonehand" (Mr. F. Hull's farm).

Five resistant cows, the property of Mr. Munro Hull, were sent as milkers to his brother's farm, Lonehand.

Isis, born August, 1912; dam, Buttercup—sire, Trampas I. A light red cow. (Clean, January, 1916; exudate, November, 1916. Stock book).

This cow was examined at "Cudgeree" on 24/6/16, when abundant exudate as well as typical tick sores were noticed. Examined at "Lonehand" on January 25th and February 5th, 1918, no ticks being discovered; on the latter date fresh exudate was visible. March 23rd: still absolutely free from ticks. June 7th: examined at Cudgeree. Only a very few immature ticks were seen. Fresh exudate was visible. Calved, September, 1918.

Pride, born August, 1912; dam, Clover. A roan cow. (Exudate, October, 1916. Stock book).

Examined at "Cudgeree," 24/6/16—very few mature ticks seen though plenty of small dead and living nymphs, etc., seen. Inspected at "Lonehand," January 25th and February 5th, 1918, and no ticks were found. March 23rd: escutcheon was covered with small ticks and one mature female was removed.

Donkey II, born 1912; dam, Donkey I. (Exudate, January, 1916. Stock book).

Examined at "Cudgeree," 24/6/16, and found to be quite free from ticks—abundant exudate present.

At "Lonehand," January 25th, 1918, a few mature females were removed from escutcheon; fair number of immature ticks present. February 5th: no ticks were found. March 23rd: no ticks observed. Calved, October, 1918.

Brownie, born May, 1913; dam, Spot, sire, Trampas I. Light red with white face. (Condition low, ticky, November, 1915; vaccinated, January, 1916, from Stormbird; vaccinated November, 1916; exudate, December, 1916. Stock book).

Examined 24/6/16, at "Cudgeree"—plenty of small ticks but extremely few engorged females and a few yellowish ticks present—no exudation.

January 25th, 1918 : examined at "Lonehand" and found free from ticks. February 5th : a patch of small ticks (larvæ and nymphs) on escutcheon. March 23rd : Brownie became so badly infested that Mr. Fred Hull washed her udder (which was principally affected) with dip fluid. This part and escutcheon had again become heavily infested, the rest of the body being comparatively clean. June 7th, at "Cudgeree": Very few ticks, escutcheon coated with thick yellow mass (nature ?)

Evidence of others who have handled Mr. Hull's cattle.

Bluebell, born, 1908 ; dam, Clover.

This cow was one sold to Butcher and Rex. Mr. Butcher (July, 1918) reported that she developed a few ticks while in their possession. She was sold to J. W. Bates, Boompa, in 1915.

Ladybird, bought at Ripley, Ipswich, December, 1910, by Mr. Hull. She was vaccinated from Clover in 1912 and has never carried ticks since then. Sold to Butcher and Rex who had her for about 6 months. Mr. Butcher (July, 1918) wrote : "We *never* saw a developed tick on her," and although she was running with tick-infested stock they (*i.e.*, Messrs. Butcher & Rex) neither dipped her nor any other stock purchased from Mr. Hull. Ladybird also was sold to J. W. Bates, Boompa, in 1915, who wrote (January 28th. 1918) to the effect that of the two resistant cows one had been dipped three times in three years, and the other not at all since she never carried ticks. He did not mention the names of the animals but it seems likely that he was referring to Bluebell and Ladybird respectively. He is reported to have bought a third in 1915 but made no mention of it.

Poppy, born 1912 ; dam, Peony.

Poppy was clean from the time she was a calf. She was sold to Butcher and Rex, Maryborough. Mr. Butcher reported (July, 1918), that she had never developed ticks while in their possession. In 1915, Poppy was sold to Mr.

W. A. Bates, of Lakeside. When giving evidence before the Select Committee (R.S.C., 1915), on December 14th, 1915, Mr. Bates stated that he had had the cow under observation for several months and that only two or three mature ticks had been noticed on her. She had never been washed while his other stock had of necessity been treated several times. He had not noticed any exudate. In reply to a communication on this subject Mr. Bates wrote (January 28th, 1918) *re* Poppy " . . . In the two and a half years I have had her, she has never been dipped or washed and has been running with tick-infested cattle all the time. She carries a few ticks at times but they do not appear to develop to any size." He also mentioned that a calf from Poppy had not needed dipping up to the time of its death (at about 18 months old).

Pixie, born 1911 ; dam, Bluebell, sire, Peter Pan.

This animal was loaned to Butcher and Rex when a heifer. Mr. Butcher (July, 1918), wrote that he failed to ever find one tick on her during the whole time she was under his care. She calved just before she was returned to Mr. Hull. The calf (which he still had) had never been dipped for, like her mother, she never carried ticks.

Vanity, born 1912 ; dam, Bluebell.

Butcher and Rex also had this animal. Mr. Butcher wrote (July, 1918), " Vanity we still have, she is a cow that always did carry a fair amount of ticks, we never dipped her and she would clean up again in a short while. We had a steer from her but he was very susceptible to ticks and we had to dip him regularly. We also have a young steer from her but I do not know yet what his tick-resisting powers will be."

Communications were received from several persons in the North Coast district who had purchased stock from Mr. Hull, in answer to inquiries as to the condition of these animals as regards tick infestation.

Mr. S. Kelly, Billi Park, Eumundi, wrote (January 28th, 1918) that the one cow he had purchased had been dipped regularly and was regularly infested with ticks.

Mr. W. E. Noble, North Arm, wrote (February 2nd, 1918), that he had bought a Jersey cow from Mr. Hull : She had retained her resistance. Two other cows became tick resistant this season and this Mr. Noble claimed to be due to contact with the Jersey.

Mrs. Bedington, Eumundi, wrote (January 31st, 1918), that she had bought two heifers from Mr. Hull, both of which carried ticks but did not become badly infested. They were dipped regularly.

Mr. R. W. Mealing, Butterfat, North Arm, wrote that of the three heifers purchased, only one had been retained. She was ticky and was dipped regularly. As this animal was ticky when sold and was from ticky stock this fact is not surprising.

For Messrs. B. H. Corser & H. Walker's experience *see* the account given for the cows Clover and Tinkerbell.

Information collected from other sources.

In view of the fact that one or more tick-resistant animals occur in very many herds and the utter impossibility of examining more than a small fraction of the total number, those who were interested in the subject were invited through the Agricultural Journals of Queensland and New South Wales (Johnston and Bancroft, 1918*a*, *b*) as well as through the local press, to send any observations they had made which might help in the investigation. Authentic observations under the following headings as regards tick-resistant animals were especially asked for.

1. Were such animals more usually of any particular breed?
2. The length and texture of the hair.
3. The colour, texture and oiliness of the skin.
4. The general condition and stamina of the beasts.
5. The length of time the animals had been resistant, whether they had possessed the resistance from birth, or had acquired the peculiarity later in life?
6. The transmission of this resistance to their progeny.
7. The nature of the country on which the animals were grazing.
8. Influence (if any) of food.
9. The effect (if any) of dipping such resistant animals.
10. Whether an exudate (which was described and differentiated from a tick sore) had ever been noticed on these cattle.

Information collected at other farms at Eumundi.

On January 24th, 1918, a farm owned by Messrs. Lewis and Finch was visited. This is situated on the opposite side of the road from "Cudgeree." There were about 40 head of milking cows which were dipped as a rule every three weeks, but owing to continued heavy rain they had not been treated for about four weeks, the result being an extremely heavy infestation of the majority. In many the escutcheon and parts of the udder were thickly covered with ticks in all stages; the fully and half-engorged females being of course the most conspicuous. Two cows—a Shorthorn strain and another of Holstein strain—were exceptionally free from ticks while another red Shorthorn was only lightly infested. One of Mr. Hull's resistant cows, Rhinea, had been running in this paddock for 12 months and remained free from ticks. It might be mentioned that about 200 fully-matured female ticks were removed in a few minutes from some half-dozen cows in the bails without making any special search.

On January 25th, we visited Mr. Sneezby's farm. The cattle had been dipped recently but one cow was pointed out which had never been dipped. A few mature females were visible and several small ticks were found on her.

On January 25th, 1918, a visit was made to Mr. Fred Hull's farm "Lonehand." The milking herd consisted of about 60 cows, five of them being the property of Mr. Munro Hull (referred to elsewhere). Approximately 20 others shewed tick resistance in a greater or less degree; these resistant animals have, however, usually been dipped with the remainder of the herd. Mr. F. Hull informed us that he had found it necessary to dip regularly during 1916; in the following year ticks were not so numerous on his paddocks and he had not dipped his stock since May, 1917.

On January 26th a number of dry cows and yearling stock were dipped; of the 30 odd animals so treated about one half were only very lightly infested. A number of clean yearlings were examined, also an exceptionally tick-free cow, Ubi.

On February 5th the milking herd was dipped, with the exception of certain animals. Very few fully-matured female ticks were visible on the dipped stock but close examination revealed great numbers of small ticks. The following are some of the cows carefully examined on these occasions :—

Melba. This cow was one inoculated as a calf from a resistant animal. Another calf was treated at the same time and became resistant ; the latter died last year. Melba was tick-free when examined on January 25th, 1918, while patches of exudate were visible. On February 5th a few larvæ were seen and exudate was again present.

Magpie, a calf of the first resistant cow owned by Mr. F. Hull. She had never been dipped and was practically free from ticks when examined on January 25th, 1918.

Wendy, Shorthorn-Jersey grade ; this cow was fairly free from ticks when examined on January 25th, 1918 ; tiny scabs could be felt by passing the hand over the body. When examined on February 5th a few small ticks were visible while a certain lumpiness was evident on the escutcheon.

Daphne, a tick-free animal, was shewing dry scabs on the escutcheon. This cow was dipped regularly in order to ascertain if her resistant powers would be thereby lessened. She was still tick-free in June, 1918.

Bluebell II, dam, Bluebell I, was also examined on January 25th, 1918. This cow was ticky but the infestation consisted mainly of small ticks and unengorged females.

On February 3rd a visit was paid to Mr. Paton's dairy farm, where over 40 cows were milking. He keeps his stock free from ticks by rotation of paddocks and regular spraying. Mr. Paton shewed two cows which never carried ticks. Both were short-haired and of Ayrshire-Shorthorn cross. One occasionally exhibits the exudate. Both are regularly sprayed.

On the same day we also visited Mr. Duke's dairy farm, where there are 37 milking cows which are dipped regularly every three weeks. One roan cow was pointed out as being especially free from ticks. The remainder of the herd was lightly infested.

On February 7th an examination of Mrs. Lewis' milkers at Bartlett's dairy was carried out. There were over 50 milking cows of all breeds and grades—Shorthorn, Ayrshire, Jersey. They were dipped four weeks ago for the second time this season. Eight cows were noticed as specially free from ticks ; in four of these the Jersey strain predominated ; in all the skin was more or less yellow, in three it was markedly so. The majority of these showed the little characteristic scabs and lumps on the escutcheon and neck. Mr. K. Lewis informed us that some years ago they had from 20-30 resistant cows that were never dipped, some of which shewed an exudate similar to that occurring on Mr. Hull's resistant stock. After a while it was found too great a trouble to cut out the resistant animals and all were put through the dip. They now find it *necessary* to dip them. Mr. Lewis considered the dipping destroyed their resistance. He also vaccinated about three cows with some serum ; all " took," becoming clean a few months later and remaining so until dipped.

On February 7th, a visit was paid to Mr. Bevan's farm, where there were seventeen milking cows which had been sprayed recently and did not exhibit many ticks. One cow was shewn which it was stated never carried ticks.

Information obtained from Messrs. Inigo Jones, O. Jenner and other farmers, Crohamhurst, via Beerwah, North Coast Line.

On April 6th, 1918, one of us visited Crohamhurst and examined a number of Mr. Inigo Jones' tick-resistant stock. Mr. Jones has 40 adult cows ; of that number 18 may be considered resistant. During the last 12 months at least nine resistant animals were sold. Jersey and Shorthorn are the outstanding breeds. The resistant animals exhibited typical exudate as well as tick sores on many of them. Mr. Jones practises vaccination, his method being to scrape the escutcheon of a ticky animal with a clean knife until drops of blood appear, then to take a scraping from the escutcheon of a resistant animal, both pus from tick sores and serous exudate being included indiscriminately, and rub this mixture into the abrasion made on the ticky animal. In a large proportion of cases this method, according to Mr.

Jones, has proved successful, the animal becoming progressively cleaner, while some cows, however, remained unaffected by the vaccination. (*See* Vallonia line in genealogical tables).

A ticky Jersey bull was vaccinated on March 23rd, 1916, from a glycerinated "culture" (*i.e.*, scraping). Six weeks afterwards the first pustule appeared and the animal gradually became resistant. He was carrying a few odd mature ticks when examined by us.

We are indebted to Mr. Jones' kindness for the pedigrees quoted later on.

While in the Crohamhurst district we were enabled by the courtesy of Mr. Jones to inspect several other farms. On April 7th, a visit was paid to Mr. Owen Jenner's farm, a small but rich one, being composed entirely of scrub land carrying paspalum and clover. The cows were in very good condition. The milking herd consisted of about 40 head, the predominating breed being Shorthorn with an admixture of Jersey. Of the forty, fifteen were quite clean; another fifteen carried very light infestation, while the remainder of the herd were heifers which, though carrying more ticks, could not be said to be badly infested. The bull had a fair sprinkling of mature ticks, chiefly on the neck and shoulders. He was very ticky last year. Mr. Jenner considered the resistance became stronger as the beast grew older. He had never practised vaccination, and could only speak in a general way about hereditary transmission of the peculiarity, never having kept any records. He was of the opinion that it may be transmitted but that there was no regularity. He always had a few clean cows, but never took much notice of them until some three or four years ago a number in some way became resistant; this condition has apparently been spreading for now there are very few animals that require washing. The young stock were also remarkably free from ticks.

After leaving Mr. Jenner a visit was paid to the adjoining farm, the property of Moore Bros. The milking herd consisted mainly of Jerseys. There were four cows which never needed washing, but with the exception of two or three animals none of the herd became really badly infested.

The cows were washed only once last year and once this year. A black Jersey bull which never carries ticks was seen, one little vesicle being visible on this animal.

The inference seems to be that ticks were not plentiful that season in this particular valley at any rate. In regard to other valleys we were told that ticks were abundant.

On April 8th, a visit was paid to the farm of Mr. Collins, who had a herd of 27 milkers, four being Jerseys and the remainder Shorthorn. The majority of the animals examined were fairly free from ticks. Mr. Collins had only washed his cows once that season. These animals were allowed out on the roads and so had good opportunities to pick up ticks. Mr. Collins told us of three resistant cows he had purchased from an adjoining farm. An outbreak of redwater occurred among his stock three months later and these three animals were the first to die.

On the same date we visited Mr. Jackson's farm. His milking herd consisted mainly of Shorthorns and Jerseys. They were tick-infested. They had been dipped about a week previous to our visit. Both bulls were ticky. One red shorthorn cow reared in N.S.W., brought into Queensland five years ago, has not carried mature ticks and has never been dipped during the last three years while in Mr. Jackson's possession. She was shewing exudate when examined. Two Jersey-grade cows bought from Mr. Jones were retaining their resistance. They were dipped regularly with the rest. Two cows—a red Shorthorn and a black and white cow were vaccinated with the fresh exudate on the N.S.W. cow, but the result is not yet known to us.

On April 9th, several farms in the Ewan Valley were visited. In W. Gregor's bullock team two little Jerseys were pointed out as being resistant to ticks, one especially so.

At Mr. Walker's farm we were shewn a sleek, glossy black Jersey cow which did not mature ticks. She had been dipped three weeks before. No exudate was present, but Mr. Walker told us he had noticed it occasionally. He also had eight bullocks which were free from ticks and had not been dipped since May, 1917. No vesicles had been noticed on them. The rest of the stock had been dipped a few days previously.

Evidence received from various sources.

In a letter dated April 11th, 1918, Mr. W. H. Davidson, of "Wilmont," Tambourine Mt., wrote that he had had experience similar to Mr. Hull in possessing practically tick-free animals shewing vesicles on the escutcheon. These cows were "close-coated, short-haired, silky-skinned, red brindle animals in good condition, gentle tempered and when at their best giving up to 14 quarts of rich milk per day. They would belong to the class a dairyman would call "good doers," of Shorthorn-Jersey-Ayrshire cross."

Mr. Oxenford, of Oxenford, South Coast Line, called on May 16th and gave the following information regarding his experience with tick-resistant stock.

A cow of his escaped into the hills and when recovered some time later, both she and her calf, which had been born in the meantime, were found to be tick resistant.

His next experience was with a mob (16 head) of young stock, all of which were resistant, purchased some years ago from Mr. W. Lane, Wonga Wallen, *via* Upper Coomera. These animals were sleek-coated grade Jerseys. They stood the tick season and were never dipped. The majority were disposed of, but three were retained, all of which carried a few ticks but never became worried. They were dipped with the others. Nothing was known about their calves and an exudate had never been noticed.

Mr. Oxenford also informed us that Mr. Lane's method of raising resistant stock was to allow them to become tick worried for their first year. The latter considered that if cattle were once dipped their resistance was destroyed. He did not practise vaccination.

During an interview, May 9th, 1918, Mr. R. Cross, Graceville, stated that some five or six years ago he had reported the presence of tick resistant stock to the Agricultural Department, whereupon Mr. Cory visited his farm. A number had remained free from ticks for three years previous to Mr. Cory's inspection and had not been washed or dipped during that time nor were they so treated up till the time Mr. Cross sold his herd two years later. Others were very ticky in spite of washing. The first two resistant animals were Roany and Roany's daughter. Mr. Cross did not know how the peculiarity began; but from these two by vaccination into scratches and horn injuries on the ticky animals he increased the number of resistant animals to eight in 12 months. He had noticed that when cows became low in condition the resistance was greatly decreased. His resistant stock were all of mixed breed and various colours, some sleek-coated and some long-haired.

A resistant cow was sold by Mr. Cross to Mrs. Sonders, Sherwood. This animal was examined on May 16th, 1918, and was found to be a black Jersey of shiny sleek appearauce. Mrs. Sonders had noticed a few full-blown ticks on the escutcheon a few days previously and rubbed that part over with grease and arsenic. The cow was then quite clean and shewed no trace of exudate. She had calved a week previously, which may have accounted for her temporarily lowered resistance.

In response to our request for information asked for per medium of the daily and country press of Queensland, a letter appeared in the "Queensland Grazier" 31st May, 1918, signed by W. G. Gray of Junggury, Ravenshoe (about 20 miles from Herberton and at an elevation of about 3,000 feet) in which the writer stated that he had in his possession three tick-resistant animals— a cow and her two calves. This cow is a Holstein-Shorthorn crossbred, purchased when 10 months old and from that time has carried very few ticks. A steer by a ticky shorthorn sire and a heifer by a Jersey sire had remained tick-free from birth and had never been dipped though running with ticky stock. Exudate had not been noticed.

A letter dated May 14th, 1918, was received from Mr. C. A. Ware, of Springdale, Bracewell, Mt. Larcom. Mr. Ware stated that he had a Jersey cow and progeny that had not required treatment for ticks for the last three years although running with several hundred head of ordinary ticky stock. The writer mentioned that his brother also had a Jersey cow and progeny that were tick resistant. Both the original cows were purchased from the same herd in the Isis district. Of four calves from the resistant cow two by Jersey bulls were just as clean as the mother while two by Hereford bulls carried ticks, but not to the same degree as the other cattle.

Mr. A. K. Henderson in an interview (November, 1915), stated that when farming on the Blackall Range several years previously he had had some experience with tick resistant stock. He had vaccinated nine cows with "a gummy substance" found exuding from one tick-free animal. Mr. Henderson had destroyed his records on selling the farm and could only give the results from memory. In about a week the first effect was noted, spreading slowly from the point of vaccination and taking some weeks to reach the shoulder. Of the nine treated, six "took" and from being tick-carriers they all had very few ticks. These cows were sometimes dipped with the rest. One cow, which Mr. Henderson retained on selling the farm and afterwards disposed of, became ticky some three years after treatment. From the slowness with which the effects of vaccination spread Mr. Henderson had formed the opinion it was not distributed through the blood but through the lymph. (See also R.S.C., 1915).

Mr. T. S. Rowbotham, of Springbrook plateau (on the N.S.W. border), who has a herd of about 90 smooth-skinned animals, chiefly Jerseys, informed us that he had found only three mature ticks during the 1917-18 tick season though he had milked 43 cows twice daily, the remainder being regularly yarded and examined for ticks but without further finds. No sign of tick irritation was observed. The greatest number of mature ticks collected by him during any one season since 1914 was six.

At the other end of the narrow horse shoe-like plateau redwater made its appearance each year. In May, 1914, he introduced 21 tick infested cattle into his property, 16 being dipped while the remaining five were left untreated in the hope that they might be the means of disseminating ticks and keep up an "immunity" from fever. The result was not successful as far as tick infestation was concerned.

On another occasion, May, 1917, he moved some of his herd to a neighbouring paddock where ticks soon appeared on the cattle, a number contracting tick fever and some dying in spite of several weekly washings in order to control the infestation. No subsequent treatment had been resorted to and the animals remained clean except for the presence of young ticks which however did not mature. He reported that when ticks were present, then "tick scabs" like those found on Mr. Hull's cattle, were to be seen. He believed that his animals would become infested if placed in ticky country.

We think that the climate has a great deal to do with the control of tick infestation on the plateau, which is between 3,000 and 3,500 feet high and experiences cold winters and exceptionally mild summer weather, Mr. Rowbotham stated that the average summer heat, as recorded by him for several years, was between 50 and 60 degrees Fahr. at mid-day, and between 40 and 50 degrees at 9 a.m., while frosts were very common in winter.

Paspalum and clover were the chief fodder plants in the tick free paddocks as well as in the paddock in which the animals became infested, whilst rye was present only in the clean paddocks.

Through the courtesy of Mr. A. H. Cory, Chief Inspector of Stock, we have received a copy of a report, dated May 7th, 1918, from Mr. Jas. H. McCarthy, Stock Inspector, Beaudesert, *re* B. Birley, Tambourine, claiming to have tick resisting cattle on his farm. The report is as follows :—

"I have the honour to advise you that, when at Tambourine recently, B. Birley informed me that he had on his property a number of tick-resistant cattle. He particularly claims that there are three cows and a considerable number of young stock owned by him, and upon which ticks will not mature. Certainly I saw on one cow a number of immature ticks dead, and from what cause I do not know. I found also a number of full-grown ticks on one cow that Birley claimed was tick-resistant. This he said might occur to a limited extent, that is to say, that an animal may carry a small number of ticks and gradually the resistance increases until total immunity is reached. This immunity is yearly increasing in his herd, he claims.

"As Mr. Birley's claim is on the lines of the Munro Hull case, I promised that I would bring it under your notice for further investigation if thought desirable. Mr. Birley challenges either myself or the Department to take two or three of his cattle, which he will place at disposal free of cost, and run them on grossly infested country, to prove his contention. As these cattle are seventeen miles from my headquarters, and day by day observation would be required, I can do nothing in the matter. If on the other hand you desire costless action arrangements can be made for removal of the three cattle to a centre for daily examination. Mr. Birley's claim is identical with the claims of Mr. Munro Hull."

Mr. Stanton, of Tingalpa, reported that three mixed Shorthorn Jersey cows belonging to his herd were tick-free whereas the remainder became infested. The former were smooth, clean-skinned animals. No sign or exudation was noticed.

Mr. James Woodward, of Terror's Creek, *via* Petrie, in a letter dated October 28th, 1918, related his experience of a tick resistant cow. This animal became crippled during the drought in 1915, and although heavily infested could not be treated for ticks except by hand-picking. Though previously a very ticky beast this cow is now strongly resistant to tick infestation. This animal is a grade Jersey with short fine hair ; she has been in good condition since the drought and running on fairly dry forest and scrub country. Mr. Woodward considers that many animals could be rendered so resistant if not dipped for from twleve to eighteen months but that such a method is impracticable owing to the excessive tick worry to which the animals would be subjected.

On 27th May, 1918, a visit was made to Barrett's dairy, Rawlin's Street, Kangaroo Point, Brisbane, where we examined a red roan cow which, it was stated, never carried ticks. This cow was the only survivor of a number of calves turned out at Lytton about 13 years ago, the remainder dying of redwater. Exudate had never been noticed by any members of the family that were interviewed, though we were informed that an elder brother had seen vesicles on this animal.

Effect of Breed on Resistance.

It has been a well known fact in America for many years, that Brahmin or crossbred Brahmin cattle shew very high tick-resisting properties. It was thought that these cattle were immune to tick fever but this was later proved to be incorrect, shewing that larval ticks must infest the animals and actually attach themselves. Importation of Asiatic cattle into the United States was stopped in 1884 and the consequent breeding of the tick-free Brahmin strains with the susceptile European cattle led to a deterioration in the tick-resisting powers of the progeny. In 1906, Mr. A. P. Borden, Manager of the Pierce Ranch, Southern Texas, after complying with quarantine regulations was allowed to introduce 33 head of pure bred Brahmin cattle. He has since bred up a large herd of Brahmin and grade Brahmin cattle. These animals were carefully examined by the members of the Royal Commission and no ticks could be found on them while the Shorthorn and Hereford cattle were found to carry ticks freely. (Cowley, Pound and Chauvel, 1913, p. 10). "Brahmin crosses are remarkable resistant to tick infestation" (p. 14).

In some extracts from Mr. Froggatt's reports (Report of Under Secretary for Agriculture, 1907-1908, p. 26) reference is made to the crossbred Brahmin cattle at Pierce Ranch. These crossbreds have fine short hair and the suggestion is that the close short hair causes the larval ticks, when they moult, to drop off as they have nothing to cling to.

In Jamaica similar facts have been observed. "The almost total immunity of the Mysore cattle from the attacks of ticks of all kinds was most marked; this was especially the case at Shettlewood and other places, where this breed of cattle was used for draft purposes. Crosses between the Mysore and other breeds were also less subject to the attacks of these pests; while Shorthorns, Devons, Herefords and Creoles suffered most. Indeed ticks shew a decided preference for all cattle which have little or no Indian or Spanish strain in their blood; they have apparently a great dislike to animals with short, fine hair; hence probably the immunity of the Indian and Spanish races.*

Tryon (R.S.C., 1915, p. 46) pointed out that although the cattle tick occurs in India and Java, ticks are rare on the cattle and the gross infestation so common in Australia is never met with. Freedom or comparative freedom from

*R. Newstead. Report 21st Exped. of Liverpool School Trop. Med. Jamaica—Medical and Economic Entomology. Ann. Trop. Med. Parasit., 3, 1909, p. 423.

ticks is also enjoyed by crossbreds with these native cattle. Mr. Tryon also quoted Dr. Nelson Mayo who stated : "An animal that has blood of the races of the East Indies named China or Brahmin holds less ticks than does an ordinary animal. This may be due to the excessive acid secretion of its skin, or to its short fine hair. The beast with short and fine hair is less affected by ticks than the densely clothed animal." Furthermore—"We have animals that are immune to ticks naturally. In a fully infested field it is frequently observed that some animals are not infested, or that other animals are very lightly infested." (R.S.C., 1915, pp. 46 and 47). Mr. Tryon suggests that what characterises the Indian cattle may occur in a few of the Queensland animals also, in which a little of their blood may persist.

In Algeria, experience shewed that the buffalo and the zebu (Brahmin strain) were also naturally resistant to disease. It was found impossible to breed the buffalo with domestic cattle but the zebu hybirds shared the perfect immunity to fever enjoyed by the Brahmin cattle. Similar conditions were experienced in Jamaica. (Q.A.J., vol. xiii., 1903, pp. 248, 249). This is directly opposed to the state of affairs existing in America where the Brahmin is susceptible to fever.

Gilruth (1912, p. 17) bears out the statements that buffaloes are free from ticks. He had occasion both on the mainland of the Northern Territory and on Melville Island, to examine freshly killed buffaloes and also fresh hides—the descendants of the Timor buffaloes, introduced in 1824-1828, and also the descendants of some Indian animals introduced in 1886. All were absolutely free from ticks, although grazing on country with badly-infested cattle. The same author found quite different conditions to prevail with the Brahmin cattle, since on the Adelaide River he examined several crossbred Brahmins which he stated "were well covered with ticks." This author has come to the conclusion that the cattle tick and the tick fever organism were most probably introduced with the Batavian cattle brought into the Northern Territory in 1872.

While tick-resistance in cattle in Queensland is confined to no one breed it may be fairly said that such resistance is more common among Jersey and Jersey grade cattle than any other race. The fine short hair and the rather oily skin, which give many Jerseys their sleek, glossy appearance, are probably factors which help to determine tick resistance. Individual animals, however, of Shorthorn, Ayrshire, Hereford or Holstein strain and crossbreds of these races have been found as strongly resistant as any Jersey.

Effect of food on Resistance.

The reputed beneficial effect of feeding sulphur to stock has frequently been mentioned in literature. Tryon (R.S.C., 1915, p. 49) stated that this sulphur administration is alluded to in the Agricultural Journal of the Cape of Good Hope* as having been formerly favoured there. It is recommended by C. A. Barber in his article on the Tick pest in the Tropics,† and is also mentioned as being an Argentine remedy ‡

In their report on Tick Fever (1896, pp. 11, 13, 32) Dr. J. S. Hunt and Mr. W. Collins reported on the experiments of Dr. Nörgaard on the internal administration of sulphur. The latter had noticed that cattle drinking from sulphurous wells were always free from ticks and that tick-infested cattle brought to such wells would after a few days lose all their ticks and remain tick-free, so long as they continued to drink such water. Efforts were being made to prepare sulphurous water artificially by boiling lime and sulphur. Dr. Nörgaard was sanguine of success, though the results of his experiments had been negative up till that time The members of the Commission stated they had seen tick-infested cattle which had access to sulphur-impregnated water. Ranch owners in Texas claimed however, that by feeding sulphur and salt they could to a certain extent relieve their cattle from infestation. These facts are also quoted by Tryon (R.S.C., 1915, p. 49). Hunt and Collins considered that this treatment seemed worthy of further trial as it had been favourably reported on from the Argentine Republic, although experiments witnessed in America had failed.

*Vol. viii., No. 16, p. 421.

†Nature, 1895.

‡"Pastoralists' Review." 1896, p 344.

Ransom* found that there was no difference in regard to tick infestation when animals were experimentally supplied with sulphur in addition to ordinary food. This was supported by Klein (1907, p. 16).

Circumstantial evidence can be quoted to the effect that lucerne confers tick-resisting powers on animals. Lignières (1901) mentioned the fact that tick infested animals from Northern Argentine when placed in the richer pastures of the South became tick-free and did not set up fresh centres of tick fever. This he attributed to the action of lucerne and also mentioned that the substitution of lucerne for natural grasses leads to the establishment of tick-free areas. Tryon (R.S.C., 1915, pp. 47-48) also quoted Lignières to this effect.

In an editorial article (Q.A.J., vol. x., 1902, p. 96) there is the record of a cow at Samsonvale which became clean on being turned into a lucerne paddock and was never thereafter troubled with ticks. In the same journal (Vol. xix, 1907, p. 142) green lucerne feeding is reported to have considerably reduced ticks on some holdings in the Blackall Range. Walker (R.S.C., 1915, p. 51) stated that lucerne feeding had been tried extensively by individual farmers and that it failed in every case.

Tryon (R.S.C., 1915 , appendix, p. 71) pointed out that experiments carried out at several agricultural stations in U.S.A. have conclusively shewn that there is a peculiar association between lucerne and sulphur. Chemical analyses have proved that lucerne contains a high percentage of sulphur. "Accordingly" Tryon concludes, "if sulphur when in the animal's system confers an immunity from tick-infestation, we should expect the same result to follow the ingestion of lucerne or any other similar sulphur-containing herbage."

Various other plants are reputed to have the power to confer tick resisting properties on stock. Tryon (R.S.C., 1915, p. 48) mentioned the statement in a West Indian Agricultural paper that "when cattle were allowed to graze on pasturage in which certain grass predominated they

*Ransom, in "The eradication of the Cattle Tick." U.S.D.A., B.A.I., Bull. 97 ,1907, p. 72.

ceased to be continually tick infested. This grass was one of the Andropogon family, the members of which are, in some cases, noted for containing essential oils." Further on the same page he stated that he had a paper by Dr. Nelson S. Mayo, Cuba, 1906, in which the latter mentioned certain plants that contain specifics which are fatal to ticks.

A. K. Henderson (R.S.C., 1915, p. 43) stated that for many years his farm on the Blackall Range, 6 miles from Nambour, was free from ticks. This he attributed to the presence of white clover. However, on going to Maleny, several hundred feet higher, he had seen some exceedingly ticky stock although white clover was growing luxuriantly there. After this experience he had not placed much reliance on the clover theory. It is stated (Q.A.J., vol. xix, 1907, p. 142) that it has been found on the Blackall Range that in paddocks properly cleared and laid down with paspalum, ticks do not breed to the same extent that they do in rough uncleared country.

Notice appeared (Q.A.J., vol. iv., 1899, p. 498) of a particularly ticky cow in the Cairns district being rendered tick resistant by feeding with saltpetre and salt. P. R. Gordon (same issue) stated that the matter had been investigated by Sir Horace Tozer and quantities of saltpetre were tried on cattle without the slightest effect.

In several communications and in an interview Mr. L. G. Jones stated his conviction that food plays an all-important part in an animal's susceptibility to tick infestation. Whilst animals graze on lucerne or paspalum (*P. dilatatum*) they remain resistant to the tick until they are turned on to a poorer pasture. Mr. Jones pointed out the impracticability of substituting artificial grasses or lucerne for natural grasses on a large scale. He furnished us with a copy of analyses of paspalum and ordinary pasture shewing the higher percentage of inorganic matter contained in the former. The percentage of sulphates and chlorine and soda was approximately twice as great, while that of ferric oxide and potash was from 3-4 times as great in paspalum as in ordinary grass. Mr. Jones gave us the result of some observations and experiments performed on sheep in N.S.W. which point to the efficacy of certain iron ore and salt mixtures in helping sheep to withstand the inroads of worms and fluke (Q.A.J., 1918, p. 48) and is of the opinion that similar treatment would be beneficial to ticky cattle. Stewart (1906, p. 1156) mentioned that cattle suffered more severely from tick worry when fodder was dry and scarce, such as during periods of drought; and that a liberal allowance of green succulent fodder invariably aided them in their fight against the tick.

In consideration of the possibility that the tick-resistance enjoyed by Mr. Hull's cattle, had been developed and maintained by them eating some plant peculiar to his property, a collection of all the more evident plants was made both from Mr. Hull's paddocks and from those opposite, where the cattle were ticky. The specimens were kindly identified for us by the Government Botanist, Mr. C. T. White. None of those submitted were rare, the majority being the common scrub and forest plants found all along the North coast. The fact that Mr. Hull has frequently had his resistant animals running in neighbouring paddocks with tick-infested stock, without any reduction in their resistance, also negatives this suggestion. The creek water was not found to be unduly charged with mineral salts.*

Effect of Locality.

Tick resistant animals occur in very many districts in Queensland. We have records of animals exhibiting such resistance from the following places :—Springbrook Plateau ; South Coast district—Tambourine Mt. ; Brisbane district—Graceville and Kangaroo Point ; North Coast disrict—Terror's Creek (*via* Petrie), Crohamhurst, Mooloolah and Eumundi ; Mt. Larcom and Ravenshoe (Atherton tableland). In almost every case the animals were running on scrub country.

Ticks develop most freely in a moist warm climate. Cold retards their development, while an intense dry heat destroys the eggs, thus the tick has never established itself

*A remarkable "remedy" for tick fever and also alleged to be efficacious in ridding beasts of the ticks themselves in the Transvaal is cited by the Editor of the Queensland Agricultural Journal (Q.A.J., vol. xxii., 1909, p. 104). The treatment consists of making an incision in the dewlap and inserting a piece of garlic bulb. Garlic is said to be an old remedy used by the Dutch for their horses when these became badly tick-infested.

in the hot dry interior. (See Stewart and others, 1915, pl. I. for tick infested areas of Queensland and N.S. Wales).

Altitude—along the coastal belt—has little effect upon the activities of the parasite. On the Atherton tableland 2,500-3,000 feet above sea level, cattle become tick-infested as they do on the Blackall Range, *e.g.*, at Maleny and Crohamhurst. Ticks appear periodically (apparently as reinfestations) on the Springbrook Plateau, but the winters are too severe to permit the pest establishing itself.

Effect of Arsenic on Resistance.

As already mentioned, Mr. Hull claims that if a resistant animal be treated with arsenic, either by spraying, dipping or washing, the resistant condition becomes at least temporarily suppressed and that such animals then carry ticks (R.S.C., p. 3, 8, 57).

He informed us (7/6/1915) that he had applied arsenical solution to a part of the hide of a resistant cow and the part so treated matured abundant ticks while the rest of the skin remained free from them. On another occasion he wrote (20/12/1915) stating that some milking cows were sprayed a few weeks previously and subsequently became tick infested so that spraying was again necessary. At the time drought conditions prevailed locally, food was scarce, and those cows which were being milked were in a very poor condition, whilst the dry stock, whose condition was much better (since they were not subjected to the task of producing milk), maintained condition and were tick-free. We think that it was the poverty of condition and not the application of dip fluid which brought about a lowering of resistance and permitted tick infestation to occur.

He believed that there exists just below the skin of resistant cattle some substance which is detrimental (or may we say distasteful) to the tick, but that such substance becomes destroyed by the action of the arsenic absorbed by the skin.

There is some difference of opinion as to whether arsenic from dip fluids does actually become absorbed. Graybill*

*Graybill, H. The action of arsenical dips in protecting cattle from infestation with ticks. U.S.D.A., B.A.I., Bull. 167, 1913, p. 19.

thought it possible that certain of the ticks used by him in some of his experiments were affected by arsenic absorbed by the skin. Brunnich and Smith* believe that the poison enters the tick partly through its own skin and partly through the host tissues, *i.e.*, that absorption of arsenic by the skin of cattle actually occurs. Watkins-Pitchford† has shown that the poisonous effect of arsenic on ticks though quite local, is not due merely to a deposition of arsenic on the surface of the skin, since if a patch of skin of a habituated animal be closely shaved and carefully washed free of all deposited arsenic, together with the hair and surface epithelium, ticks subsequently applied die just as if such precautions had not been taken. He also found that ticks placed on an animal *after* dipping, died. Cooper and Laws‡ confirmed the latter observation, and have stated that experimental inquiry tends to prove that the poison is imbibed by the tick while feeding on its host.

They endeavoured to answer the question as to whether the tick takes up arsenic from the blood or from the skin of the dipped host, and found that neither the feeding of arsenic to such cattle nor the subcutaneous injection of the poison into the blood stream caused the death of ticks. Consequently ticks did not take up a lethal dose from the host's blood** though the blood may contain enough arsenic to exert a toxic action on hæmoprotozoa††. "The epidermal cells possess a special affinity for arsenic and once this arsenophile proclivity is satisfied, the excess of arsenic is available for absorption by the blood. It is obvious that the *total* amount of arsenic in the general blood system cannot be very great since the general health of the animal is not interfered with in any way. But a consideration of the amount of arsenic applied every week (*i.e.*, in regular dipping) . . . . and especially the appearance

*Brunnich and Smith. Factors influencing efficacy and deterioration of cattle-dipping fluids. Q'land Agric. Jour., 1914, pp. 81-92.

†An illustrated pamphlet on tick destruction, etc. (p. 50), 1911, Maritzburg, quoted by Cooper and Laws. Some observations on the theory and practice of dipping. Parasitology, 8, 1915, pp. 190-217 (p. 196).

‡Cooper and Laws, *l.c.*, p. 196-7.

**Cooper and Laws, *l.c.*, p. 199

††Cooper and Laws, *l.c.*, p. 202, 203.

exhibited by the inner surface of the skin of an animal which has been dipped in a solution only slighly too strong, would lead us to suppose that the amount of arsenic present in the blood circulating in the *most peripheral vessels of the skin* would be very considerable. . . . . It is quite conceivable that . . . this peripheral blood containing a large quantity of arsenic would be immediately diluted by the general mass of blood from the internal parts of the animal so that the total amount in general circulation would not be excessive."

In experiments where arsenic was injected subcutaneously, only those ticks in the immediate vicinity of the puncture were killed, those a few inches away being unaffected (Cooper and Laws, p. 208-9). These authors, along with Watkins-Pitchford, believe that "arsenic is cumulative in its action and that the quantity absorbed by the tissues of the skin is augmented by each subsequent dipping until a certain maximum is reached," the excess being absorbed into the blood stream and eliminated into the urine by the kidneys (p. 200). Analyses of the skin of animals dipped at short intervals has proved that arsenic does accumulate as a result of repeated application, penetration of the poison taking place as a result of osmosis (p. 201).

If Mr. Hull's observation, that dipping suppresses resistance, be correct then one might explain it by assuming that the arsenic absorbed as a result of one or of a few dippings, is sufficient to alter the anti-tick quality of the blood or lymph and thus convert the resistant cow into an ordinary cow so far as tick infestation is concerned. Since the protective effect of arsenic lasts only for a few days after dipping,* one would have to assume that the influence of the arsenic as a tick destroyer does not persist as long as its influence in suppressing the hypothetical anti-tick quality in peripheral blood.

We are not satisfied that arsenical dipping by itself will suppress tick resistance since loss of condition would probably afford a sufficient explanation in the cases mentioned by Mr. Hull.

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*Graybill. U.S.D.A., B.A.I., Bull. 167, 1913; Watkins-Pitchford in Cooper and Laws, *l.c.*, p. 201.

The majority of cattle owners who have interested themselves in any way in this subject, are of the opinion that dipping makes no difference; but several persons in the South Coast district, however, hold with Mr. Hull, that the effect of dipping is to induce an animal to carry ticks.

Information obtained by us from Mr. Henderson (R.S.C., 1915, p. 41) was to the effect that a cow which had become resistant after vaccination relapsed to a ticky condition three years later. This animal had been dipped but Mr. Henderson was not prepared to say whether loss of resistance was, or was not, due to dipping.

Actual facts observed by us seem to be overwhelmingly in favour of the view that dipping has no appreciable effect on resistance. In February, 1918, Mr. Fred Hull undertook to dip regularly one of his clean cows—Daphne; in June last she was still free from ticks. In almost every herd examined a few (1-8) tick-resistant animals were noticed. These are usually put through the dip with the rest of the cattle, cutting out individual animals giving too much trouble, while in cases where a dip is not used and spraying or washing is resorted to, resistant animals are treated if ticks are noticed on them, without apparent diminution of their tick resisting property.

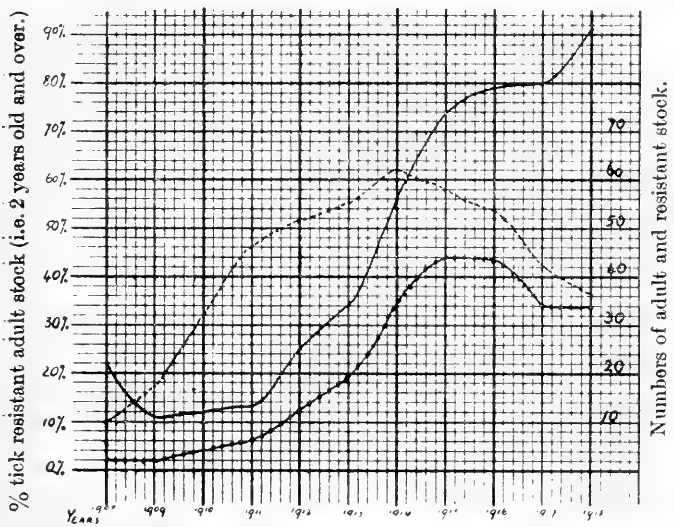
The experience of Messrs. Jones and Jenner, of Croham-hurst district, both of whom have a large number of resistant animals which are occasionally treated with an arsenical solution, supports this view.

Persistence of Resistance.

Tick resistance may be lessened by (1) low condition brought about by drought or prolonged milking and poor feed, (2) by subjection to unnatural conditions, *e.g.*, stalling and rugging. In animals living under favourable conditions, *i.e.*, as regards food and water, resistance may persist from birth, or from whatever time the animal acquired such resistance. Strongly resistant animals may, if able to maintain their condition, withstand tick infestation even during unfavourable circumstances.

On February 11th, 1916, Mr. Hull reported that two days previously he had brought in 28 head of cattle from relief country, where they had been running for three months during the drought. Of these, four were heavily tick-infested and in poor condition ; ten were lightly infested and in fair condition, while the remaining fourteen were in good condition and absolutely free from ticks, eight of these showing exudate.

As examples of persistence of resistance in individual animals in the same locality, the cows Sweetbriar and Primrose may be mentioned. The former has been clean since birth in 1910, and the latter since she acquired resistance in 1914. These are amongst the most strongly resistant



The lightly dotted lines refers to the actual number of adult stock, the heavily dotted line to the actual number of *resistant* adult stock carried each year at Cudgeree, Eumundi.

animals on Mr. Hull's property. Resistance may persist when an animal is removed to another locality, *e.g.*, Poppy, born in 1912, remained tick-free at Eumundi up till 1915, while since that year she has been at Maryborough and Lakeside in both of which districts she has remained strongly resistant.

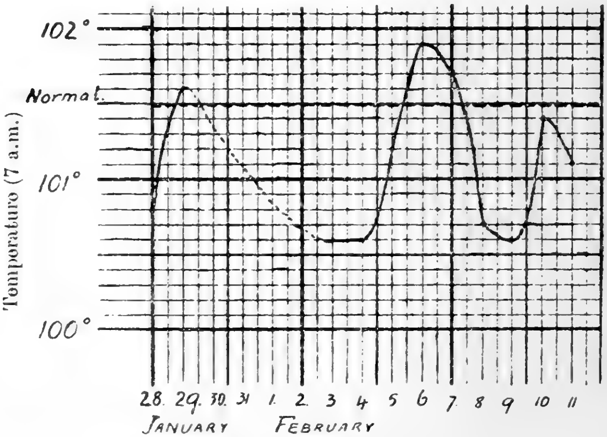
For further instances, one might consult the accounts given earlier regarding individual cows.

The heavy infestation of Clover just prior to death may be accounted for partly by old age and partly by extreme poverty of condition as reported to us by Mr. Butcher.

The rate of spreading of the resistant condition amongst Mr. Hull's herd may be readily noted by consulting the graph (p. 289). The drop in the percentage, 1909-1911, is partly accounted for by the addition of a number of non resistant animals to the herd.

Temperature of Resistant Animals.

As regards the temperature of resistant animals tests made during January and February, 1918, failed to shew any abnormality. Of the temperatures per vaginam recorded from thirteen resistant cows, most were found to fall within the normal range of variation—*i.e.*, between 100.8 and 101.6 degrees, the extremes obtained being 100.4 and 102.3* ; we thus agree with Pound's statement (1914, p. 111), based on his observations regarding Clover and Tinkerbell. The temperature chart for a period of fifteen days (January-February, 1918), for the cow Fairy is appended.† We are of opinion that observations made during winter would give similar results.



Temperature chart of cow Fairy.

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*Dodd (1908, p. 11) mentions that a variation of several degrees in temperature from the normal 101.5 may be met with in healthy young cattle during our summer.

†W. Osborne. Elements of Animal Physiology, 1909, p. 64, gives 101.5—102°F. as the normal temperatures of a cow (per rectum).

"*Winter Ticks.*"

Mr. Hull repeatedly claims that his resistant animals mature more ticks in winter than in summer. We think that this is probably due to the fact that the cows which are under closest observation, are the milkers. During the winter, milking cows frequently fall into somewhat low condition, which, as is well known, brings about a diminution of their tick-resisting properties. Resistant cows when dry, seldom become tick infested.

We might mention that occasionally during both summer and winter, we received specimens of *Rhipicephalus sanguineus* taken from cattle and from a horse (Eumundi), while Mr. Inigo Jones forwarded during last winter a number of ticks (*Hæmaphysalis* sp.) which he had collected from his cows (Crohamhurst).

Is Resistance Transmissible?

Mr. Hull claimed that the peculiarity is transmissible, (1) hereditarily; (2) by vaccination; (3) by contact.

Mr. Pound (1914, p. 110) published a statement prepared by Mr. Hull, giving a list of his resistant cattle (31st March, 1913) under the headings, (*a*) resistant by vaccination, 6; (*b*) by contact, 7; (*c*) by heredity, 6; while the rest of the herd (38) were at the time all more or less infested.

1. *Transmission by Heredity*:—Mr. Hull maintains that the progeny of resistant animals become resistant, though such quality does not usually manifest itself until after the first year of life. The occurrence of some cases of animals showing a strong resistance to tick infestation from birth seems to support the hypothesis.

Mr. Pound has reported adversely, mentioning that Clover's calf and Tinkerbell's calf were just as liable to tick infestation as an ordinary animal (1914, p. 111, 112, ; 1916, p. 90; R.S.C., p. 21; Corser, R.S.C., p. 64; Thorn, R.S.C., p. 28). Clover's calf was two and a half years old and the other six months, in October, 1915. In March, 1915, one of us visited Yeerongpilly and was shown a young calf from Tinkerbell as well as Clover's heifer, both of them markedly infested with fully engorged ticks as well as others in earlier stages. Information was given by Messrs. Pound and Thorn that these ticks were applied as larvæ in February. Infestation in this case was artificial as it was in 1917

(Thorn, R.S.C., p. 28). The only fair way to test resistance is—as has been emphasied by Mr. Cory, Chief Inspector of Stock, Queensland (R.S.C., p. 53, 54)—to place such animals on natural pastures where ticks are known to be present and then note whether the parasites *mature* on those cattle.

On one occasion the strongly resistant cow Peewee, and her young calf (five months old) were running with ticky cattle elsewhere for some months. On their return to Eumundi the former was clean while the calf was tick infested.

So that the relationship of the various resistant animals belonging to Mr. Hull's herd might be more easily seen, we append a genealogical table (pp. 293-5). In the case of Peony it will be noticed that the peculiarity has persisted to the fourth generation.

Tick resistance appears to us to be a quality capable of hereditary transmission but like many other qualities it may or may not be inherited. We know nothing regarding the tick resistant qualities (if any) of the male parents and consequently it is impossible to discuss the tables satisfactorily.

We know that natural immunity to disease is a hereditable quality both in animal and plant life.

It is likely that some strongly resistant animals which are known to occur in many herds are to be regarded as a mutation in so far as this particular character is concerned, and if such be the case then its inheritability is to be expected. Before concluding that a resistant calf from a resistant parent (no matter how such resistance were attained) has inherited such quality, one must remember that it has been proved in the case of resistance to bacterial invasion, that anti-bodies formed in the maternal blood may be transferred through the placental circulation to the blood of the offspring, the latter thereby becoming resistant or immune to such invasion for a period of some months after birth, but subsequently losing such resistant power. Before such loss occurred, it might be possible for the animal to have acquired protection naturally, *i.e.*, to have elaborated its own anti-tick bodies in response to continual stimulation by larval tick attack, so that the immunity becomes an active one.

Pedigree of resistant animals.

Signs used (adapted from Mr. I. Jones' tables).

b. born; d. died; R. resistant; RR, strongly resistant; R?. apparently resistant, but too young for us to be certain; Rwt. redwater case; RT. resistant generally, but occasionally ticky; s. sold; T. ticky; T°. slightly ticky; TT. very ticky; T-R. ticky, but became resistant; T-RV. ticky, but became resistant after vaccination; TT-RR. very ticky, but became strongly resistant; TV. ticky, and remained ticky after vaccination.

MR. MUNRO HULL'S HERD.

JESSAMINE (bought from Geo. Story, Runcorn). b. 1906; T-RV, 1912; s. 1912.

- heifer (?)
- Rhinca RR. b. 1910; S. 1918
  - steer (?)
  - Squib RT. b. 1915
    - Cracker (?) b. 1917.
  - Bally R? b. 1917
- bull destroyed
- bull (destroyed)
- Baby RR. b. 1914
  - Bunting (?) b. 1917
  - steer (?) b. 1918
- steer (?)

PEONY (bought at Toowong). b. 1904; s. 1912.

- Tinkerbell R. b. 1908; s. 1912
  - steer (?)
  - Sprite RR. (sire Don, Jersey) b. 1911
    - Fay R b. 1914; s. 1916
    - Tinkerbell III. R b. 1917
    - Elfin (?) (steer) b. 1918
  - steer (?)
  - heifer (?)
- Scarlet R. b. 1909
- Curley R. (sire, Trampas I.) b. 1910
- Poppy R. b. 1912; s. 1915
  - steer R.

VIXEN TV. (bought at Eumundi, 1910). s. 1914.

- Fairy T-RV. (sire, Dayman's Jersey) b. 1911
  - Fay R. (?) b. 1914; s. 1916
  - Possum T. (sire, Robbie (Jersey) b. 1915; s. 1917
  - Vixen T-R (?) b. 1916
  - Peter Pan T. (steer) b. 1917.
- Roany R. (sire, Trampas I.) b. 1912; s. 1916
- heifer (?)

Clover, RR. (bought at Pinkenba, 1908). s. 1912; d. 1915.

- Bluebell, R.T. (sire, Andy) b. 1908; s. 1915
  - Sweetbriar RR (sire, Don, Jersey) b. 1910
    - Bramble R (?) (bull); b. 1916
    - heifer b. 1917; d. 1918
  - Pixie R. (sire, Peter Pan) b. 1911 s. 1915
    - heifer R. b. 1915
  - Vanity RT. b. 1912; s. 1915
    - steer T.
    - steer (?)
  - Bluebell II. T-R
- bull (destroyed)
- Heatherbell R. (sire, Illawarra bull) b. 1910; s. 1914
  - Wallum T-RR. b. 1913
    - bull (destroyed)
    - Banksia (?) b. 1917
- Pride R. (sire, Illawarra bull) b. 1912
  - steer (?)
  - heifer b. 1917 b. 1918
- heifer T. b. 1913

Spot TT-R. b. 1904; d. 1915.

- Buttercup TT-RR, 1914 Sire, Gordon's Jersey b. 1907; d. 1918.
  - Twinkle R. b. 1911; d. 1915
    - steer R. b. 1915
  - Isis RR. b. 1912
    - Lotus R. b. 1916
      - bull (destroyed)
    - steer (?)
- Peter Pan b. 1908
- Primrose TT-RR, 1914 Sire, Alwyn's Jersey b. 1909
  - Rosie RT b. 1915
  - Violet R (?) b. 1917; d. 1917
  - Primula (?) b. 1918
- 3 bulls (destroyed)
- Brownie T-RV, 1916 b. 1913
  - Spot T-R (?) b. 1915
    - Stormy, heifer b. 1917 s. 1918
    - (destroyed)
- Speck R. b. 1914; s.
- Jockey RR. b. 1915
  - calf, b. 1918.

YELLOW I. TT-RV
(bought at Yandina, 1913)
s. 1914.

Yellow II. T-R
b. 1912; s. .

Yellow III. T-RR.
d. 1917

DONKEY I. R.
(bought at Yandina, 1913)
s. 1914.

Donk y II. T-R
b. 1912

Steer T.
b. 1916

heifer (?)
b. 1918.

STARLING T-R.
(bought at Rosewood, 1911).
d. 1915

Dot R.
b. 1914; d. 1918

steer
b. 1917; s. 1918.

STORMBIRD T-RR.
(bought at Rosewood, 1911).)

Trampas II. R.
(bull)
sire, Trampas I.
b. 1915

Petrel R.
b. 1916.

heifer
b. 1918

steer (?)
b. 1918.

PEEWEE T-RR.
(bought at Rosewood, 1911)

Nigger R.
b. 1916

SEAGULL T.-RR.
(bought at Rosewood, 1911).

Sulky R.
b. 1913; s. 1916

Steer T°
b. 1917

heifer (?)
b. 1918

MR. INIGO JONES' HERD.

Mr. Inigo Jones has kindly provided us with the pedigree of some of his animals a copy of which is here given:—

XENIA TT-RV.

Erminie RT.

Xenia

Prudence T.

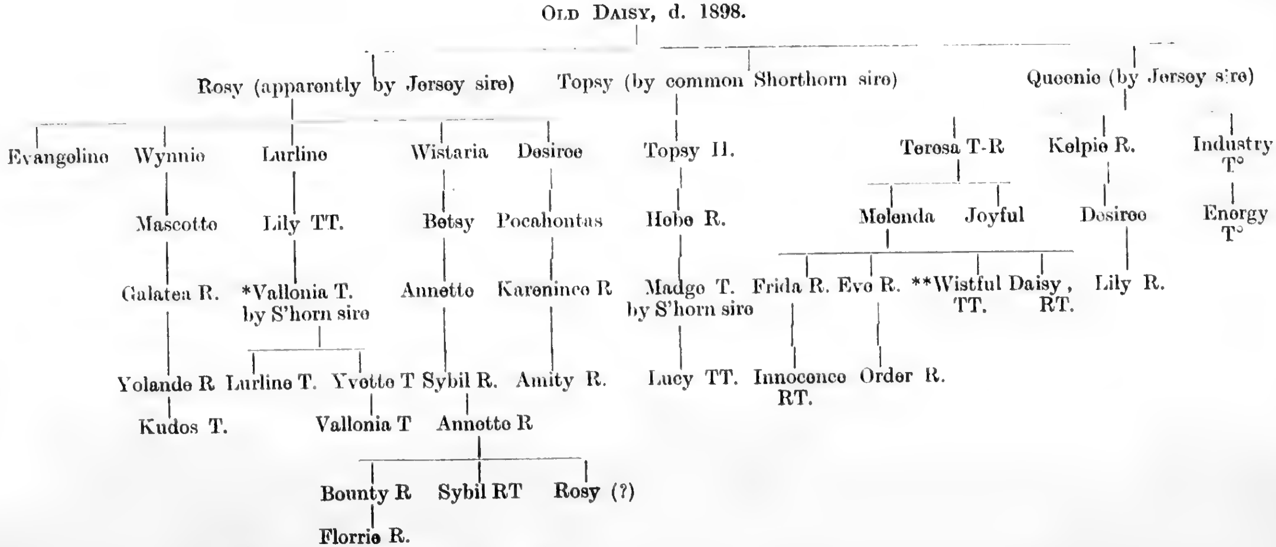
Chloe RT.

Rachel T°

Queenie RT.

Quality T.

Gazelle T°



All are by Jersey bulls unless stated otherwise.

*This line will not take the vaccination, **Wistful died of tick worry.

Rosy II., Rwt.
|
Fedora T.
|
Pocahontas R.
|
Charity T° — Novelty R.
|
Fedora T°

*Daphne TT.
|
Venus T. — Zoe R. — Sprat T.
|
Young Sprat T.

*" This line will not take, but Zoe associated with Novelty, and perhaps became clean in that way." (I. Jones).

"LONEHAND COWS" (Mr. F. Hull).

Ubi, R.	Bright, R.	Beauty, R.	Daphne, R.
Gerty, R.	Magpie, RT.	calf, R. (?)	calf, R. (?)

INFORMATION SUPPLIED BY Mr. C. A. WARE.

Jersey Cow, R.
|
calf, R. — calf, R. — calf, T° — calf, T°

$\underbrace{\text{calf, R.} \quad \text{calf, R.}}_{\text{by Jersey sire}}$ $\quad$ $\underbrace{\text{calf, T°} \quad \text{calf, T°}}_{\text{by Hereford sire}}$

INFORMATION SUPPLIED BY Mr. W. G. GRAY.

Holstein—Shorthorn Cow.
| R

steer, R. (by ticky Shorthorn sire) — heifer, R. (by Jersey sire)

It should be of interest to observe the result of mating resistant cows with a resistant bull. By so doing one should be able to readily decide what part heredity plays. Moreover, if the quality be proved to be inheritable from either parent, no matter whether as a dominant or a recessive, then a ready means of increasing the number of resistant cattle in a herd is available.

2. *Transmission by "vaccination"*:—There is a considerable amount of evidence in favour of the view that resistance can be transmitted by "vaccination," *i.e.*, by taking a little of the exudate from a resistant animal and rubbing it into an abrasion on a ticky subject. Mr. Hull experimented on this line with some success, but since at first he waited for a scratch or horn wound to appear on the ticky animal at the same time as fresh exudate was available, his progress was necessarily slow. Later he performed the scratching with a clean knife. During the last few years he has given up vaccination since he considers the animals become tick free naturally if left alone. The results of vaccination of the following ten animals were :—

Jessamine	vaccinated	1911	clean	1912
Ladybird	vaccinated	1911	clean	1911
Woodbine	vaccinated	date ?	clean	date ?
Fairy	vaccinated	1915	clean	1916
Maudy	vaccinated	1913	clean	1914
Betsy	vaccinated	1913	clean	1915
Prettyface	vaccinated	1914	clean	1915
Brownie	vaccinated	1916	clean	1916
Holly	vaccinated	date ?	remained	ticky
Zephyr	vaccinated	date ?	remained	ticky

Eight out of ten thus became resistant, usually in the following year and in one case in the second year after vaccination. As a contrast of this apparent success one may consider the case of the 10 heifers purchased from Rosewood in 1911 ; these were never dipped nor (with one exception, Beauty) were they vaccinated, yet eight out of nine survivors became tick resistant in periods varying from two to four years ; the four which have been retained are some of the most strongly resistant animals on the place.

Positive evidence of the efficacy of vaccination was given by Mr. Henderson (R.S.C. 1915, p. 41). Of nine animals so treated six became resistant, the peculiarity developing about six weeks later.

Mr. Inigo Jones, Crohamhurst, practises vaccination, his method being described elsewhere. He has found that some animals will not "take" but that the treatment is usually efficacious.

Mr. R. Cross, Graceville, is another adherent to the vaccination theory (*see* statement already given).

Pound reported against such mode of transmission (1914, 1916), as also did Thorn (R.S.C., p. 29). One of us endeavoured to "vaccinate," using "exudate" sent down to Brisbane by Mr. Hull on various occasions. The substance when sent dry was pounded up with glycerine or else "extracted" with glycerine and after carefully cleansing the skin with alcohol, was placed in cuts made on the hind quarters of animals.

In January and March, 1917, owing to the kindness of Mr. D. A. Rooke, we were enabled to test the effect on a number of his cows at Caloundra. Three ticky animals were "inoculated" on the former occasion. One of these, together with four cows and a bull, was inoculated in March. No alteration in the degree of infestation has been observed to date, those which were vaccinated being neither more nor less infested than the rest of the herd.

A small herd of Jersey and Shorthorn crossbreds in Brisbane was also utilised (November, 1915-June, 1917). One was "vaccinated" once. and two twice, but there was no appearance of an exudation up to the time that they were disposed of (June, 1917). Though attempts were made to infest these with larvæ artificially and though some ticks were present in the paddock, they remained practically free, as did also the three control cows. These animals, which are now the property of Mr. Jacobson, Mooloolah, were examined in March last. Five of them which were running with dry stock, were all very lightly infested, while another was perfectly clean though its companions in the milking herd were quite ticky. The last named was one of our control animals, while three of the former group had been "vaccinated." The results of our experiments, then, are negative.

3. *Transmission by contact*:—By this Mr. Hull means that the resistant condition is "picked up" naturally, *i.e.*, that larvæ which hatch from the eggs laid by the few ticks maturing on resistant cattle, convey "something" derived from such animals to those which they infest and thereby set up resistance. We have already stated our inability to find any organism in smears of the exudation. Larvæ from ticks taken from resistant animals were applied in considerable numbers and on several occasions to cattle in Brisbane during 1916. The latter did not show any difference from the controls in regard to tick attack, all being very lightly infested. The application of larvæ to animals which had been "vaccinated" did not meet with success.

Two batches of larval ticks, one lot being the progeny of four engorged females taken from Rosie, the other the offspring of six taken from Sunset, were sent on 3rd April, 1918, to Miss M. Walker, Woolooga, who replied on 18th June, that on two or three occasions, after applying these larvæ to an experimental heifer, there appeared in the vicinity of the anal and genital region of the latter, about two days after application, tiny yellow blisters which, on being squeezed, exuded a drop of clear yellow fluid. In July, another letter was received in which Miss Walker stated that quite similar blisters had appeared on the animal after the application of ordinary larvæ.

A number of heifers were brought from Rosewood to Eumundi and allowed to remain in Mr. Hull's paddocks for a certain length of time to ascertain whether they would acquire resistance. They were not subjected to vaccination and were treated with an arsenical solution only at the time of leaving Eumundi for Rosewood. Their condition while at Eumundi has been noted elsewhere in this report. We are awaiting observations as to the effects noticed during the forthcoming tick season.

Our examination of Mr. Hull's records reveals the fact that of the stock which never acquired resistance while on his property—young animals (*i.e.*, calves and yearlings) excluded—four remained there two years without acquiring it; two, three years; four, four years; nine, five years; one, six years; and one, seven years.

Our experiments in regard to "vaccination" and "contact" have given much the same result as that reported by Messrs. Pound and Thorn. We would like to point out however, that we used only glycerinated material. Perhaps the employment of fresh exudate may have led to more satisfactory results.

In this connection we would like to emphasise our remarks made earlier in this paper (see under section "Tick poison") when dealing with the question of tick poison, the production of anti-tick bodies and the possibility of using an animal with blood rich in such substances, as a "bleeder" for supplying material for inoculation in order to obtain passive immunity.

Mr. Hull forwarded the following account (19th February, 1916), of his experiments in regard to transmission by "vaccination" and "contact."

I. *Blood* from Clover inoculated into three cows and three calves.

Result :—One cow re-acted for piroplasmosis. The three cows remained liable to ordinary tick infestation until disposed of. Calves exhibited no abnormal conditions until disposed of at two years old.

II. *Exudate* from "tick sores" on Clover *vaccinated* into nine young cows obtained from different districts.

Result :—Five re-acted by exhibiting a serous exudate on escutcheon, close to vulva, and developed resistance, requiring no treatment as regards ticks. Close observation revealed presence of abundant dead larvæ and occasional fully-engorged females, the latter increasing in number in the winter months. This condition was maintained until cattle were disposed of several years later.

III. *Inoculation* by exudate from "tick sores" on Clover into five young cows.

Result :—Three re-acted and maintained similar conditions as in Experiment II.

IV. *Contact experiment.* Ten young cows from 12-15 months old obtained from Rosewood—inoculated without loss by A. E. Cook, of Eumundi, against piroplasmosis.

These ten heifers together with a number of the subjects of previous experiments (including Clover) were run on an isolated paddock of about 30 acres, leased for this purpose, whereon no stock had been running for a considerable time and which was practically surrounded by standing sub-tropical scrub and at some distance from any public road. After some nine months these heifers were brought home and closely watched.

Results:—One subject, Rosewood, died during the following winter, cause not known. One subject, Misery (so named from its persistently poor condition) matured innumerable ticks, and is in this condition to-day (Feb., 1916), after dropping her second calf.

The balance re-acted similarly to subjects of previous experiments, showing at variable periods during the summer months the clean serous exudate on escutcheon, with occasional fully-engorged females present, but retaining full immunity as regards necessity for any special treatment against cattle-tick.

Of these subjects seven are alive to-day (Feb., 1916) on this property, viz. Kittiwake, Seagull, Peewee, Cuckoo, Stormbird, Beauty, Misery; the two cows Starling and Mulga succumbed under drought conditions obtaining at the end of 1915. All living subjects have dropped their second calves.

Of the progeny of these there are extant Starling's heifer, Dot; Stormbird's bull, Trampas II., all other having been destroyed or died through stress of drought conditions last year (1915).

V. *Vaccinated by glycerinated virus* from tick sores on Tinkerbell into two calves at "Lonehand," the property of Mr. Fred Hull.

Result:—One subject extant to-day as a fully-matured cow, on third calf, showing similar conditions as regards resistance.

VI. *Contact experiment.* Two calves, Brownie (dam, Spot, a very ticky, aged cow) and Wallum (dam, Heatherbell, out of Clover) were enclosed in company from birth until nine months old without contact with other calves or grown cattle. The object in view was to ascertain if the resistant qualities enjoyed by the daughter of Clover would be conveyed to the progeny of a very susceptible subject.

Result :—Both calves retained resistance while running free with ordinary cattle until the summer of 1915, when, owing to drought conditions, they became poor and emaciated, maturing fully engorged ticks to such an extent that treatment became necessary. Both are still under observation to ascertain whether, with improved conditions, this resistance will become established. The calf of Brownie (Spot) is still living and will be used to determine whether the resistance enjoyed by its parent (and possibly obtained by contact from Wallum) has been transmitted.*

VII. Isolation of nine calves on ten acres of grass land, heavily infested with ticks, six being the progeny of ordinary tick susceptible cattle and three being the progeny of " proven resistant " stock.

Result :—Three of the controls succumbed to extremely heavy infestation. Two had to be destroyed subsequently, having failed to recover. One recovered but showed no resistant qualities when disposed of.

The three resistant stock suffered but light infestation and rapidly developed into clean-coated heifers.

Two of these are identical with the mature cows Donkey and Yellow now registered as resistant, have passed their first period of lactation, both showing serous exudate on escutcheon.

(Signed) MUNRO HULL,
February 19th, 1916.

FERTILITY OF TICKS TAKEN FROM RESISTANT CATTLE.

A number of ticks taken from twenty of Mr. Hull's resistant animals during the past three years (1915-1918) have been watched by us in order to determine whether their fertility has become diminished. Ticks from ordinary controls have also been tested. For a considerable time Mr. Hull was not able to raise larvæ from such ticks, while

*Wallum has fully regained resistance and is to-day quite tick-free while Brownie has been carrying a few ticks all throughout the period. 10th July, 1916. M. Hull.

specimens forwarded by him regularly to Dr. Porter, Cambridge University, laid eggs from which larvæ hatched but lived only for a day (R.S.C., p. 12), investigation failing to reveal the cause of such widespread destruction.

Pound (1914, p. 110) stated that ticks picked up naturally by Clover and Tinkerbell as well as those applied artificially, eventually laid eggs which hatched normally, the progeny being in no way impaired. In his report for 1915-1916 (1916, p. 90) practically the same information is given.

One of us found that there was little difference (if any) in regard to the laying and hatching of eggs of ticks taken from a resistant cow and from a ticky control animal (R.S.C., p. 59). In some cases no hatchings were obtained, but these were due to climatic or other conditions—chiefly drying.

Fertility tests were carried out at Eumundi with ticks obtained from November, 1917, to February, 1918. These ticks, 55 of which were from the following eleven resistant animals, Dot, Donkey, Fairy, Jockey, Kittiwake, Peewee, Rosie, Rainbow, Squib, Sunset and Yellow; and 42 from seven non-resistant animals (mostly calves) were placed in loosely stoppered tubes and kept in a fairly cool, moist place on the easterly side of the house. These observations were concluded in Brisbane in February and March. The results were:—

Ticks from	(*a*) resistant.	(*b*) non-resistant animals
Normal fertility (*i.e.*, ticks of whose eggs 80 % or over hatched)	54 % (approx.)	.. 78 % (approx.)
Partial fertility (*i.e.*, under 80 %—usually about 50 %)	42 % (approx.)	.. 17 % (approx.)
No hatching	3 % (approx.)	.. 4 % (approx.)

Tests carried out by Mr. Hull during 1917 afforded very different figures. He supplied us with full details of these tests. His results were based on observations of 113 ticks removed from 11 resistant animals and 138 ticks removed from 10 ticky animals during the period February-November, 1917.

Ticks from	(*a*) resistant.	(*b*) non-resistant animals.
Normal fertility ..	4 % (approx.)	.. 19 % (approx.)
Partial fertility ..	13 % (approx.)	.. 38 % (approx.)
No hatching	83 % (approx.)	.. 42 % (approx.)

These ticks were kept in match boxes and in a rather hotter and drier part of the house than that used by us.

During the period 1915-1918, Mr. Hull sent down engorged ticks from various cows, both resistant and non-resistant, whose names were indicated by him.

Of course one found many ticks that did not lay, also many which laid few eggs and many which laid a normal number of eggs from which no larvæ hatched, but there were quite enough normal hatchings in the case of eggs of ticks from resistant animals to justify the above remarks. On several occasions we noticed that, though under exactly the same conditions, there was a very marked difference in the activity of larvæ, those whose parents were taken from ordinary cattle being much more lively and living much longer that those from resistant animals. This may perhaps be an individual matter as far as the parent ticks were concerned.

We have, then, had plenty of opportunity to test the fertility of such ticks. We have already emphasised the fact that extremely few ticks mature naturally on such animals. In regard to such engorged ticks, we found that the percentage of those with normal fertility was less than in the case of ticks from control animals. The percentage of those whose eggs did not hatch was practically the same in the two sets. The same statements apply to the " winter ticks " spoken of by Mr. Hull—*i.e.*, cattle ticks taken by him from resistant animals during the winter.

Mr. Hull carried out the following experiment. A solitary engorged tick was found (11/12/16) on a resistant animal (Sunset). There was normal egg-laying and hatching, the larvæ being applied on 10th February, 1917, to another resistant cow at the base of the tail. The infested area was observed twice daily. The larvæ became attached especially in creases of the skin. On 19th February only 80 nymphs could be counted. Next day several males and two nymphs were to be seen. Only one female reached maturity.

We carried out a similar experiment (January and February, 1918) the results of which (detailed under cow Squib) agree with those stated above.

We would like to draw attention to the results obtained by Bishopp and Wood (1913, pp. 176-178), who applied large numbers (700-1,500) of larvæ of *Dermacentor* *albipictus* to cattle, but only a few engorged females were developed from them.

Fairly frequently one may meet with undersized yellowish female ticks in which the malpighian tubes appear to occupy a great deal more than the normal space. Such ticks apparently are nearly always unable to engorge. They occasionally lay a comparatively few pale eggs which in every case failed to hatch, although from eggs from three specimens of such ticks (December, 1915), larvæ were developed but failed to emerge. It may be objected that such ticks have not been fertilised but those which have been dissected have contained abundant spermatozoa. Such ticks have been taken from a number of resistant animals and also from certain cows which are at present classed as non-resistant. At least one of the latter, viz. Vixen, is regarded as "cleaning up" as far as tick infestation is concerned. Mr. Henderson (R.S.C., p. 41) referred to this type of tick as occurring on his "immune" stock.

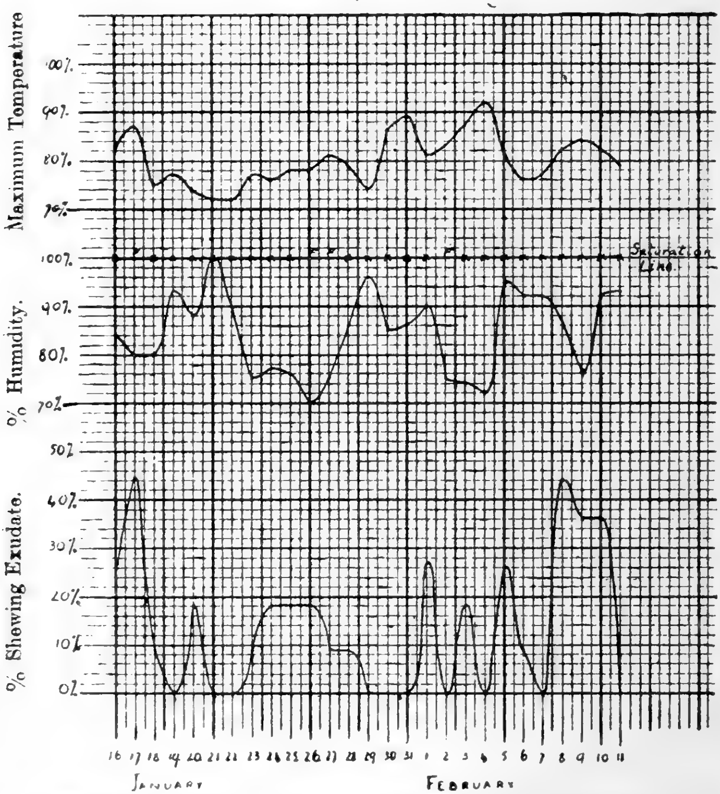
In this connection we might draw attention to the following observation by Dr. Wynne (1896, p. 40): "*Ascites of female tick.* One morbid condition of the adult female tick is worth noting though I am unable to offer any explanation. Very rarely and apparently only on certain animals the ticks look like miniature white grapes, almost transparent, of a pale greenish yellow. . . They are little bags of fluid, in the interior of which the various internal organs can be seen lying. It appears to be a true dropsy of the peritoneal cavity as on dissecting the tick the condition of the organs recalls vividly the appearances seen in ascites of man."

The ticks referred to by us are certainly not like "bags of fluid" but are somewhat shrunken.

Exudate.

Associated with tick resistance may be an exudate. This exudate, or so-called serum, has on many occasions been referred to by Mr. Munro Hull, who was, as far as we know, the first to bring it under public notice in Australia. It consists of drops of a clear yellow fluid, which appear on the skin on various parts of the body, neck, dewlap, butt of tail and escutcheon, notably on the last-named, where it is more evident owing to the shortness of the hair. These drops become thick and sticky, ultimately forming little granular masses or thin flat yellow scabs, according to the size of the original drop. The largest patches seen were about the size of a sixpence or slightly larger. In some animals these little masses of exudate are perfectly clear, the skin appearing through them quite uninflamed. In others some blood may be present, then the resultant scab is discoloured. When dry these scabs are readily flaked off leaving a rounded area of smooth clean skin beneath. There is no positive evidence to prove that each patch of exudate is caused by the bite of a tick, though, occasionally, larval ticks have been found attached to a dry scab having become entangled in the sticky fluid. This exudation of lymph must be due to one or both of two causes (1) either a slight mechanical injury to the tissue which, while not penetrating a blood capillary, allows an escape of lymph from the tissues ; such might be caused by the larval tick inserting its rostrum, and then withdrawing it and going elsewhere ; or (2) to an increase in blood pressure, involving an extravasation of lymph from the capillaries. The formation of small hard lumps on the flanks, and in the vicinity of the escutcheon and neck of resistant animals, upon the centre of which a patch of fresh exudate may or may not appear, would be accounted for by an increase in blood pressure, since when scored, blood flows very freely from such lumps. The affected area is rather irritable, the cows shewing a desire to lick or rub the part.

Mr. Hull has found that this exudate is in abeyance during the winter months. Notes taken from his letters shew that this phenomenon is most likely to occur during the months October-June. In 1916, his last record of its occurrence before the winter, was on June 24th, when one of us examined the animals, exudate being then abundant. The first record of it in the following spring was on October 20th, when exudate was present in small patches. In the beginning of the next month, during some humid weather, it appeared abundantly. The cows were in splendid condition and no ticks had been noticed on them. Records of the occurrence of the exudate came to hand from time to time up till April 28th, 1917, although little or none appeared during the first few months of 1917. Its first appearance in the following spring was on October 10th, 1917. The condition continued to be shewn by various cows at intervals during January, February and March, 1918 (see details regarding different cows). On April 6th, Mr. Hull reported that no exudate was apparent. On May 2nd he wrote that Baby was shewing heavy exudate, while the same condition, but far less pronounced, was



The days on which more or less rain fell, are indicated by a cross on the saturation line. F represents the days on which there was no rain at all.

visible on Wallum. On June 7th, inspection revealed only one cow—Buttercup—with fresh exudate, but Brownie, Isis and Baby shewed evidence of extensive exudation a day or two prior to examination.

Evidence of the effect of the weather on the "lumpy" condition already referred to, is afforded by the following notes taken from Mr. Hull's letters. On January 9th, 1917, he noted that nine of his resistant cows were shewing a lumpy, knotted condition. Next day a sudden change in the weather occurred. The barometer fell and a westerly wind sprang up, the lumpy condition subsided without any extravasation of lymph.

An attempt has been made to correlate the daily temperature records taken during January and February, 1918, with the exhibition of exudate. The accompanying graph shews the results obtained by plotting maximum temperature, humidity per cent. and per cent. of animals shewing exudate, against each day. It appears that there is a rough correspondence between the three curves, the humidity per cent. being an inversion of the other two. The exudate appeared more abundantly on days of fairly high temperature accompanied by less humid conditions. The humidity was very high throughout—as might be expected during the rainy season, so that the term "less humid" is only a relative one, meaning that there was less moisture in the atmosphere than when it was actually raining. Although some rain fell on practically every day, the mornings were frequently fine, warm and sultry (conditions favourable to the exudation), becoming stormy or showery in the afternoon.

Mr. Inigo Jones, Crohamhurst, however, finds that the exudate appears on his cows in winter as well as summer.

At the end of July, Mr. Jones undertook to examine several resistant cows at regular intervals throughout the winter and note especially the presence (or absence) of ticks and exudate. On September 23rd, he forwarded his report. The four selected cows, Erminie, Queenie, Pocahontas and Frida were examined on July 15th and 30th, August 15th and 30th, and September 15th. The exudate was visible and normal on all occasions, and owing to the severity of the winter and consequent low condition of the cattle a few ticks were observed on each occasion. On August 15th, he reported that a calf, Rosy V., aged eight months, the daughter of a resistant cow, showed a typical exudate for the first time. She was apparently tickless. Erminie calved on 15th August, 1918; Queenie on 6th October, 1917; Pocahontas on 29th April, 1918; Frida on 18th July.

The condition just described appears to graduate into a type of tick-sore, so far only noticed on resistant animals. The scab formed over such a tick sore consists of two very distinct parts—an outer ring of a clear yellow substance, apparently composed of exactly the same matter as that spoken of above, surrounding a dark blood-stained core, on the upper surface of which there is a pit, where the mouth parts of a tick have been inserted*; very often the tick is still present. Development up to the adult stage occurs in such ticks but the females are unable to bloat and remain stunted, sickly-looking individuals, eventually dropping off with the scab. The under surface of this hard black core, surrounding the rostrum of the tick, is tipped with pus. When such a scab is removed a corresponding pit is seen in the skin of the beast. The distribution of ticks, tick sores and exudate on the skin of a beast is very irregular. For instance, a fold of skin three by two inches on the escutcheon of the cow Fairy was carefully drawn to shew such distribution. About two-thirds of the area was occupied by small dry yellow granules and six larger hard red scabs, while one nymph was present; the other third contained two pairs of ticks—adult and female (unbloated)—each pair being attached to an inflamed area of skin. In close proximity were an adult male and a nymph creating no disturbance. An area of similar size, was examined on another cow, Baby; several dozen larvæ (apparently just attached) were visible, but, while the larvæ were concentrated at two points, dry yellow granules were just as abundant in the intervals as around the larvæ. Three typical tick sores were present as well as some hard dry scabs. Such instances could be multiplied indefinitely.

A type of tick sore quite distinct from that described above, is found on certain cows, notably Kittiwake. These might be termed tick-blisters, as each forms a little rounded excrescence on the skin, filled with lymph. These seem to form usually round the point of attachment of a larval or nymph tick.

*W. Herms (Jour. Parasitol., 2, 1916, p. 140), has given an account of the tick sores produced by *Ornithodorus coriaceus*. He mentions the presence of lymph exuding from the wounds.

Little whitish sores containing pus are also formed in response to tick irritation. Thick, whitish scurf may also be formed from the same cause, notably at the butt of the tail and in the ears.

With regard to the appearance of an exudate on Clover and Tinkerbell, Pound (R.S.C., 1915, p. 20), stated that such vesicles as did occur on them, were the result, purely and simply of tick irritation. On arrival at Yeerongpilly in December, 1912, and again during the stalling experiments of June-July, 1914, these cows are reported to have been covered with sores of a vesicular and pustular character (Pound, 1914, p. 110). Further on, however, in the same report he mentioned that bacteriological examination was made of "the serous exudate." Several kinds of ordinary skin bacteria were found; while such pyogenic cocci as *albus* and *aureus* were observed in the pustules, but no other organisms were detected that could be regarded as fatal to the cattle tick. Pound (R.S.C., 1915, p. 20), also stated that no such vesicles occurred when the animals were kept on non-infested country.

Smears of blood and exudate taken from a number of resistant animals during the period 1915-1918, failed (on examination by us) to reveal the presence of any organisms other than those which one might expect to find as a result of contamination.

Cultures were made of some exudate sent down in capillary tubes. These were submitted to Dr. Bradley, Microbiologist to the Health Department, Brisbane, who reported as follows :—"The plate culture submitted shewed several types of colonies. The types of these were such as usually occur from air or water contamination. None resembled known pathogenic organisms, except a few which may have been varieties of Staphylococci (commonly found in the skin of men and animals). Many of the colonies were apparently dead as no growth occurred on sub-culture of the smaller types. Gram stained film shewed gram positive cocci and gram positive bacilli."

Cultures made in agar slopes were incubated at 37 degrees C. for several days; several shewed a growth of mould but no organisms other than those noted above were detected.

Only one definite reference to such exudate is to be found in literature. In the conclusion of a paper on the "Biology of some North American ticks of the genus *Dermacentor*," Bishopp and Wood (1914, p. 179) made the following statement: "Three of our bovine hosts used in experiments shewed such a tendency to immunity. As stated in Table VI. (Infestation No. 8), no females became engorged on a Jersey calf used as a host in comparison with a bull (Infestation No. 9). This calf as well as two other animals were tested several times without a single specimen developing to repletion. It should be mentioned that these hosts showed marked resistance to the attack of other species of ticks. This resistance appears to be due largely to an unusually strong tendency to form scabs at the point of attack, thus healing the wound, and throwing off the tick with the scab. On all hosts scabs are usually produced as the result of the insertion of the mouth parts of the ticks. When the larvæ first become attached a translucent yellowish exudate is thrown out at the point of attack. The subject of resistance will be discussed at greater length in another publication." This is also mentioned by Tryon (1916, p. 50). We have been unable to find further reference to this other publication, which may throw greater light on the problem.

Schroeder (1905, p. 57), stated that "When ticks are numerous it has been observed that a sticky substance frequently accumulates on the skin of cattle: this may be either an exudate from the irritated skin or an accumulation of the discharges from the ticks. After a while this substance hardens into dark, granular flakes and peels off. It is best seen in the creases of the skin. Whether it exudes from the skin or is discharged from the tick does not alter the fact that its original source is the body of the cow or steer. If it exudes from the skin it is strong evidence that the skin is extremely irritated . . . ." The same author also describes the effect of a tick bite on the skin of an animal—"When a cattle tick is detached from the skin of a cow, a small circular spot, sometimes partly denuded of hair, and slightly reddened, is seen, with a minute, barely visible puncture in its centre, from which a drop of blood may ooze. When examined under the microscope the skin in the narrow circle about the puncture is found to be densely packed with infiltrated cells." This "sticky accumulation" does not exactly correspond with the exudate observed by us: the former is found to occur when ticks are numerous, whereas the latter is most marked on cattle on which few or no ticks are present.* With regard to the suggestion that it is a discharge from the ticks, it has been noticed that certain ticks of the genus *Ornithodorus* when feeding "become surrounded by a clear fluid which comes from their malpighian tubes and coxal glands."†

Although we have failed to find even larval ticks in the great majority of the patches of exudate examined by us—even after using the microscope, we believe they are a direct result of larval tick attack on certain cattle, *i.e.*, cattle which possess some individual physiological peculiarity. Such animals are resistant and apparently the small quantity of tick toxin—perhaps even the mere mechanical stimulus of the rostrum—is able to so increase the local blood pressure that there is an exudation of lymph. We have already stated our opinion that the blood of resistant animals will be found to possess certain differences in regard to its biochemical composition.

It may be objected that this exudate makes its first appearance each season before the presence of ticks is noticed, but we must point out that larvæ begin to infest cattle some little time before their occurrence is noted by an ordinary observer.

Summary.

The cattle tick in Queensland may cause tick fever and tick worry.

There exists a degree of resistance to tick fever and this is largely influenced by individual idiosyncrasy, age, sex, and general health of the animal as well as by food and other conditions.

Tick worry is at present a more serious complaint than tick fever in Queensland. It is apparently due, at least in part, to the injection of a toxin by the tick.

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*See also Herms. Jour. Parasitol. 2, 1916, p. 140.

†Patton and Cragg, Medical Entomology, 1913, p. 639

Many cattle become habituated to tick infestation and this, in individual cases at least, leads to some degree of resistance. Such resistance is probably due to the formation of anti-tick poison bodies by the blood of the animal.

Tick resistant cattle are known from a number of Queensland localities. Asiatic breeds are tick resistant. Of the various breeds commonly met with in this State, Jerseys appear to be less affected than others by ticks.

Tick resistance seems to be influenced by food only in so far as the latter affects the general health of the animal.

The effect of the application of arsenical solutions to resistant cattle has not been satisfactorily determined. Perhaps the use of arsenical solutions prevents the realisation of such resistance.

Tick resistance persists, provided the resistant animal's health be maintained.

The temperature of resistant animals appears to be normal.

There is good reason to conclude that the resistant tendency is hereditarily transmissible.

Although there is considerable positive evidence of the transmissibility of resistance by vaccination, we have not succeeded in proving it.

In many cases the condition has been acquired naturally. We think that habituation is a step towards resistance which seems to us to be a physiological reaction to the introduction of a tick toxin.

The comparatively few ticks which mature on resistant cattle appear to have their fertility, as a rule, somewhat impaired.

Associated with tick resistance in many animals is an exudation of a lymph-like substance on the skin. This condition is quite distinct from the typical tick sore, though it is apparently a response to tick attack.

In conclusion, we desire to express our appreciation of the assistance we have received from many individuals whose experiences have been quoted in our paper; the Under Secretary, Department of Agriculture, Queensland, for permission to utilise certain paddocks for our experimental animals ; and to Mr. D. Rooke, for allowing us to use his cattle for experimental purposes.

We would like to acknowledge particularly the help afforded us by Messrs. Inigo Jones and Munro Hull, especially the latter, who has allowed us full access to his records and to whom we are indebted for hospitality on many occasions.

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Abstract of Proceedings of the Royal Society of Queensland.

To Members of the Royal Society of Queensland.

Your Council has pleasure in submitting its report for the year 1917.

The result of the year's work is very satisfactory. As a result of the activities of members engaged in research work, ten papers were accepted and printed in the annual volume, which was issued in December. The fact that papers are issued and printed very shortly after being read is a distinct advantage to members, and in this respect there are few Societies in Australia which compare favourably with our Society. For this, some acknowledgment is due to our printers for the prompt and efficient manner in which they carry out our work.

We have again to acknowledge our gratitude to the Queensland Government, who have continued their policy of aiding the publication of scientific research work by once more voting a sum of £50 to the Society.

The Council has met nine times, the attendances being :—E. H. Gurney, 9 ; A. B. Walkom, 9 ; J. Shirley, 8 ; C. D. Gillies, 6 ; W. R. Colledge, 6 ; R. Hamlyn-Harris, 4 ; T. H. Johnston, 6 ; H. A. Longman, 7 ; H. C. Richards, 7.

During the year three members have been elected, six have resigned, and we have lost by death two ordinary members (Dene B. Fry and Dr. T. P. Lucas), and one corresponding member (Rev. G. Brown). We have to express our sincere regret at the loss of these members, and extend our sympathy to their relatives.

The Balance Sheet is satisfactory, showing a credit balance of £1 8s. 11d.

(Signed) E. H. GURNEY,
President.

A. B. WALKOM,
Hon. Secretary.

4TH MARCH, 1918.

THE ROYAL SOCIETY OF QUEENSLAND.

Cr. — **BALANCE SHEET for the Year 1917.** — **Dr.**

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
Balance from 1916	5	5	7	Insurance	1	0	0
Subscriptions	75	2	0	Postage and Petty Cash	5	18	1
Government Subsidy	50	0	0	Librarian's Postage	2	0	0
				Printing (Pole & Co.)	119	9	1
				Bank Charge and Exchange	0	11	6
				Balance in Bank	1	8	11
	£130	7	7		£130	7	7

Examined and found Correct.

(Signed) H. J. PRIESTLEY, *Hon. Auditor.*

4/3/18.

(Signed) JOHN SHIRLEY,
Hon. Treasurer

Abstract of Proceedings, 25th March, 1918.

The Annual General Meeting of the Royal Society of Queensland, was held in the Geology Lecture Theatre, in the University, on Monday, 25th March, 1918, at 8 p.m.

Mr. E. H. Gurney, President, in the Chair.

The Minutes of the previous Annual Meeting were read and confirmed, and the Annual Report and Financial Statement were received.

The following were proposed as ordinary Members of the Society :—H. Leighton Kesteven, D.Sc., M.B., Ch.M., H. Burton Bradley, M.B., Ch.M., and Miss M. J. Bancroft.

The following Officers for 1918 were elected unopposed :—

Patron : His Excellency Sir Hamilton Goold-Adams, G.C.M.G., C.B., etc.

President : A. B. Walkom, B.Sc.

Vice-Presidents : E. H. Gurney (*ex officio*).
H. A. Longman

Hon. Secretary and Librarian : C. D. Gillies, M.Sc.

Hon. Treasurer : J. Shirley, D.Sc.

Hon. Editor : A. B. Walkom, B.Sc.

Members of Council :—W. R. Colledge.
T. Harvey Johnston, M.A., D.Sc.
H. C. Richards, D.Sc.
F. Smith, B.Sc., F.I.C.
C. T. White.

Hon. Auditor : Prof. H. J. Priestley, M.A.

On being installed, the new President was congratulated by the Society on his qualifying for the degree of Doctor of Science of the University of Sydney. Dr. Walkom suitably responded.

The retiring President, Mr. E. H. Gurney, read an address on " Soil Fertility." In returning a vote of thanks Hon. A. J. Thynne and Dr. T. Harvey Johnston emphasised the importance of the subject, and recommended further investigation.

Abstract of Proceedings, 29th April, 1918.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre, in the University, on Monday, 29th April, at 8 p.m.

Dr. A. B. Walkom, President, in the Chair.

The Minutes of the previous Meeting were read and confirmed.

The President, on behalf of the Society, congratulated Mr. H. A. Longman on his appointment to the Directorship of the Queensland Museum. Mr. Longman suitably responded.

Mr. E. W. Bick, Curator of the Botanic Gardens, Brisbane, was proposed for membership by Mr. C. T. White and Dr. Shirley.

Dr. H. Leighton Kesteven, Gladstone, Dr. H. Burton Bradley, and Miss M. J. Bancroft, B.Sc., were elected Ordinary Members of the Society.

Mr. C. T. White, Colonial Botanist, communicated a paper on "Tropical Acacias of Queensland," by Mr. J. H. Maiden, F.R.S. Dr. Shirley, Messrs. Longman, Bennett, White and Swain commented on the paper.

Dr. T. Harvey Johnston read a paper, entitled "Notes on Certain Entozoa of Rats and Mice," and illustrated his remarks by means of lantern and micro-slides.

Abstract of Proceedings, 27th May, 1918.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre, in the University, on Monday, 27th May, at 8 p.m.

Dr. A. B. Walkom, President, in the Chair.

The Minutes of the previous meeting were read and confirmed.

Mr. E. W. Bick was elected an ordinary Member of the Society.

Mr. S. B. Watkins, M.Sc., was proposed for membership by Dr. Shirley and Mr. Colledge.

A collection of plants made at Wallumbilla and Charleville, Western Queensland, by Mr. E. W. Bick, was exhibited by Mr. C. T. White. The collection included specimens of *Trichinium* ·*eucocoma* and *Angophora melanoxylon* which had not previously been collected in Queensland.

Mr. H. A. Longman exhibited a centipede, *Cormocephalus aurantiipes* New., which he had observed masticate and devour several of its own young whilst in captivity.

Dr. T. Harvey Johnston exhibited a specimen of the common littorinid *Bembicium melanostoma* from Caloundra, in which the whorls were not fused externally. This was the only case observed, though some thousands of specimens of the species have come under notice. He also exhibited a marine leech, *Pontobdella* sp. from Caloundra taken attached to the under surface of stones in rock pools, also on sharks *Orectolobus maculatus* and *O. ornatus*; and lying free in a distended condition in the water along the shores of the beach.

Dr. Shirley exhibited: (1) *Embothrium Wickhamii* F.v.M. var. *pinnata* Moore and Betche, found on the edges of the MacPherson Range, known as the Red Silky Oak and having a pink, well-grained timber suitable for cabinet making. (2) *Sarcopteryx stipitata* Radlk. from Roberts' Plateau, provides a good timber for coach-making. Its locality was not previously known.

Mr. C. D. Gillies read a paper on "The components per month of the Rhizopodan Fauna of a Brisbane Lagoon." Dr Johnston, Messrs. White and Colledge commented on the paper.

Messrs. F. Smith and C. T. White read a paper "An Interim Census of the Cyanophoric Plants in the Queensland Flora."

The authors listed 69 indigenous plants scattered through 22 natural orders. Twenty-three Queensland plants are recorded for the first time as yielding hydrocyanic acid. Suspected poison plants were the subject of especial attention.

Abstract of Proceedings, 24th June, 1918.

A Special Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre, in the University, on Monday, 24th June, at 8 p.m.

Dr. A. B. Walkom, President, in the Chair.

The Minutes of the previous meeting were read and confirmed.

Mr. S. B. Watkins, M.Sc., was elected an Ordinary Member of the Society.

The proposed alteration of Rule 12 was accepted by the Society, this rule now reading, " Candidates for election shall pay the entrance fee and subscription for the current year (or in the case of a Member being elected after 30th June, half year's subscription only), *within one month after being elected.*

Mr. C. T. White exhibited, (1) A collection of plants representative of the Gayndah District, Burnett River, made by him in May last year ; (2) Specimens of *Fieldia australis* A. Cunn., and *Drymophila Moorei* Baker, two plants recorded from " the sources of the Logan River," by Baron Mueller in the Victorian Naturalist for December, 1895, but which by an oversight had been omitted from different works on the Queensland Flora. *D. Moorei* had been collected by the exhibitor in the higher parts of the Macpherson Range, (*vide* Bailey in Queensland Agric. Gazette, vol. 28, p. 202), but *F. australis* seems not to have been collected in Queensland since Taylor and Collins gathered it 23 years ago.

Dr. Shirley showed specimens of two plants of the order Flacourtiaceæ from Roberts Plateau, *Streptothamnus Moorei* F.v.M., and *S. Beckleri* F.v.M., both of which are new to the Queensland flora. These plants were determined by Mr. J. H. Maiden.

Messrs. Longman and Bennett commented on the exhibits.

A paper by T. L. Bancroft, M.B., on " Some further notes on the life history of *Ceratodus forsteri*," was communicated by Dr. T. Harvey Johnston. Dr. Johnston and

Messrs. Longman, Tryon and Bennett took part in the discussion which followed.

Mr. C. D. Gillies read a paper on "Variation in the sepals of *Bruguiera Rheedii.*" Drs. Johnston and Richards, and Messrs. Longman, Tryon and White commented on the paper, which was of a biometrical nature.

Abstract of Proceedings, 29th July, 1918.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre, in the University, on Monday, 29th July, at 8 p.m.

Dr. A. B. Walkom, President, in the Chair.

The Minutes of the previous meeting were read and confirmed.

Acting-Professor R. Hawken, B.A., M.E., was proposed for membership by Dr. H. C. Richards.

Dr. H. C. Richards read a paper on "The Building Stones of Queensland" and illustrated his remarks by means of microscope and lantern slides. Messrs Jackson, Petrie, Forster, and Gordon, took part in the discussion which followed.

Abstract of Proceedings, 30th September, 1918.

A Special Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre, in the University, on Monday, 30th September, at 8 p.m.

Dr. A. B. Walkom, President, in the Chair.

The minutes of the previous meeting were read and confirmed.

Acting-Professor R. Hawken, B.A., M.E., was elected an Ordinary Member of the Society.

The proposed alteration of Rule 30, providing for the exhibition of specimens, etc., before the reading of papers was accepted by the Society; the Instructions to Authors drawn up by the Council were also approved.

Mr. H. A. Longman exhibited a specimen of *Neoceratodus forsteri* (Krefft), 495 mm. long, which was caught in the Coomera River by Messrs. Whalley Bros., and presented to the Queensland Museum through Mr. A. A. Gilmour, manager of the State Fishery. This lung fish was secured about eight miles from where sixteen large specimens, ranging from thirty-three to forty-five inches in length, were liberated by the late D. O'Connor in August, 1895 (Proc. Roy. Soc. Qld., xii, 1896, p. 102). It is thus evident that this specimen was actually bred in the Coomera.

Drs. Johnston, Richards, and Walkom commented upon the exhibit.

The following papers were read:—

(1). The Vocabulary of the Mt. Spencer Blacks, by F. Bennett, B.Sc.

(2). On the occurrence of Pacinian corpuscles in the pancreas of the domestic cat, by C. D. Gillies, M.Sc., and O. W. Tiegs.

(3). Mutation in a Proteaceous tree, by C. T. White and H. A. Longman.

(4). An abnormal vertebral column in *Hyla cærulea* White, by C. D. Gillies, M.Sc., and B. B. Taylor.

(5). Notes on a new Rotifer, by W. R. Colledge.

In the discussions which followed, Dr. Johnston, Messrs. Longman, White, and Gillies took part.

Abstract of Proceedings, 28th October, 1918.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre, in the University, on Monday, 28th October, at 8 p.m.

Dr. A. B. Walkom, President, in the Chair.

The Minutes of the previous meeting were read and confirmed.

Mr. G. E. Drewitt was proposed as a member of the Society.

Mr. C. T. White exhibited a collection of plants from the Laidley district.

The following papers were read :—

1. The nature, occurrence and origin of Alunogen at Vandyke, near Springsure, by H. C. Richards, D.Sc.
2. The volcanic rocks of Springsure, by H. C. Richards D.Sc.

In the discussions Messrs. Longman, Bennett, and Gurney took part.

ABSTRACT OF PROCEEDINGS, 25TH NOVEMBER, 1918.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Theatre Lecture, in the University, on Monday, 25th November, at 8 p.m.

Dr. A. B. Walkom, President, in the Chair.

The Minutes of the previous meeting were read and confirmed.

Mr. G. E. Drewitt was elected an ordinary member of the Society.

The following Papers were read :—

1. Notes on Miscellaneous Endoparasites, by T. Harvey Johnston, M.A., D.Sc.
2. A Tick-Resistant Condition in Cattle, by T. Harvey Johnston, M.A., D.Sc., and Mabel J. Bancroft, B.Sc.

Discussion was postponed till a later date.

Library Exchanges Received, 1st November. 1917, to 31st October, 1918.

AFRICA.

Government of the Gold Coast: Geol. Survey Report, 1916.

S. African A.A.S.: Report, 1916.

AMERICA.

BRAZIL.

Instituto Oswaldo Cruz: Memorias, 8 (23), 9 (1).

CANADA.

Dept. of Mines: Bulletin, 15, 16, 19, 22-26; Memoir, 84, 87, 95, 98-103; Museum Bulletin 27; Publication 217; Report, 468, 474; Summary Rept. of Geol. Surv., 1916; Summary Rept., Mines Branch, 1916.

Royal Astronomical Society of Canada: Journal, 11 (7-10), 12 (1-6); Observer's Handbook for 1918.

Royal Canadian Institute: Trans. 11 (2).

MEXICO.

Instituto Geologico: Anales, 2, 3; Boletin, 34.

Observatorio Meteorologico: Boletin Mensual, July, 1916—Feb. 1917.

Sociedad Cientifica: Memorias, 36 (1, 2), 37 (1).

UNITED STATES.

Academy of Natural Sciences, Philadelphia: Proc., 69 (1).

American Geographical Society: Geog. Review, Oct. 1917—Aug. 1918.

American Museum of Natural History: Ann. Rept., 48; Anthropological Papers, 10 (Index), 11 (13), 16 (2), 18 (2-4), 21 (1), 22 (1-2); Guide Leaflet Series, 46, 48; Handbook Series, 3, 6; Museum Journal, 17 (6-8), 18 (1-5); Bibliography of Fishes, Vol. 2; General guide to Exhibition Hall.

American Philosophical Society: Proc., 56 (1-6).

Boston Society of Natural History: Proc., 35 (2, 3).

Californian Academy of Science: Proc., 4th Ser, 6 (8, 9), 7 (1-11), 4 and 5 (Index), 2 (pt. 1, no. 11; pt. 2, no. 12).

Dept. of Commerce and Labour: Cotton Crop of 1916; Special Publication, 41.

Field Museum of Natl. History: Pub., 191, 193, 194.

Florida Geological Survey: 9th Ann. Rept.

Illinois State Lab.: Bulletin, 11 (6, 7), 12 (2-4).

Indiana Academy of Science: Proc., 1915.

Lloyd Library: Bibliographical Contributions, 3 (1).

Lowell Observatory: Bull., 79, 80.

Michigan Academy of Science: Report, 1915, 1916.

Missouri Botanic Gardens: Annals, 4 (2,3), 5 (1, 2).

National Academy of Sciences: Proc., 3 (10-12), 4 (1-7).

New York Academy of Sciences: Annals, 25 (pp. 1-308), 27 (pp. 193-243).

Ohio State University: Bull., 22 (11); Journal of Science, 18 (1-7); Oberlin College Lab. Bulletin, 20.

Smithsonian Institution: Ann. Rept., 1916.

United States National Museum: Ann. Rept., 1916; Bull., 101.

University of California: Botany, 5 (12, 13), 6 (15, 16); Zoology, 17 (11-18), 18 (1-13, 15, 16); Scripps Institution for Biologic Research, Bull., 3, 4.

University of Illinois: Biological Monographs, 2 (4).

University of Kansas: Bull. 18 (2).

University of Minnesota: Agric. Expt. Station, Bull., 165, 169-171; Minnesota Geological Survey, Bull., 13.

Wilson Ornithological Club: Wilson Bulletin, 29 (3, 4), 30 (1, 2).

ASIA.

India.

Agricultural Research Institute, Pusa: Report, 1916-7.

Board of Scientific Advice for India: Report, 1916-7.

Geological Survey of India: Pal. Indica, N.S., 3 (2), 6 (3); Records, 48 (3, 4).

Report on Progress of Agriculture in India for 1916-7.

Java.

Jaarboek van het Mijnwesen: 1914, 1915, 1916 (1 part).

Philippine Is.

Bureau of Science, Manila: Journal of Science, 1-10 (Contents and Index); 11 [B (3, 4)]; 12 [A (2-6), B (5, 6), C (3,6), D (4-6)]; 13 [A (1-3), B (1-4), C (1-3), D (1-3)]; Mineral Resources of Philippine Is. for 1916.

AUSTRALASIA.

Australasian Antarctic Expedition: Scientific Results, Zoology and Botany, 3 (2), 4 (2, 3), 5 (1-6), 6 (1).

New South Wales.

Australian Museum: Records, 11 (12), 12 (1-6); Report, 1916-17.

Botanic Gardens: Forest Flora, 7 (2); Genus *Eucalyptus*, 3 (index), 4 (2-5); Report of Director, 1916.

Dept. of Agriculture: Agric. Gazette, 28 (11, 12), 29 (1-6, 8-10); Science Bull., 15.

Linnean Society of N.S.W.: Proc. 42 (3, 4), 43 (1, 2).

Naturalists' Society of N.S.W.: Australian Naturalist, 3 (15, index), 4 (2-4).

State Fisheries: Ann. Rept., 1916.

Technological Museum: Report, 1916, 1917.

University of Sydney: Calendar, 1918.

New Zealand.

Auckland Institute: Ann. Rept., 1917-8.

Dominion Laboratory: Ann. Rept., 50.

Geological Survey: Ann. Rept., 11; Bull., 19, 20; Pal. Bull, 5, 6.
N.Z. Board of Science and Art, Bull., 1.
N.Z. Institute: Trans. and Proc., 49, 50.
N.Z. Journal of Science and Technology: 1 (1-5).

NORTHERN TERRITORY.

Report of Administrator: 1916-7 and supplement.

QUEENSLAND.

A.B.C. of Queensland Statistics, 1917.
Chief Protector of Aboriginals: Ann. Rept., 1917.
Geological Survey: Pub., 255, 256, 258, 259, 261, 262; List of Publications 1879-1918; Q.G.M.J., Dec., 1917-Oct., 1918.
University of Queensland: Column Analysis and Design.

SOUTH AUSTRALIA.

Department of Chemistry: Bull., 7., 9.
Department of Forestry: Bull., 6.
Geological Survey: Ann. Rept., 1916; Mining Review, 27.
Public Library: Report, 1916-7.
Royal Geographical Society: Proc., 18.
Royal Society: Proc., 41.

TASMANIA.

Geological Survey: Bull., 26, 27; Min. Resources, 5.
Royal Society: Proc., 1917.

VICTORIA.

Aust. Institute of Mining Engineers: Proc., N.S., 28-30.
Commonwealth Advisory Council of Science and Industry: Bull., 2-7; Pamphlet, 1; Report of Exec. Committee to 30th June, 1918.
Commonwealth Statistician: Yearbook, 10; Australian Joint Life Tables, 1901-10.
Dept. of Agriculture: Journal, 15 (10-12), 16 (1-10); Report of Council of Agricultural Education, 1918.
Dept. of Fisheries (Commonwealth): Zoological Results of Fishing Experiments, 4 (5).
Dept. of Mines: Ann. Rept., 1917; Bull., 40.; Records of Geol. Survey, 4 (1); Report on Brown Coal.
Field Naturalists' Club: Victorian Naturalist, 34 (7-12), 35 (1-6).
Royal Australian Ornithologists' Union: Emu, 17 (3, 4), 18 (1, 2).
Royal Society: Proc., 30 (1, 2).
Scientific Australian: 23 (2-4).

WESTERN AUSTRALIA.

Geological Survey: Ann. Rept., 1916; Bull., 66-69, 71-74, 76.

OCEANIA.

Bernice Pauahi Bishop Museum, Honolulu; Memoirs, 4 (3 and index), 7 (1).

EUROPE.

ENGLAND.

British Museum: Catalogue of Ungulate Mammals, 5; Guide to British Freshwater Fishes; Guide to Models of Disease Insects; Instructions for Collectors, 1A, 12, 13; Instruction to Study of Meteorites; Economic Series, 2-7.

Cambridge Philosophical Society: Proc., 19 (2-4).

Conchological Society: Jour., 15 (8, 9).

Literary and Philosophical Society, Manchester: Proc., 61 (1-3).

Royal Botanic Gardens, Kew: Kew Bull., 1917.

Royal Colonial Institute: United Empire, 8 (9-11), 9 (1, 2, 5, 6, 7, 9).

Royal Society of London: Proc., A. 645-665, B 623-628; Yearbook, 1918.

Solar Physics Observatory, Cambridge: Ann. Rept., 4, 5.

International Catalogue of Scientific Literature: Anatomy, 13th.

FRANCE.

Notes ptéridologiques: 3, 4.

University of Montpellier: Série mixte, 5.

ITALY.

Rassegna Mensile di Botanica: Malpighia, 28 (3-6).

Società Africana d'Italia: L'Africa Italiana, 36 (2, 6), 37 (1).

Società Toscana di Scienze Naturale, Pisa: Proc. Verb., 25 (5), 26 (1-3).

SCOTLAND.

Royal Botanic Gardens, Edinburgh: 6 (29, 30), 10 (46).

Royal Society of Edinburgh: Proc., 38 (1).

SPAIN.

Academia Real dell Ciencias y Artes, Barcelona; Memorias, 13 (19-32), 14 (1-2).

Musei Barcinonensis Scientiarum: Nat. Op., Bot., 1, 2; Biologico-oceanografica, 1; Geol., 1; Zool., 2, 7, 11.

SWITZERLAND.

Société de physique et d'Histoire naturelle, Geneva: Compte rendu, 34, 35 (1, 2); Mémoires, 38 (6).

List of Members.

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