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TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

VOL. LIII

(NEW ISSUE)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

ISSUED 31ST AUGUST, 1921

Wellington, N.Z.

MARCUS F. MARKS, GOVERNMENT PRINTING OFFICE

WILLIAM WESLEY AND SON, 28 ESSEX STREET, STRAND, LONDON W.C. 2

NEW ZEALAND INSTITUTE.

NOTICE TO MEMBERS.

The publications of the New Zealand Institute consist of—

1. **Transactions,** a yearly volume of scientific papers read before the local Institutes. This volume is of royal-octavo size.

2. **Proceedings,** containing reports of the meetings of the Board of Governors of the New Zealand Institute and of the local Institutes, abstracts of papers read before them and of papers dealing with New Zealand scientific matters and published elsewhere, list of members, &c. The *Proceedings* are of the same size as the *Transactions,* and are bound up with the yearly volume of *Transactions* supplied to members.

3. **Bulletins.** Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of the *Transactions.* The bulletins are of the same size and style as the *Transactions,* but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

Library Privileges of Members.—Upon application by any member to the Librarian of the New Zealand Institute or of any of the affiliated Societies such works as he desires to consult which are in those libraries will be forwarded to him, subject to the rules under which they are issued by the Institute or the Societies. The borrower will be required to pay for the carriage of the books. For a list of the serial publications received by the Library of the New Zealand Institute during 1920 see pp. 570–75.

Addresses of Members. — Members are requested to notify the Secretary of any change of address, so that the same may be noted in the List of Members.

MEMORANDUM FOR AUTHORS OF PAPERS.

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being. Wide spacing between the lines and ample margin should be left.

2. The author should read over and correct the copy before sending it to the Editor of the *Transactions*.

3. A badly arranged or carelessly composed paper will be sent back to the author for amendment. It is not the duty of an editor to amend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific and generic names, titles of books and periodicals, and foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature and the International Rules for Botanical Nomenclature must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g.*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible.

8. Photographs intended for reproduction should be the best procurable prints, unmounted and sent flat.

9. *Line Drawings.*—Drawings and diagrams may be executed in line or wash. If drawn in line—*i.e.*, with pen and ink—the best results are to be obtained only from good, firm, black lines, using such an ink as Higgin's liquid India ink, or a freshly mixed Chinese ink of good quality, drawn on a smooth surface, such as Bristol board. Thin, scratchy, or faint lines must be avoided. Bold work, drawn to about twice the size (linear) of the plate, will give the best results. Tints or washes may not be used on line drawings, the object being to get the greatest contrast from a densely black line drawn on a smooth, white surface.

10. *Wash Drawings.*—If drawing in wash is preferred, the washes should be made in such water-colour as lamp-black, ivory black, or India ink. These reproduce better than neutral tint, which inclines too much to blue in its light tones. High lights are better left free from colour, although they may be stopped out with Chinese white. As in line drawings, a fine surface should be used (the grain of most drawing-papers reproduces in the print with bad effect), and well-modelled contrasted work will give satisfactory results.

11. *Size of Drawings.*—The printed plate will not exceed 7¼ in. by 4½ in., and drawings for plates may be to this size, or preferably a multiple thereof, maintaining the same proportion of height to width of plate. When a number of drawings are to appear on one plate they should be neatly arranged, and if numbered or lettered in soft pencil the printer will mark them permanently before reproduction In plates of wash

drawings, all the subjects comprising one plate should be grouped on the same sheet of paper or cardboard, as any joining-up shows in the print. Text-figures should be drawn for reduction to a width not exceeding $4\frac{1}{3}$ in. If there are a number of small text-figures they should be drawn all for the same reduction, so that they may be arranged in groups.

12. *Maps.*—A small outline map of New Zealand is obtainable at a low price from the Lands and Survey Department, Wellington, upon which details of distribution, &c., can be filled in according to the instructions given above for line drawings.

13. *Citation.*—References may be placed in a list at the end of an article or arranged as footnotes. The former method is preferable in long papers. In the list references are best arranged alphabetically, reference in the text being made by writing after the author's name, as it occurs, the year of publication of the work, adding, if necessary, a page number, and enclosing these in parentheses, thus: "Benham (1915, p. 176)." Example of forms of citation for alphabetical list:—

BENHAM, W. B., 1915. Oligochaeta from the Kermadec Islands, *Trans. N.Z. Inst.*, vol. 47, pp. 174–85.

PARK, J., 1910. *The Geology of New Zealand*, Christchurch, Whitcombe and Tombs.

When references are not in alphabetical order the initials of the author should precede the surname, and the year of publication should be placed at the end. Care should be taken to verify the details of all references—date, pages, &c.—and initials of authors should be given.

14. In accordance with a resolution of the Board of Governors, authors are warned that previous publication of a paper may militate against its acceptance for the Transactions.

15. In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost price.

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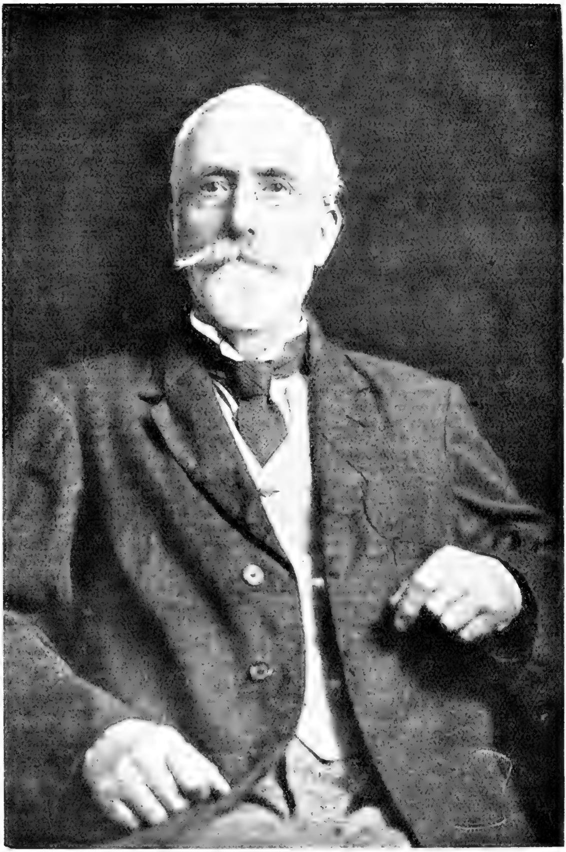

D. E. Hutchins

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OBITUARY.

SIR DAVID ERNEST HUTCHINS, 1850-1920.

The late Sir David E. Hutchins, born on the 22nd September, 1850, was educated at the well-known Blundell's School, Tiverton, England, and after leaving went, when twenty years old, to the famous École Nationale des Eaux et Forêts at Nancy, France, where he gained his diploma in forestry. From Nancy he went to India as Deputy Conservator in Mysore, and spent some ten years in the Indian Forest Service. Here he showed his wide views of forestry in two papers which he wrote on Australian trees in the Nilgiris and on the coastal planting of *Casuarina*. These papers are still standard works on their subjects. From India he was transferred in 1882 to Cape Colony, where, after some years passed in charge of the Knysna forests, he succeeded Count Vasselot de Regné as Chief Conservator of Forests, and remained until 1905. Sir David's work as a forester in South Africa has received the highest praise from such well-known authorities as Sir W. Schlich, the late Professor Fisher, M. Pardé, H. R. McMillan, and others. Under his regime in South Africa not only was scientific management applied to the remaining indigenous forests, but extensive plantations were made of eucalypts and other exotics, which are now yielding an annual revenue of about £20,000.

On his retiring from the South African Forestry Department Sir David was later employed by the British Government to report on the forests of British East Africa, where he succeeded in demarcating reserves, and, among other things, in establishing economic plantations of the Chinese coffin-wood tree (*Persea nanmu*). He was appointed Chief Conservator of Forests for this territory, and after three years' service there he retired from regular Government employment. At various times in his career he was called upon to visit different countries and report on forestry problems. In 1907 he was employed by the Colonial Office to report on the value of the Kenia forests, and in 1909 to inspect the forests of Cyprus.

In addition to his experience in India, South and East Africa, Sir David during several visits had gained an intimate knowledge of the forests of Algeria, Italy, Spain, Portugal, Belgium, France, and Germany.

Sir David came out to Australia in 1914 with the British Association for the Advancement of Science, and remained there to study forestry in that land. Whilst in Australia he wrote a valuable book on Australian forestry, *A Discussion of Australian Forestry, with Special Reference to the Forests of Western Australia* (1914-15), and by his persistent advocacy stirred up such an interest in the matter that in all the various States of the Commonwealth Forestry Departments are now firmly established.

In 1916, on the invitation of the Government, Sir David Hutchins came to New Zealand to report on forestry in this Dominion, and it was mainly on his advice that it was decided to establish forestry as a separate and independent State Department here. He was also the original promoter of the New Zealand Forestry League, as he recognized that some such body is essential to sustain the interest of the public in a matter which, unfortunately, is liable to be thought to concern our successors more than ourselves.

Whilst in New Zealand Sir David devoted the whole of his time to the study of forestry in this country, and when not in the field inspecting native forests and plantations he was writing on those matters. Before his death the Government had published his *Report on the Waipoua Kauri Forest* (1918), and Part I of *Forestry in New Zealand* (1919), and up till the time that he passed away he was engaged in writing Part II of this latter work.

For forestry in the British Empire probably no one has done such service as Sir David Hutchins, and it was for this that he in 1920 received the honour of knighthood, which, in connection with forestry, had previously been conferred only on three official heads of the great Indian Forest Service. His published works were numerous, including, besides those mentioned above, *Report on Transvaal Forestry*, 1903; *Report on Rhodesia Forestry*, 1904; *Extra-tropical Forestry*, 1906; *Forests of Mount Keria*, 1907; *Report on Forests of British East Africa*, 1909; *Cyprus Forestry*, 1909; and others.

He died at his residence, Khandallah, on the 11th November, 1920.

E. PHILLIPS TURNER.

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COLONEL THOMAS WILLIAM PORTER, C.B., 1844-1920.

Colonel Porter came of a soldiering family. His father, Lieut.-Colonel Porter, 7th Bengal Native Infantry, died in India during the Mutiny. On his mother's side he was Highland in descent, of the aristocratic and ancient Roses of Kilravock Castle, Geddes, Nairnshire, a family whose records go back for over a thousand years. He was a nephew of Lord Strathnairn, a prominent figure in military history. He went to sea at the age of thirteen as a midshipman in the Royal Navy, and served in H.M.S. "Hercules" in raids against pirates on the China Station, 1857–58. Leaving the Navy in 1859, he came to Australia and New Zealand, and entered upon the military life in the Maori War. He joined the Colonial Defence Force Cavalry, and after spending some time in charge of a blockhouse at Mohaka (H.B.) he served in his first engagement with the Hauhau natives at Waerenga-a-Hika Pa, near the present town of Gisborne, at the end of 1865. There he distinguished himself by assisting a wounded comrade under fire, receiving a slight wound. After the disbandment of the Cavalry, Porter joined the New Zealand Armed Constabulary, and during the campaigns against Te Kooti on the east coast, and against Titokowaru on the west coast, he served in command of Maori contingents. He was continuously on active service from 1868 to the beginning of 1872, and during that period fought in scores of engagements and skirmishes. His courage and skill were conspicuous at the siege of Ngatapa, in the Gisborne district, where he commanded a portion of Major Ropata Wahawaha's Ngati-Porou contingent. After sharing in the final defeat and pursuit of Titokowaru and the west-coast Hauhaus, in the interior of Taranaki in 1869, he returned to the east coast with his No. 8 Division, Armed Constabulary, and then took a very prominent and useful share in the campaigns against Te Kooti in the Urewera Country. In this most arduous chase, lasting for three years, Porter (then Captain) was a marvel of energy and physical endurance. The Ngati-Porou contingents under Ropata and Porter sometimes remained months in the formidable forest ranges, far from their base of supplies, often without any food but what the bush afforded, rigorously searching the almost unknown Urewera terrain for the rebel bands. Numerous skirmishes were fought and fortified positions captured, and in September, 1871, Porter and his Ngati-Porou decisively defeated Te Kooti at Te Hapua. (The final shots in this forest war were fired by Captain Preece's force in February, 1872.) The infamous Kereopa, the fanatic murderer of the Rev. C. Volkner at Opotiki in 1865, was captured by a detachment detailed by Captain Porter in the Upper Whakatane, November, 1871.

After the close of the Maori wars Colonel Porter, who during his prolonged and incessant activities was four times wounded, filled many important military and Civil Service appointments on the East Coast. In 1889 he was once more called upon to take the field against Te Kooti, who with a large body of followers insisted on a visit from Waikato to the east coast. The old rebel was arrested by the Colonel at Waiotahi, Bay of Plenty, and sent back to Auckland. When the South African War began Colonel Porter once more sought active service. He commanded the

Seventh New Zealand Contingent of Mounted Rifles in the Transvaal, Orange Free State, Zululand, and later the Ninth Contingent. For his services on the veldt (1900–2) he was awarded the Queen's Medal (four clasps) and created Commander of the Bath. For some time before retiring from the service of the State, in 1908, Colonel Porter was Acting Under-Secretary for Defence.

He was the author of *The Life and Times of Major Ropata Wahawaha*, and had also completed a history of the war with Te Kooti (published in several forms) and a book of East Coast Maori legends.

Colonel Porter was actively interested in the Historical Section of the Wellington Philosophical Society, formed in September, 1918. He held the office of vice-chairman from the beginning, and his picturesque figure, his manly and military bearing, and his conversation, based on a long, varied, and active experience, were always of interest.

His contributions on Maori subjects were highly valuable, and had his life been prolonged he would no doubt have added considerably to the store of New Zealand historical data. He died on the 12th November. 1920, at the age of seventy-six years.

James Cowan.

K. Wilson

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KENNETH WILSON, 1842-1920.

Kenneth Wilson, M.A., was born at Leeds in 1842, the youngest son of Thomas Wilson, M.A., Director of the A. and C. Canal Navigation Company. He entered the Leeds Grammar-school, completing his school education there, and leaving with a scholarship which took him to St. John's College, Cambridge. At Cambridge he took his degree, and at that place he imbibed that pronounced appreciation of the classics of English literature which he retained throughout his life. After leaving Cambridge Mr. Wilson spent some years as assistant master at Mostyn House, Cheshire, and on being offered a position on the staff of King Edward VI School at Southampton he accepted it, and remained there until he came to New Zealand in 1881 as Headmaster of Wellington College, with which he was connected for many years. During this period many men now in Wellington and elsewhere passed through the school, and they recall with friendly affection the upright and distinguished figure of the Headmaster. For the last thirty years of his life Mr. Wilson resided in Palmerston North; his was a familiar figure, and his devotion to the beloved classics provided one of the few remaining links with that period of English University life when the Classical Tripos represented the beginning and the end of educational excellence. Though actively engaged in teaching during his residence in Palmerston North, he found time for other pursuits, and in conjunction with Mr. Welch was one of the founders of the Manawatu Philosophical Society. He was President, and for eleven years Secretary, of the society, and its members have good reason for remembering him, since it was mainly due to his enthusiasm and tireless, patient work that the society is in the strong position it occupies to-day. Mr. Wilson, who lost a son in the war, died on the 10th October, 1920, aged seventy-eight years.

Chas. T. Salmon.

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ROLL OF HONOUR

SHOWING MEMBERS OF THE INSTITUTE WHO WERE ON ACTIVE SERVICE DURING THE WAR.

Name.	Available Details of Service.	
	Wellington Philosophical Society.	
E. H. Atkinson ..	Lieutenant, Royal Naval Volunteer Reserve.	
C. M. Begg ..	Colonel, N.Z. Medical Corps	C.B., C.M.G. Died of sickness.
Val. Blake ..	Lieutenant, Canterbury Infantry	Killed in action.
F. K. Broadgate ..	Lieutenant, N.Z. Engineers	Killed in action
P. W. Burbidge ..	Sergeant, 34th Specialists.	
W. H. Carter ..	Canterbury Infantry.	
L. J. Comrie ..	Sergeant-Major, 36th Reinforcements.	
V. C. Davies ..	Regimental Sergeant-Major, 1st N.Z. Rifle Brigade	
W. Earnshaw ..	Engineer Lieut.-Commander, R.N.	
C. J. Freeman ..	N.Z. Rifle Brigade.	
C. Freyberg ..	Lieutenant, West York (Prince of Wales's Own) Regiment.	
J. G. B. Fulton ..	Corporal, 10th Reinforcements.	
H. E. Girdlestone..	Company Sergeant-Major, Wellington Infantry	Killed in action.
H. Hamilton ..	Sub-Lieutenant, Royal Naval Volunteer Reserve	
C. G. Johnston ..	Lieutenant, 1st N.Z. Rifle Brigade	Killed in action
G. W. King ..	Lieutenant, N.Z. Tunnelling Company.	
E. Marsden ..	Major (temp.), N.Z. Engineers	M.C.; mentioned in despatches.
J. M. Mason ..	Lieut.-Colonel, N.Z. Medical Corps.	
D. McKenzie ..	Trooper, Wellington Mounted Rifles.	
H. M. Millar ..	Sergeant, N.Z. Engineers' Divisional Signalling Company.	
W. L. Moore ..	Captain, N.Z. Field Artillery	Mentioned in despatches.
T. D. M. Stout ..	Lieut.-Colonel, N.Z. Medical Corps	D.S.O.
R. M. Sunley ..	Corporal, Specialists.	
W. M. Thomson ..	Captain, N.Z. Medical Corps.	
H. S. Tily ..	Sergeant, N.Z. Field Artillery.	
H. Vickerman ..	Major, commanding N.Z. Tunnelling Company	D.S.O., O.B.E.; mentioned in despatches.
C. J. Westland ..	Corporal, N.Z. Machine Gun Corps.	
	Auckland Institute.	
F. L. Armitage ..	Captain, N.Z. Medical Corps.	
S. B. Bowyer ..	Gunner, N.Z. Field Artillery.	
R. Briffault ..	Captain, N.Z. Medical Corps.	
P. H. Buck (Te Rangi Hiroa)	Major, N.Z. Medical Corps	D.S.O.
S. Cory-Wright ..	Captain, N.Z. Engineers, Divisional Intelligence Officer	M.C.
W. J. Crompton ..	1st Battalion, Otago Regiment.	
F. N. R. Downard	Lieutenant, N.Z. Rifle Brigade.	
G. Fenwick ..	Captain, N.Z. Medical Corps.	

Roll of Honour—*continued.*

Name.	Available Details of Service.	
	Auckland Institute—*continued.*	
R. H. Gunson ..	Lieutenant, Motor Boat Reserve.	
G. H. Hansard ..	Sergeant-Major, 33rd Machine Gun Corps.	
D. Holderness ..	Lieutenant, N.Z. Engineers.	
R. T. Inglis ..	Captain, N.Z. Medical Corps.	
J. C. Johnson ..	Captain, N.Z. Medical Corps.	
C. W. Leys ..	Lieutenant, Royal Naval Volunteer Reserve.	
K. Mackenzie ..	Captain, N.Z. Medical Corps.	
H. A. E. Milnes ..	Lieutenant, Auckland Infantry Regiment ..	Killed in action.
W. R. B. Oliver ..	Corporal, Canterbury Infantry.	
G. Owen ..	Lieutenant, N.Z. Rifle Brigade and N.Z. Engineers.	
A. C. Purchas ..	Major, N.Z. Medical Corps.	
E. Robertson ..	Captain, N.Z. Medical Corps.	
C. B. Rossiter ..	Captain, N.Z. Medical Corps.	
T. C. Savage ..	Captain, N.Z. Medical Corps	Died of sickness.
Rev. D. Scott ..	Chaplains Department, N.Z. Expeditionary Force.	
H. L. Wade ..	Captain, Auckland Mounted Rifles.	
F. Whittome ..	Corporal, N.Z. Rifle Brigade.	
	Philosophical Institute of Canterbury.	
H. Acland ..	Colonel, N.Z. Medical Corps.	
G. E. Archey ..	Captain, N.Z. Field Artillery.	
J. W. Bird ..	Sergeant-Major, Instructional Staff.	
F. J. Borrie ..	Captain, N.Z. Medical Corps.	
F. M. Corkill ..	Captain.	
William Deans ..	Captain, Canterbury Mounted Rifles.	
A. A. Dorrien-Smith	Major.	
A. Fairbairn ..	Captain.	
H. D. Ferrar ..	Trooper, N.Z. Mounted Rifles.	
C. E. Foweraker ..	Corporal, N.Z. Medical Corps.	
F. G. Gibson ..	Captain, N.Z. Medical Corps.	
J. Guthrie ..	Captain, N.Z. Medical Corps.	
W. Irving ..	Captain, N.Z. Medical Corps.	
L. S. Jennings ..	Captain, Otago Regiment	Killed in action.
H. Lang ..	2nd Lieutenant, N.Z. Rifle Brigade ..	Killed in action.
E. Kidson ..	Captain, Royal Engineers.	
G. MacIndoe ..	Signaller, Otago Infantry Brigade	Killed in action.
P. S. Nelson ..	Private, Canterbury Regiment	Killed in action.
F. S. Oliver ..	Sergeant, Headquarters Instructional Staff.	
H. V. Rowe ..	Sergeant-Major, Headquarters Instructional Staff.	
Sir R. H. Rhodes	Colonel, Red Cross Commissioner.	
A. Taylor ..	Captain, N.Z. Veterinary Corps.	
G. T. Weston ..	Lieutenant, Canterbury Regiment.	
F. S. Wilding ..	Captain, N.Z. Field Artillery.	
J. P. Whetter ..	Captain, N.Z. Medical Corps.	
A. M. Wright ..	Captain, N.Z. Medical Corps.	
	Otago Institute.	
S. C. Allen ..	Captain, N.Z. Medical Corps.	
R. Buddle ..	Surgeon, H.M. Ships "Crescent," "Cumberland," and "Warwick"	Mentioned in despatches.
L. E. Barnett ..	Lieut.-Colonel, N.Z. Medical Corps	C.M.G.
F. C. Batchelor ..	Lieut.-Colonel, N.Z. Medical Corps.	
Rev. D. Dutton ..	Chaplain, N.Z. Expeditionary Force.	
A. Mackie ..	Sergeant, N.Z. Expeditionary Force ..	M.M.
E. J. O'Neill ..	Lieut.-Colonel, N.Z. Medical Corps	C.M.G., D.S.O

Roll of Honour—*continued.*

Name.	Available Details of Service.	
	Otago Institute—*continued.*	
T. R. Overton ..	Lieutenant, N.Z. Pioneers.	
H. P. Pickerill ..	Lieut.-Colonel, N.Z. Medical Corps	O.B.E.
R. Price ..	Major, Otago Infantry	Killed in action.
E. F. Roberts ..	Captain, Royal Engineers.	
S. G. Sandle ..	Major, N.Z. Expeditionary Force.	
F. H. Statham ..	Major, Otago Infantry	Killed in action.
W. D. Stewart ..	Lieutenant, Otago Infantry.	
W. A. Thomson ..	N.Z. Machine Gun Corps.	
R. N. Vanes ..	Lieutenant, N.Z. Expeditionary Force.	
D. B. Waters ..	Captain, N.Z. Tunnelling Corps.	
H. F. H. Whitcombe	Gunner, N.Z. Field Artillery.	
	Manawatu Philosophical Society.	
E. C. Barnett ..	Captain, N.Z. Medical Corps.	
D. H. B. Bett ..	Captain, N.Z. Medical Corps.	
A. A. Martin ..	Major, N.Z. Medical Corps	Killed in action.
J. Murray ..	Lieutenant, Auckland Infantry.	
H. D. Skinner ..	Private, Otago Infantry	D.C.M.
W. R. Stowe ..	Major, N.Z. Medical Corps.	
	Hawke's Bay Philosophical Institute.	
H. F. Bernau ..	Captain, N.Z. Medical Corps.	
J. P. D. Leahy ..	Major, N.Z. Medical Corps.	
E. F. Northcroft ..	Corporal, 41st Reinforcements.	
E. G. Wheeler ..	Corporal, Wellington Regiment.	
G. T. Williams ..	Wellington Mounted Rifles	Died of sickness.
	Nelson Institute.	
F. A. Bett ..	Captain, N.Z. Medical Corps.	

Note.—The roll is as complete as it has been found possible to make it. The Editor would be glad to be notified of any omissions or necessary amendments.

PRESIDENTIAL ADDRESS.

THE following is the presidential address delivered before the New Zealand Institute Science Congress, Palmerston North, on the 28th January, 1921, by Thomas Hill Easterfield, M.A., Ph.D., F.I.C., F.N.Z.Inst., Director of the Cawthron Institute of Scientific Research, and Emeritus Professor in Victoria University College:—

LADIES AND GENTLEMEN,—Our meeting to-night is saddened by the absence of two of our members whose names are familiar to you all: I allude to the late Sir David Hutchins and Mr. Kenneth Wilson. It was the intention of Sir David Hutchins to read a paper on forestry at this Congress. His whole life had been devoted to the study of forest problems in Africa, India, Australia, and New Zealand, and the fact that our Dominion has at last adopted an active forest policy is in no small measure due to his persistent advocacy of this step.

Mr. Kenneth Wilson was one of the founders of the Manawatu Philosophical Society, and its first President. He was for many years a member of the Board of Governors of the New Zealand Institute. That the present meeting is being held in Palmerston North is largely due to his efforts.

Addressing, as I am, an audience containing but few with an intimate knowledge of the science which has been my life-study, I decline to weary you by attempting any account of the progress made in chemistry or in any branch of it. I have therefore chosen as the subject of my address "Some Aspects of Scientific Research."

At an early stage in the history of the human race man must have learnt that knowledge is the equivalent of power, and that the acquisition of new knowledge is of great importance in the struggle for existence. It is not probable that the idea of systematic experiment was common—indeed, the idea is still foreign to the conception of the average man. It would be natural for the first systematic observations to be made on the apparent movements of the heavenly bodies—the most systematically recurring of all natural phenomena. The fact that the orientation of the starry heights is definite for the seasons of the year could not long have escaped observation, and a practical interest would thus be added to the study of the heavens. It is probable that the arrangement of the constellations much in their present order was carried out in Babylonia at least three thousand years before the Christian era. In no other branch of knowledge have early observations of the same degree of exactitude remained on record.

From many points of view agriculture must be regarded as the most important of human activities, and at a very early stage man must have been faced by the problems of the soil. Experience gained by long observation must have taught that certain crops will thrive only under certain more or less narrowly defined conditions of soil, season, and climate. How far the early agricultural knowledge was due to chance observation, and how far to direct experiment, we shall never know. Even in the Stone Age much agricultural knowledge had been accumulated, for both wheat and barley occur in those interesting pile dwellings, the remains of the villages of the neolithic lake-dwellers of Switzerland.

Chemistry may still be defined as the study, in the widest sense, of the properties of substances, and the foundations upon which modern chemistry has risen must have been laid in a period of remote antiquity. The pursuit of the discovery of the philosopher's stone and of the elixir vitae made alchemists and iatro-chemists acquainted with the properties of substances which otherwise might have been ignored, and even the art of the poisoner must have extended knowledge in a like direction.

Illuminating as is the study of the old-time knowledge, it seems to teach that the principles of scientific inquiry were understood by very few of the ancient observers. Such ingrained ideas as that astronomy is inseparable from astrology, or chemistry from witchcraft, or, again, that nature's riddles may be solved by ingenious argument without appeal to observation or experiment, militated greatly against the development of accurate knowledge. Only after the arrival of that indefinite period of transition known as the Renaissance would it appear that the pursuit of knowledge for its own sake became common—or, indeed, that such pursuit was regarded as legitimate. Even amongst civilized peoples of the present day the proportion of persons who show any real desire to learn more of the laws of nature than is already known is not very large, and the announcement of some important discovery in physics, chemistry, or biology receives but little notice from the general public. It may be that the desire for knowledge is latent in every human being, but that owing to our so-called civilization, or to some failure in our systems of education, the smouldering fire is seldom fanned into burning flame. Possibly the extension of those very clever researches in education which have been so energetically carried out in America during recent years may show us how to make every pupil interested in at least one branch of knowledge, and thus materially change the attitude of the public towards science and scientific research.

The sixteenth, seventeenth, and eighteenth centuries provided an ever-increasing number of intellectual workers prepared to devote time and labour to exact scientific investigation. The idea of quantitative measurement became more general; new instruments were invented, such as the microscope and telescope, the thermometer and barometer, and these assisted greatly in further discovery and in the elaboration of a new technique. The establishment of botanic gardens assisted and stimulated the systematic study of plants. The seventeenth century saw the foundation of the Royal Society of London, and of the Academies of Science in Rome, Florence, Paris, and Berlin. This period also marked the triumphs of William Harvey, Francis Bacon, Robert Boyle, Isaac Newton, Descartes, Huygens, Malpighi, and Leeuwenhoek.

The eighteenth century was very prolific not only in scientific discovery, but also in its technical applications. Linnaeus and de Jussieu published their botanical systems; John Hunter raised surgery to the rank of a scientific profession; James Hutton founded the science of geology, Werner and William Smith the cognate science of palaeontology; Joseph Priestley discovered oxygen and ammonia, whilst Scheele, the brilliant Swedish apothecary, prepared chlorine and glycerine, citric, tartaric, oxalic, lactic, prussic, and uric acids; Henry Cavendish showed the chemical nature of water, and determined the mass of the earth; Lavoisier explained clearly the nature of combustion; John Robison and Volta observed the phenomenon of the electric current, and William Nicholson that of electrolysis.

Amongst the technical applications of this period John Roebuck and Le Blanc respectively established the manufacture of sulphuric acid and soda, the key industries of the heavy chemical trade. James Watt revolutionized all manufactures by giving a practical form to the steam-engine and placing the theory of this prime mover upon a sound basis. The general adoption of steam-power necessitated a great increase in the number of skilled mechanics, and thus facilitated the production of all kinds of scientific instruments. In 1798 William Murdoch erected the first gas-works; by the end of the next century the capital invested in gas undertakings in the United Kingdom represented a sum of more than £100,000,000.

Of the achievements of science during the nineteenth century I shall say little — the subject is too vast to allow of any survey to-night. I would, however, point out that whereas at the beginning of the period there were no schools or universities in Great Britain at which provision was made for the practical study of the sciences, there are now but few secondary schools in the Empire at which experimental science in some form is not taught. The University of Cambridge introduced an honours examination in the sciences in 1851, and there were nine successful candidates, of whom one, my old master, Professor Liveing, is still a distinguished member of the University. In 1900 there were 136 successful candidates for this examination, and at the present day the "Natural Sciences Tripos" is the largest of the Cambridge honours schools.

Before any experimental research is commenced, a careful study and verification should be made of the statements due to earlier investigators. First of all the latest text-books are consulted—and I regret to say that generally they do not give much help. Then a systematic research is made amongst the original papers published in the scientific journals throughout the world. The neglect of this study and checking of the work of previous authors has caused much delay in the progress of science, and has led to much waste of time in work upon problems which had already been elucidated. I would remind you that the fundamental law of chemical action discovered by the Norwegian investigators Guldberg and Waage was overlooked for more than twenty years; Mendel's discoveries with regard to heredity remained unknown for thirty-five years; whilst Cavendish's experiment indicating the presence in the atmosphere of the inert gases now known as the Argon group was unnoticed or forgotten for more than a century.

Investigators are therefore greatly handicapped if unable to consult a well-equipped and properly catalogued library containing complete sets of the most important British and foreign scientific journals. There is at present no efficient library of this type in New Zealand, and one of our greatest needs is the provision of such a central library, specially arranged for convenience of consultation, and from which, under suitable safeguards, books could be posted to investigators in other parts of New Zealand. The difficulty of equipping such a library will obviously increase year by year, since the demand for the back numbers of scientific journals increases annually, and every new American and European university endeavours to secure an efficient reference library.

To the workers in the biological sciences good museums are also essential, and I must add my protest to that of former Presidents of this Institute who have pointed out the negligence—in my opinion, criminal negligence—of successive Governments in not providing suitable accommodation for the irreplaceable collections at present buried in the ancient and inadequate wooden buildings of the Dominion Museum in Wellington.

Research consists essentially of the collection of facts, the arranging of these in order, and the arriving at deductions from the statistics thus collected and arranged. It is true that in one science the actual methods adopted may be—in fact, must be—very different from those employed in some other science. Thus in zoology the facts are arrived at by such methods as the observation of animals in their natural habitats, the dissection of animals, the study of their embryology, and the examination of the histological characters of animal tissues; whereas in chemistry research consists largely of the preparation of new compounds, the determination of their composition, physical constants, and other properties, and the study of the nature of the changes which occur when substances are brought into contact under different physical conditions. When sufficient facts have been collected it becomes possible for some generalization to take place, the accuracy of which can be tested by further experiments suggested by the generalization. This generalization we call a "theory" or "hypothesis," and if all deductions based upon the hypothesis are found to be in accordance with fact the theory is accepted as a general guide for future work until facts are discovered which force upon us the rejection or modification of the theory. A theory is thus to the scientific experimenter what a map is to the explorer. If the map is wrongly drawn the explorer will soon find himself in difficulties. If the errors are only small the map will be of use as a sketch-map, but the explorer will learn not to rely upon it for points of detail. So also an hypothesis, which is the incomplete expression of a sound principle, may be of considerable use, in that it will indicate much which would not be foreseen without it. Eventually, however, it will be found wanting, since it is not a strictly true representation, but only allows us to "see as through a glass, darkly." Again, just as a correct map may be misinterpreted, so also a strictly accurate hypothesis may through unsound reasoning lead to deductions which are quite unwarranted. Theories, then, are of great practical utility; indeed, rapid practical development usually follows each great advance in theoretical conception.

It is obvious that research work may be undertaken either from a desire for knowledge itself or in order that the knowledge may be turned to some economic use. Research undertaken with the latter object is commonly spoken of as "technical research," and undoubtedly its prosecution is looked upon by the public with far more sympathy than is the research based upon a desire for knowledge alone. Whilst not deprecating in any way the technical application of scientific knowledge, I believe that the view of the public, that technical research is of more importance than research carried out with the object of increasing our knowledge of the laws of nature, is fundamentally wrong, for it cannot be too strongly emphasized that in every science the greatest advances which have been made, and which have led ultimately to the most important technical developments, have usually been those which were carried out by seekers after truth with regard to the laws of nature, and not to those who expected commercial returns from their investigations. On the other hand, I would enter my protest against the views of those who scoff at their fellow-workers when attempting to apply scientific knowledge to commercial development and to the benefiting of mankind. It has been my privilege to study under some of the greatest scientific thinkers in Great Britain and on the Continent of Europe, and I can say that, though most of these men devoted their labours to the elucidation of nature's laws, they were ever ready to take an interest in the application of their discoveries to useful ends, and to encourage their students to accept positions in which scientific knowledge could be applied to the solution of the problems of the factory and the workshop. No greater example of this can be quoted than that of the late Emil Fischer, whose death in 1919 caused sorrow in all scientific circles. Though the first of the so-called aniline dyes was prepared by William Henry Perkin in 1856, the real chemical nature of these substances remained a mystery until Fischer unravelled the tangled skein in 1878, after which he was offered a very lucrative post as director of research in one of the most important of the German aniline-dye factories. This offer he refused, preferring the small salary of a university professor and the control of a school of scientific research. It is interesting to note that researches on coal-tar colours no longer occupied his attention, but that the remainder of his life was chiefly devoted to the study of substances playing an important part in animal and vegetable physiological processes. His next achievement was the placing of the uric-acid group upon a satisfactory basis; for, though uric acid had been discovered so long ago as 1770 by the great Swedish chemist Scheele, the number of its later-prepared derivatives being legion, and though many facts concerning the group were known, the key had yet to be found before the relationship between these substances could be understood. From uric acid Fischer passed to the sugar group, then to the proteins, and lastly to the tannins. The story was the same in each case. These four groups are of immense importance in the chemistry of the plant and animal kingdoms. In each case confusion reigned supreme before the group was investigated and brought into an orderly system by the great investigator. No one could accuse Fischer of the degradation of chemical research by turning his great talents to mere commercial problems; and yet I do not think I have ever met a man who more acutely realized the value of technical research for the people. He was always sympathetic with the manufacturer, and large numbers of his students found occupation as research chemists in the great chemical factories of the world. During the war his energies were naturally largely devoted to war problems. He warned the Westphalian manufacturers of the inefficiency of the steps they were taking in the matter of nitrogenous products for high explosives, and was rebuffed by the military authorities. At his instigation a Food Commission was established in Germany, and he fearlessly warned the authorities that military victory was of less importance than the health of the people, which could not be maintained with the inadequate food-supplies. I instance Fischer because he was the greatest organic chemist of his age, but all other great investigators whom I have known have shown a similar attitude towards the technical applications of science.

My own opinion is that it is impossible to differentiate sharply between pure and applied science. He who works out the life-history of a minute insect or obscure plant is adding to our store of entomological or botanical knowledge. He may, however, be throwing light, though unwittingly, upon some great agricultural problem. Are we to consider that the science is "pure" if no immediate economic result follows, and "applied" if our discovery turns out to be of economic importance? Michael Faraday cannot have conceived of the technical importance of his investigations when he succeeded in the liquefying of gases, or when he discovered benzene, or when he enunciated the laws of electrolysis, or even when he discovered the remarkable phenomena of electro-magnetic induction. Yet upon each of these discoveries not one but many great industries have been founded.

Training in the methods of pure science is regarded by many eminent technologists as the best foundation for technical practice. I would remind you that the detection of the German guns on the western front, and their accurate location before the great advance of 1918, was due to the application of his electrical knowledge by a young Cambridge graduate of Australian birth, whose research work up to the time of the war was of a strictly scientific character.

For the progress of science in New Zealand there is great need for a strong spirit of research to permeate the community. In every trade, in every profession, in our social relationships and religious questionings, a more burning desire for knowledge of the whole truth is required.

It is a matter for regret that such a small proportion of the students entering our University colleges become investigators. If we attempt to assess the blame, I do not think we can put any considerable portion of it upon the professors, for in general a professor of science has his time so fully taken up that it is only by extraordinary effort that he can himself get any serious amount of research work done. Yet experience shows that only those teaching institutions become important centres of research activity in which the professors are devoting their main interest to scientific inquiry, and the direction of such inquiry on the part of their students. One contributing cause in some of our University colleges is that too much of the instruction is given in the evening, with the philanthropic object of enabling those who are working by day to receive instruction outside of working-hours. Excellent as this practice is from one point of view, it is not in the interests of national efficiency, and it appears to be based upon the supposition that it is more important to give opportunities to all than that it is of the greatest importance to the State to have in the community a supply of highly trained scholars. " These things ought ye to have done and not to have left the other undone " is a maxim as true to-day as when it was first spoken.

A point which I should like to stress is that we have great need at the present day for investigators who can carry on researches in the borderland between the different sciences. How seldom we meet a biologist who can understand the researches of a chemist, or a chemist who similarly can appreciate the work of a biologist! Yet there is an immense amount of work to be done in the borderland between chemistry and biology, and for this work to be successful the investigator's theoretical and practical knowledge of both of these sciences must be of a very high order. Distinguished physiologists have assured me that the greatest hindrance to research in their departments was the fact that so few of the students desiring to carry out research had attained facility in the technique of the chemical laboratory, and that familiarity with theoretical chemistry which allows of the thinking without effort in terms of chemical phenomena. I believe that all great investigators now recognize that it is impossible for any one science to stand alone, and the difficulty which faces the educator in scientific subjects is to combine breadth of outlook with specialized knowledge in the short period which can be given to a student's training. Several solutions of this difficult problem have been suggested. One is that an effort should be made to teach each subject more rapidly, by eliminating all unnecessary detail. From the examination point of view this system might be perfect, but I have great doubts as to whether the hastening-up of the acquiring of scientific knowledge by such a method can be effected satisfactorily. Time is essential for the absorption of ideas, and if the ideas are to take root and be fruitful of results the student must regard each principle from a large number of standpoints. He must discuss it with his fellow-students, and he must perform many experiments. Having made this criticism, I suggest that it would be of great interest if the teachers of some one science were to agree to carry out a series of experiments extending over several years, and checked by a constant comparison of observations, in order to ascertain the quickest way in which that science could be taught effectively. I am not certain that either the students or the Councils of the University colleges would welcome a research on the lines which I have suggested.

A second suggestion which has been made is that a longer course of study should be demanded from those who proceed to a science degree in the University. A change of this kind has been made in medicine, the length of study having been lengthened from four to five and then from five to six years. Obvious objections to such a course are the greatly increased expense to the student, and the fact that so many of those who work for a science degree do not intend to become scientific specialists, being satisfied to attain the comparatively low standard demanded of the science master in the secondary school. If there were more openings in this country for well-trained scientific men there is little doubt that many students would be prepared to undergo a longer and more intensive period of training.

Still another suggestion which has been made is that more attention should be paid to the teaching of science in the secondary schools. In some of the schools in New Zealand the science teaching is well done; in others, however, it is certain that the subject receives the "cold shoulder." With the large number of subjects which enter into the secondary-school curriculum, it could only be by very careful organization and excellent teaching that the average boy could obtain such a grounding in science as would allow him to hasten through the University course of instruction with greater rapidity than is the case at present.

No institution has done as much as the New Zealand Institute for the encouragement of scientific research in this Dominion. Established in 1867 by an Act of the General Assembly, the Institute bound together the philosophical societies already in existence in different parts of New Zealand. The preamble of the Act states that it is expedient to promote the general study and cultivation of the various branches and departments of science, literature, and philosophy—in other words, to encourage the advancement of every branch of knowledge. The first volume of the *Transactions* of the Institute was published in May, 1869, and contained articles on geology, ethnology, chemistry, zoology, geography, and engineering; such practical subjects as gold-extraction, the preparation of New Zealand flax, the smelting of Taranaki ironsand, and experiments with hydraulic mortar are amongst the articles; so that, as at the present day, the philosophers of that time interested themselves with subjects of both theoretical and practical importance. I trust that this interweaving of science with practice will always continue amongst the scientific men of this Dominion. I am glad to be able to tell you that though for fifty years the Government grant to the Institute remained at £500 it has this year, on the recommendation of Sir Francis Bell, been increased to twice that sum. Unfortunately, the cost of printing the *Transactions* has increased in almost equal proportion, so that the balance left for work in other directions is still small.

The New Zealand Institute exists, then, mainly for the encouragement of scientific investigation; and the medium which the *Transactions* of the Institute provide for publishing the results of scientific observations has done much to stimulate those who, without this encouragement, would never have gone on with their researches. The Institute has lost no opportunity of placing before Cabinet, and other authorities, the need for some definite policy in connection with research work in New Zealand.

Until a few years ago no help could be obtained for the financing of any researches in this country. On the representation of the Institute a research grant of £250 was in 1917 placed on the estimates by the Hon. G. W. Russell. This amount is now increased to £2,000, but is small in comparison with the large quantity of work which ought to be carried out. During the war the Institute conferred with a number of bodies interested and drew up a scheme for the advancement of scientific and industrial research. After slight modification by the Efficiency Board, the proposals were forwarded by the Chairman of that body to Cabinet with a very strong endorsement. I understand also that the general principles of this scheme were approved in the report of the Industries Commission; but effect has not yet been given to the recommendations, which involved an annual expenditure of some £20,000 for the first five years. I know that the matter has received the sympathetic attention of the Minister of Internal Affairs and of the Minister of Education, and that other members of Cabinet recognize the importance of taking action in this matter. New Zealand spends half a million annually on national defence—it is a wise insurance-premium against attack from our enemies. Would it not be wise to also spend one-tenth of this sum annually on research as an insurance against disaster due to ignorance? None of the money spent on defence can be revenue-producing, but funds spent upon a wisely-directed scheme of scientific and industrial research could not fail to increase the efficiency of our primary and secondary industries, to develop our natural resources, and to add to our national wealth and prosperity. I see little hope of removing the crushing financial burden left by the war unless a determined attempt is made to ascertain the extent of our resources and to develop them upon the practical lines indicated by scientific investigation.

I trust that an efficient national research scheme will soon be agreed to by Parliament, that no attempt will be made to differentiate between the claims of pure and applied science, and that provision will be made—

(*a*.) For the encouragement of research in all the scientific Departments of the Government; for I am certain that, great as are the results that have been accomplished by those Departments, still more would have been achieved if, in the Departments concerned, a number of scientific men had been employed whose time was given entirely to the solving of problems, men who were completely freed from ordinary routine work. It is, I think, quite evident that a scientific officer whose time is almost wholly taken up with routine work, and who attempts research work during the time when the pressure of the routine work slackens, can have but little chance of giving such an amount of thought and concentration to the problems as will ensure a high standard of efficiency. The economic results which would be obtained if really first-class investigators were employed in the way which I have mentioned would far more than justify the expense which would be involved.

(*b*.) For enabling the University colleges to become real living centres of research activity. Indeed, I should be glad to see the carrying-out of research work regarded as the most important duty of a University professor. This would involve the giving of more assistance to him in his teaching, and the better equipping of the college laboratories.

(*c.*) For providing facilities for research in every institution in which problems are being seriously attacked. Such institutions should receive sympathetic aid from the State. The Fish-hatchery at Portobello, in which investigations are being carried on with the object of conserving and improving the supply of fish for the whole of New Zealand, is an institution which is worthy of much help. The Cawthron Institute, too, in which researches are carried out on such technical subjects as soil-chemistry, the diseases of crops, the control of insect pests, and the utilization of waste products, could not in fairness be overlooked.

(*d.*) For the continuing of the present system of grants to private workers, a class which has contributed a very large proportion of the scientific papers published in the *Transactions* of the Institute.

I am of the opinion that a very grave mistake will be made if in any general scheme for research the New Zealand Institute, which for so many years has devoted its attention to this problem, is not given a place of great prominence.

One fact which greatly militates against the advancement of science in New Zealand and the production of a continuous output of expert research work is the lack of employment for qualified graduates when they leave the University. One of the most admirable points in the New Zealand University system is that for a candidate to obtain honours in any science he must, in addition to the examination, present a thesis containing the result of his own original work. The obtaining of the M.Sc. degree, then, is to some extent a guarantee that the science graduate has reached the research standard, and I can certify that the work which has been presented by many of the candidates in chemistry has been very good indeed. When, however, the graduate leaves the University he generally finds it difficult to obtain in New Zealand a position in which his advanced knowledge can be employed, and the more enterprising amongst these men leave the country, and, as a rule, do not return. No community can afford to lose a large proportion of its best talent, and it is little consolation to know that many of these men are now holding positions of distinction in England, India, America, and Australia. I am sure you will be pleased to know that all the professors of chemistry in New Zealand are University graduates who have returned to their native land after post-graduate study in England or on the Continent of Europe. Although we can scarcely hope to retain the most brilliant of our graduates—men of the calibre of R. C. Maclaurin and Ernest Rutherford—nevertheless many would return to New Zealand if some systematic attempt were made to provide suitable employment for them. It would, I believe, be in the interests of the whole country if a certain number of Civil Service appointments were made annually of honours graduates, who would be attached to specified Departments as research officers, and who would carry out investigations under the direction of the scientific head of the Department. A condition of these appointments should be that the officers must not be called away to do ordinary routine work when the Department became short-handed, but that they should devote themselves to the researches which they were undertaking, and to no other work. In agriculture alone there must be many problems which could be worked out under the direction of the Dominion Agricultural Chemist or Biologist. The Dominion Analyst, too, could, I am sure, find important researches for a number of these investigators. If these officers proved efficient, facilities should be given for them to rise to positions of high salaries, for their work for the nation would be of extraordinary value. Difficulties would no doubt be met in establishing such a scheme, but I am convinced that if the scheme were properly organized great results would follow. Something has already been done by the Civil Service Commissioners in insisting that the cadets in the scientific Departments shall attend University classes at the expense of the State, and that their grading shall to some extent be influenced by the progress which they show in their University work. Some of these men are already showing great promise of becoming investigators and I do not doubt that the system will give great opportunities to many cadets who would otherwise have little chance of securing a sound scientific education. One great advantage of the system is that, since these young men are mostly taking the full B.Sc. course, which involves the study of four sciences and the acquisition of a reading knowledge of at least one foreign language, they are obtaining a far greater breadth of outlook than could otherwise be the case.

Science during the last two hundred years has revolutionized the state of our knowledge. It has contributed more than any other factor to our material wealth. It has shown us the nature of disease, and has placed in our hands in large measure the means whereby disease can be combated. The scientific discoveries of Mendel are of far-reaching importance. They have widened our ideas of the origin of species, and their practical applications have produced results of great value to agriculture. Dalton's introduction of the chemical, in contradistinction to the metaphysical, conception of the atom formed the basis upon which the magnificent edifice of nineteenth-century science was based. The idea of a spatial arrangement of atoms hinted at by Wollaston and formally enunciated by Le Bel and Van't Hoff as an outcome of Pasteur's researches on asymmetry opened up a new science of stereo-chemistry, the importance of which to modern physiology is becoming daily more apparent. The new sciences of radio-chemistry and physics have shown, through the work of Bragg and Rutherford, not only how the atoms are arranged in crystalline substances, but also the structure of the atoms themselves. Can we doubt that the practical outcome of these investigations will be a harvest as important as that which followed the implanting of the Daltonian idea? The application of mathematics to the simple electrical ideas of Faraday has opened to us, through Clerk Maxwell and his successors, an almost limitless field of work for the physicist and electrical technologist, and wireless telegraphy is but one outcome of Maxwell's conceptions.

The race for the future must be largely a race for the acquisition from nature of her many secrets. Are we in this country to take our fair share in the work, or shall we wait for it to be done elsewhere, in the hope that we may benefit by the labours of other nations, without ourselves taking part in the necessary sacrifice? If this latter niggardly attitude is to be assumed, we must, as a nation, expect to sink into obscurity. New Zealand's problems should be attacked by New-Zealanders, and the work must be carried out in New Zealand and not in other countries. I emphasize this point, for the absurd view has been put forward that our scientific problems should be attacked for us by non-resident scientists. Such men could have little understanding of the nature and environment of our difficulties compared with that which would inspire our own investigators. Their results could not appeal to us in the same way as research carried out in our own forests, fields, and laboratories. Questions occasionally arise for the answering of which the help of outside specialists must be called, but this is no argument in favour of refusing to adopt a self-reliant policy and to undertake the solution of our own problems. In no spirit of narrowness I appeal for active support and sympathy on behalf of the scientific workers of New Zealand, knowing well that national progress will be influenced deeply by the extent to which this sympathy and support are given or withheld.

TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE.

Art. I.—*The Maori Genius for Personification; with Illustrations of Maori Mentality.*

By Elsdon Best, F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 18th May, 1920; received by Editor, 18th May, 1920; issued separately, 27th June, 1921.*]

Of the singular mythopoetic concepts of the Maori folk, and their inner meaning, but little has been recorded. Such information on native myths as is contained in published works is in most cases a bare and hard translation, a soulless rendering of the original that ignores the vivifying spirit of the myth and the teachings that it contains. The spirit that prompted the evolution of such concepts is ignored, or perhaps not understood. The cause of this neglect lies in our ignorance of the mentality of uncultured man, and of his endeavours, in times long past, to seek and explain the origin of man, of natural phenomena, and many other things. In the peculiar plane of mental culture pertaining to such folk as the Maori, such matters are taught in the form of allegorical myths, and the most remarkable feature of such myths is that of personification. At some remote period the Maori strove to envisage primal causes, to grasp the origin of life, of manifestations, and of tangible objects. In these endeavours he trod the path followed by other folk of a similar culture stage, and his mental concepts, his myths, teem with personified forms and with illustrations of animatism. Personifications hinge upon animatism; for given the belief that all natural objects and phenomena possess an indwelling and vivifying spirit, then such a spirit is always apt to develop into a personified form. These primitive beliefs, coupled with that which looks upon all things as having come from a common source, contain the kernel of Maori mythology.

Though the primal being of Maori myth was Io, the supreme god, yet it was not taught that he begat any other being, but, in some unexplained manner, he caused earth and sky to exist. These are personified in Rangi, the Sky Parent, and Papa, the Earth Mother, and these were the primal parents. Their progeny amounted to seventy, all of whom were *atua,* or supernatural beings, and among them was Tane, or Tane the Fertilizer, he who fertilized the Earth Mother, and who was the origin of man, of birds, fish, vegetation, minerals, &c.

All things that exist, saith the Maori, are a part of Rangi and Papa, the primal parents—that is to say, they originated with them. Nothing belongs to the earth alone, or to the heavens alone ; all sprang from that twain, even unto the heavenly bodies that gleam on high, and the heavenly bodies of all the other skies above the one we see : and all those bodies are worlds.

It was taught in the *tapu* school of learning that water is one of the chief constituents or necessities of life. It is moisture that causes growth in all things, other necessary agents being the sun, the moon, and the stars. Lacking moisture, all things would fail on earth, in the heavens, in the suns, the moons, and the stars of all realms. Clouds are mist-like emanations originating in the warmth of the body of the Earth Mother. All things possess warmth and cold, all things contain the elements of life and of death, each after the manner of its kind. It was Tane (personified form of the sun) and Tawhirimatea (personified form of winds) who sent back the mists to earth in the form of rain, as a means of cherishing and benefiting all things, for all things absorb moisture, each after the manner of its kind. Air, moisture, warmth, with various forms of sustenance, were the origin of the different forms around us, of the differences in such forms, as in trees, in herbage, in insects, birds, fish, stones, and soils ; these things control such forms, and their growth. Hence death assails all things on earth, in the waters, in the sun, the moon, and the stars, in the clouds, mists, rain, and winds ; all things contain the elements of decay, each after the manner of its kind.

Again, there is no universal mode of life and growth among all things ; each lives, moves, or grows after the manner of its kind. All things possess a home, or receptacle, or haven of some kind, even as the earth is the home of many things. Even the *wairua* (spirit) has its abode in all things ; there is no one thing that does not possess a spirit or soul, each after the manner of its kind. And inasmuch as each and every thing possesses an indwelling spirit or soul, then assuredly everything possesses the elements of warmth, each after the manner of its kind.

Now, as all things in all the realms of the numberless worlds are so constituted, it follows that the female element pertains to all things. Everything has its male and female element. Lacking the female element, nothing could survive, for by such, combined with moisture, do all things acquire form, vitality, and growth. Warmth is another element by means of which things are nurtured, and earth supports all. Even stone is formed of earth, moisture, and heat, and so endowed with life and growth after the manner of its kind.

Now, as such was the intention of Io (the supreme being)—that is, to arrange the functions of all things—even so the denizens of the heavens were appointed as guardians and directors of all things in all the heavens, on earth, and in the heavenly bodies. The twelve heavens are connected with the moons, but the sun is above all—it is the controller of all things.

Because all things are influenced by good and evil, by anger, jealousy, ambition, and because all follow some form of leadership, even so was it that guardians were appointed to watch each realm and report their condition to Io. And because of the differences that exist in all things, thus it is that all possess strength and weakness, goodness and evil, justness and lack of justice, each after the manner of its kind. Hence the guardians appointed as lords of the eleven heavens, of the earth, and of the spirit world. As these beings appointed as guardians are the salvation of all things by promoting their welfare, and are the emissaries of Io, thus it is that all eyes and all ears are directed to Io-matua, Io the Parent, for he is over all. He is the very acme of all welfare, of life, the head and summit of all things.

Since Io is the head of all things, all things become *tapu* through him, for without a lord nothing can become *tapu*, and so he is termed Io the Parent. Since he is termed Io the Parent, and represents the physical and spiritual welfare of all things, we see that the origin of such welfare is with the parent—that the parent holds and controls the welfare of everything. And since all things are centred in him, there is nothing left to be controlled or directed by any other god or being. All things in the twelve heavens, and in all realms, are thus gathered together before him. It is now clear that there exists nothing that does not come under his sway; all comes under Io the Parent.

All things possess a *wairua* (spirit, or soul), each after the manner of its kind. There is but one parent of all things, one god of all things, one master of all things, one soul of all things. Hence all things are one, and all emanated from Io the Eternal. . . .

It may be thought that the foregoing remarks, which are translated passages from a speech made nearly sixty years ago by a teacher of the *tapu* school of learning, do not embody much information as to personifications, but they do illustrate Maori mentality. They show clearly how the superior minds of a comparatively uncultured folk broke free from shamanism and a belief in malignant deities, and strove to conceive a supreme being of nobler attributes; how the ancestors of the Maori, wrenching asunder the bonds of gross superstitions, and seeking light from the darkness of ages, pressed forward on the difficult path toward monothesim.

Anthropomorphic Personifications.

We have already seen that the heavens and the earth are personified in Rangi and Papa, the Sky Parent and the Earth Mother, from whom all things are descended. They were the primal parents, and appear frequently in Maori myth. The Earth Mother is spoken of as the mother of mankind, as the guardian and nurturer of her offspring. Not only did she give birth to man, but she also produces food for him, and gives shelter to his worn body when the soul leaves it at death. After the rebellion of their offspring the Sky Parent wished to punish them, but the Earth Mother said, "Not so; though they have erred, yet they are still my children. When death comes to them they shall return to me and I will shelter them; they shall re-enter me and find rest." Hence the burial of the dead.

It is probable that many of the offspring of the primal parents are personifications—some certainly are, and these come under the title of departmental gods. All these primary offspring were males, and all were supernatural beings. They numbered seventy, and each had his own province and functions.

The most important of these children of Rangi and Papa, though not the eldest, was Tane, and he was the personified form of the sun, as will be shown in another paper. But Tane was also the Fertilizer — he who fertilized the Earth Mother, and so produced man and vegetation; hence he also personifies the male element, as well as forests, trees, &c. His daughter was Hine-titama, the Dawn Maid, who, on being pursued by Tane (the sun), fled from him, and so passed into Night, the underworld and spirit world. She became ruler of that realm of Night. And ever Tane is begetting offspring (Dawn Maids), who pass through their brief life in the upper world and then retire to the realm of Night. For Hine-titama had said to Tane, "Return, O Tane, to bring forth our children to the world of Light, while I remain here to receive them, for their welfare shall be my care." And ever does the Queen of Night battle with dread Whiro of the world of Darkness in order to protect her charges.

Another daughter of Tane was Hine-rau-wharangi, she who personifies growth in the vegetable world.

Whilst Tane is the personified form of the sun, the common vernacular term for the sun is *ra*, Ra Kura and Tama-nui-te-ra being honorific names for the sun. Tane-te-waiora personifies sunlight. In our crude translations of native myths we render "Waiora a Tane" as "life-giving waters of Tane." This is quite wrong; in this connection *waiora* means sunlight, and it is so called because the Maori taught that the sun is the origin of life. This *waiora* is a concrete expression, not two distinct words, and is closely allied to the words *vaiora* of eastern Polynesia, meaning "to be, to exist." The waning moon does not bathe in life-giving waters of Tane to regain her youth; she bathes in the sunlight of Tane, and so returns to us again young and fair—which may be termed a scientific fact.

The moon is personified in Hina-keha, or Pale Hina, and Hina is a far-spread name for that orb, as also is that of *ra* for the sun, a name that in ancient times was known in Babylonia and Egypt. Hina, being a female, is not included among the children of Rangi and Papa. Rona is the maid in the moon, her full name being Rona-whakamau-tai, or Rona the Tide-controller. Rono, according to Fenton, was a name of the moon god in Assyrian myth. Here we find a parallel in Polynesia, where Rongo, Longo, Lono, is evidently a personification of the moon. This is made clear in Hawaiian mythology, wherein Sina, personified form of the moon (*cf.* Sin of Babylonia), the Hina of New Zealand, on being translated to the heavens took the name of Lono.

Another of the primal offspring was Tu, he who personifies war and its attendant evils; he was an important departmental god. In Assyrian myth Tu represented the setting sun and death, while Ra-tum (the setting sun) was god of death in Egypt, and *ra tumu* denotes the setting sun in eastern Polynesia (Churchill's *Easter Island*, p. 126).

In opposition to Tu of evil fame we have Rongo, another of the seventy brothers, who personifies peace and the arts of peace, such as agriculture, and all fruits of the earth. Hence Rongo is appealed to in peace-making functions, and by cultivators of food products.

Another member of the family was Tawhirimatea, in whom are personified the winds of space. The personifications of wind number about thirty, each representing a different form. These are known as the Whanau Puhi (the Wind family).

Yet another of the brothers is the dread Whiro, he who personifies darkness, death, and evil. In the fierce war that waged between Tane (representing light and life) and Whiro (representing darkness and death) the latter was defeated. Hence he retired to the underworld, where he ever wages war against mankind and drags them down to death, while ever the former Dawn Maid, now Queen of the Underworld, strives against him for the souls of the dead.

In Tangaroa we have the personified form of fish, and he shares with Rona the task of controlling the ocean tides.

Te Ihorangi personifies rain, while Parawhenua-mea is the origin and personification of the waters of earth. The former was one of the primal offspring, but the latter, a female, was one of the daughters of Tane by Hine-tu-pari-maunga, the Mountain Maid; hence the streams seen descending from the great ranges. The offspring of Parawhenua-mea (water) was Rakahore, who represents rock, and who took to wife Hine-uku-rangi, the Clay Maid, and produced the personified forms of stones, such as Hine-tuakirikiri (Gravel Maid), and Hine-tuahoanga (Sandstone Maid), Hine-tauira (a form of flint), and many others. Another of the family was Tuamatua, who took to wife Wai-pakihi (Shoal Water), and begat different forms of stones, and sand.

Parawhenua-mea was taken to wife by Kiwa, guardian of the ocean, which is known as the Great Ocean of Kiwa. But the ocean is personified in one Hine-moana (Ocean Maid).

One Mahuika personifies fire. In the first place, fire emanated from the sun. When Tama-nui-te-ra (honorific name of the sun) decided to confer a benefit on man he sent them fire by, or in the form of, one Auahi-tu-roa (a personified form of comets). Mahuika had five children, and their names are those of the five fingers of the hand. (In Indian myth, Agni, the fire god, had ten mothers, who were the ten fingers of the hands.) These were the Fire Children, or family, and in the myth of Maui we see that Mahuika plucked off one of her fingers and gave it to him as fire. When pursued by Fire, Maui called upon Te Ihorangi (rain) to save him; hence rain fell, and fire fled for shelter to Hine-kaikomako (personified form of the *kaikomako* tree, *Pennantia corymbosa*). Thus is it that when man seeks to generate fire he hews a piece off the body of Hine-kaikomako whereby to procure it. The sister of Mahuika, one Hine-i-tapeka, represents the fire of the underworld—volcanic fire.

Now, the sun has two wives, Hine-raumati, or Summer Maid, the personified form of summer, and Hine-takurua, or Winter Maid, the personified form of winter. The latter is a fisher, and the former a cultivator of food products. The sun dwells half a year with the Summer Maid, and the other half with the Winter Maid. The offspring of the former is Tane-rore, whose dancing is the quivering appearance of heated air in the summer-time. It is personified in Parearohi.

We have in Hine-ata a personified form of morning; of day in Hine-aotea; and of evening in Hine-ahiahi, the Evening Maid. All three are females. This is a Moriori myth.

In Hine-te-uira and Tama-te-uira we have personified forms of lightning, one of each sex; and there are ten other such forms. Tawhaki also seems to be connected with lightning, as also was Mataaho.

Whaitiri personifies thunder, but each kind of thunderstorm has its own personified form, such as Rautupu, Whaitiri-pakapaka, Ku, Ea, Aputahi-a-pawa, Tane-matau, and others. Thunder is often personified in Hine-whaitiri, the Thunder Maid. It will be noted that a considerable number of personified forms are of the female sex. Hine-kapua is the Cloud Maid.

Personifications of the rainbow are Kahukura, Uenuku, and Haere. Uenuku was originally a person of this world. He dwelt on earth, where he attracted one Tairi-a-kohu (personified form of mist), who had come down from celestial regions in order to bathe in the waters of the world. She visited Uenuku only during the hours of darkness, and strictly forbade him to make her known to his people. So beautiful was she that Uenuku felt compelled to disobey her. By a cunning trick he delayed the departure of the Mist Maid, and so exposed her to the people, whereupon she deserted him and never again returned to earth. Uenuku was now disconsolate, and he set off in search of her. He traversed distant regions and many realms, but never again beheld the Mist Maid. Finally death came to him as he still sought her, and his *aria*, or visible form, is the rainbow we see in the heavens. Parallels of this curious myth are widely known in Europe and elsewhere, as shown in the writings of the late Andrew Lang.

A rainbow composed of bands of different colours has as many personified forms, each colour bearing its own name.

Hine-korako is the personified form of a lunar halo or bow.

Personified forms of the comet are Wahieroa, Tunui-a-te-ika, Upokoroa, Auahi-tu-roa, Taketake-hikuroa, Meto, Auroa, Unahiroa, and possibly Puaroa.*

Fire is sometimes termed Te Tama a Upokoroa (the son of Upokoroa, the long-headed one), because the seed of fire was brought to earth by a comet, and hence Mahuika produced the Fire Children. These comet-names are suggestive in their meanings, as "long-headed" and "long-tailed."

Personifications of meteors are Tamarau and Rongomai.

Hine-pukohu-rangi and Tairi-a-kohu are personified forms of mist, and Hinewai represents fine misty rain.

Ruaumoko represents earthquakes. He is the youngest child of the Earth Mother, but never came forth to this world. When he moves within the body of Papa an earthquake results.

Volcanic phenomena are represented by Hine-tuoi, Ioio-whenua, Hine-tuarangaranga, Te Kuku (or Te Pupu), Te Wawau, and Tawaro-nui.

The personified forms of wind and of rain are said to have cohabited, and their issue, twelve in number, represent different forms of snow, frost, hail, and ice.

In Wero-i-te-ninihi, Wero-i-te-kokota, Maeke, Kunawiri, &c., we have personifications of cold, and the first two are also star-names—stars marking winter months.

An old cosmogonic myth is that Te Ao (Day) and Te Po (Night) produced as offspring Oipiri and Whakaahu, or Winter and Summer, who were born in space ; both are females. Oipiri, whose full name is Oipiriwhea, pertains to night, and her name has the same signification as that of Takurua-hukanui, or Cold-engendering Winter ; she produces snow, ice, frost. Whakaahu belongs to the day, or to this world, which she represents. Both of these female personified forms were taken to wife by Rehua, he who personifies the heat of summer. Their attendants are ever contending against each other, but neither side ever gains a permanent victory. This

* Puaroa, *cf.* Pusaloa = comet (Samoa).

illustrates the struggle between summer and winter, which occurs often, but is never final. Tama-uawhiti, also known as Hiringa, represents Whakaahu—that is, summer. He is the same as Tama-nui-te-ra—that is to say, the sun—and he represents desire for knowledge, industry in procuring food-supplies, and other important activities. He is termed *te puna o te matauranga* (the source of knowledge). An old saying is, "*Kotahi tangata ki Hawaiki, ko Whakatau anake; kotahi tangata ki Aotearoa, ko Tama-uawhiti*" (There is only one person at Hawaiki—namely, Whakatau; there is one person at Aoteroa, Tama-uawhiti). This is equivalent to saying, "The most important being at Hawaiki is Whakatau; the most important thing in New Zealand is the sun"—as it probably was to a people coming from the tropics. It is probable that Whakatau is a personification, possibly of winter, for we have a sentence in the above myth that runs thus: "Whakatau was a warrior, equalling Oipiriwhea." We have already seen that Whaitiri, Wahieroa, and Tawhaki, of Polynesian myth, are personifications, and Hema is a name for the south wind at Hawaii.

Whakaahu, Takurua, and Rehua are also star-names, whilst Oipiri seems to be connected with Pipiri, a double star that appears in June.

Tioroa represents winter, and Takurua is employed in a similar sense. Spring is personified in Mahuru.

We have seen that Hiringa (or Tane-i-te-hiringa) represents knowledge, but the acquisition of knowledge and the power of thought, mental activities, are personified in Rua-i-te-pukenga, Rua-i-te-hiringa, Rua-i-te-mahara, Rua-i-te-wananga, &c.

Space is personified in Watea and Rongomai-tu-waho, and misfortune in Aituā.

In personified forms of clouds we have Hine-kapua, Tu-kapua, Aoaonui, Aoaoroa, Uhirangi, and Takerewai, and these all dwell in the house called the Ahoaho o Tukapua (the open space of Tukapua). Here they ever dwell, for they are in fear of Huru-mawake, Huru-atea, Huru-nuku, and Huru-rangi (personified forms of the four winds), fearing to be jostled and swept away to the bounds of Rangi-nui (the heavens).

The two principal personified forms of wind are Tawhirimatea and Tawhiri-rangi. These personified winds in general, but each wind has its own personified form. The personified forms of ice, snow, and frost we have already encountered; they dwell upon the summit of Mahutonga (an emblematical term for the south), in the realm of Pārāweranui. The Wind Children of Tawhirimatea bring hither the semblance of those offspring in the drifting snow and driving hail. One Tonganui-kaea took to wife Pārāweranui (personified form of the bitter south wind) and produced some two dozen offspring, all of whom are personifications of different forms of wind. These are the Whanau Puhi, the Wind Children, who bore Tane to the twelfth heaven when he went to obtain the three baskets of occult knowledge.

The Wind Children abide at the Tihi o Manono, in Rangi-naonao-ariki (the tenth heaven, counting upwards), where also dwell their elder brethren, the personified forms of the four winds—north, south, east, and west. For there dwell Pārāweranui, Tahu-makaka-nui, Tahu-mawake-nui, and the other elders; all live in the houses Pumaire-kura, Rangitahua, Rangi-mawake, and Tu-te-wanawana-a-hau.

The plaza of the Wind Children is known as Marae-nui, as Tahuaroa, as Tahora-nui-atea. It is the *marae* of Hine-moana, the Ocean Maid, the vast expanse of the great ocean. This plaza is the playground of the Wind

Children. To this meeting-place they come from all parts to frolic and gambol on the broad heaving breast of the Ocean Maid. From the frigid south comes Pārāwera-nui, from the blustering west hurries Tahu-makaka-nui, from the east glides Tahu-mawake-nui, and from the fair north comes the *marangai*, while from every intermediate point the younger Wind Children troop forth to hold high revel on their great playground of Mahora-nui-atea, illuminated by Tane-te-waiora, or by the Whanau Marama, the Children of Light that gleam in cloudless skies when Tane has departed.

A list of the many personified forms of wind would be tedious, but some of the more prominent ones were Rakamaomao, Titi-matangi-nui, Titi-matakaka, and those given above.

Tane is the personified form of trees, for a reason already explained, and in this connection his name is Tane-mahuta—for Tane, like the old-time gods of Babylonia, has many names, according to his activities or manifestations.

When engaged in his great search for the female element Tane took to wife many beings, who produced trees. In many instances such beings are viewed as the personified forms of such trees. Thus Mumuwhango represents the *totara*, Te Puwhakahara the *maire* and *puriri*, Ruru-tangiakau the *ake*, Rerenoa the *rata* and all parasitic and epiphytic plants, Hine-waoriki the *kahika* and *matai*, Mangonui the *tawa* and *hinau*, Hine-mahanga the *tutu*, Hine-rauamoa the *kiokio* fern, and so on. Puahou represents the *parapara*, Poananga the *clematis*, while Hine-kaikomako we already know in her character of fire-preserver for mankind. Toro-i-waho represents all *aka* (climbing and creeping plants), Tauwhare-kiokio all tree-ferns, Putehue the gourd-plant, and Haumia the edible rhizome of the bracken.

Te Rara-taungarere seems to represent the fertility of trees and plants, while Rehua was also connected with forests; he is mentioned with Tane in connection with forests (White's *Ancient History of the Maori*, vol. 1, p. 145), and *lehua* was an old Hawaiian term for forest.

Tane, under the name of Tane-mataahi, represents all birds, though Punaweko is said to have been the origin and personification of forest-birds, and Hurumanu the same in regard to sea-birds. One Tane-te-hokahoka is also spoken of as one who brought birds into being; probably this is another name for the great Tane. Rupe personifies the pigeon.

In addition to these major personifications, we have, as in the case of trees, personified forms of different species of birds. Thus Terepunga and Noho-tumutumu represent the *kawau* or cormorant, Parauri the *tui*, Hine-karoro the seagull, Hine-tara the tern, Moe-tahuna the duck, Matuku the bittern, Tu-mataika the *kaka* parrot, Koururu the owl, and others might be given.

In regard to fish, we have Tangaroa, who represents all fish. Tutara-kauika represents whales. Puhi is the personified form of eels, Takaaho of sharks. Te Arawaru represents shell-fish.

Rakahore is the personified form of rock, and Rangahua seems to represent stones. These are the more important beings, but Hine-tuahoanga represents all forms of sandstone, Hine-one all sand. Poutini personifies greenstone in general, and is also a star-name. Hine-aotea, Hine-auhunga, Hine-tangiwai, Hine-kahurangi, Hine-kawakawa, and Tauira-karapa represent different kinds of greenstone, while Whatuaho and Mataa represent obsidian. These will suffice as illustrations.

Even swamps are personified in Hine-i-te-huhi and Hine-i-te-repo. South Island Maori state that Hine-tu-repo was the wife of Maui, and it was she who was interfered with by Tuna or Puhi, personified form of the eel. Maui himself seems to have personified day or daylight; hence his contest with Hine-nui-te-po, of the realm of darkness. Transform the eel into a snake, and in the inner reading of the Maui, Hine, and Tuna myth you have the true version of our borrowed myth of Eve and the serpent. This story also explains why the tail of an eel is known as *hiku rekareka* and *tara-puremu.* The name of the woman is usually given as Hina, a suggestive name.

The glow-worm is personified in Hine-huruhuru and Moko-huruhuru, the earth-worm in Noke, and the lizard in Rakaiora. One Peketua was the origin of lizards, and the first to appear was the *tuatara.* Peketua moulded some clay into the form of an egg, and took it to Tane, who said, "*Me whakaira tangata*" (Give it life). This was done, and that egg produced the *tuatara.* All land-birds were then produced from another egg, fashoned by Punaweko, and sea-birds from yet another, made by Hurumanu. Birds and *tuatara* had a common origin.

Maru is the personified form of some celestial phenomenon. Among the Awa folk of the Bay of Plenty Wainui is a personification of the ocean, and Tahu personifies food.

Though Whiro is the origin of death, &c., yet there are many personifications of different kinds of disease and misfortune. Among them are Maiki-nui, Maiki-roa, Maiki-arohea, Tahu-maero, Tahu-kumia, Tahu-whakaeroero, and Tahu-pukaretu. All these dread beings are the henchmen and agents of Whiro, the evil one. They dwell within Tai-whetuki, the abode of disease and death, which belongs to Whiro, and ever they afflict mankind. Thus does Whiro still continue his struggle against Tane, continuing to slay man, animals, trees—all things of this world that sprang from Tane. Thus is man destroyed in the upper world, and when his spirit reaches the underworld Whiro strives to destroy that also. Had not Hine-titama, the Daughter of Light, descended to the underworld, there to war with Whiro and so rescue the spirits of her children, then they would have been cast by Whiro into Tai-whetuki and Tai-te-waro, there to perish. When men of this world die, their spirits are drawn down to the underworld by Rua-toia and Rua-kumea, and are there received and protected by Hine. For, in the days when the world was young, when Hine fled from Tane, the sun god, her abiding words were, "I go to the lower realm that I may protect our descendants; to the underworld I will draw them down and cherish them; their spirit-life shall be my care. *Maku e kapu i te toiora o a taua tamariki.*"

But ever Maiki-nui and Maiki-roa lurk within Tai-whetuki, the House of Death, while Rua-toia and Rua-kumea convey the souls of men to the care of the Daughter of Light, erst the Dawn Maid.

There are two aspects of Maori myths, or two forms in which they are related. One of these is the common or "fireside" version, the other is the "inner" version, as conserved in the school of learning, and taught only to those entrusted with the task of preserving the esoteric knowledge of the elders of the tribe. These remarks do not apply to ordinary folk-tales, but to what may be termed the higher class of myths. The ordinary version of such myths is known to all members of the tribe, and may be related at any time or in any place. The other version is seldom heard, and is usually unknown to the bulk of the people.

As an illustration of this double aspect, we will take the case of the myth concerning the origin or cause of the ocean tides. The common version is that tides are caused by the inhalations and exhalations of a colossal marine monster known as Te Parata. The school of learning ignored this as a fable, and taught something nearer the truth—namely, that when all realms were being placed under the control of certain guardians the *marama-i-whanake,* or waxing moon, and Rona were appointed to control the tides of Hine-moana (personified form of the ocean). Again, the common version of the story of Rona is that she was transferred to the moon as punishment for having insulted that orb because one night its light became obscured when she was proceeding to fetch a calabash of water. She is yet visible in the moon, with her calabash by her side.

We have also the instance of Tane, whose many names were often inserted in genealogies showing the descent of man from the gods and the primal parents. The inclusion of these names as those of different beings was strongly condemned by the learned. The same remarks apply to Tiki and others.

We have given abundant evidence that the Maori was permeated with the spirit of animism and of animatism—that is to say, he believed in spiritual beings, and also attributed life and personality to things, but not a separate or apparitional soul as in the case of man. Yet the writer has heard statements made to the effect that the Maori possessed no power of abstract thought. Now, if there is one quality that the Maori did possess, it was that power.

In a brief account of Maori personifications it is impossible to give the various myths relating to them or in which they figure. We can only scan the long list and mention the more interesting of such personified forms. The following condensed account of one of the exploits of Tane will, however, serve to show how the wise men of yore handed these myths down, and how they taught racial beliefs to succeeding generations. Tane, the personified form of the sun, is necessarily the origin of light; hence he is spoken of as the enemy or opponent of Whiro, who personifies darkness. After a long contest and many battles on the horizon and elsewhere, darkness is defeated and retires to the underworld, though Whiro still wars against Tane. As the personified form of evil things, he causes his satellites, Maikinui and others, to assail the offspring of Tane, who succumb in their thousands. Tane, as personified form of knowledge, is called Tane-te-wananga; it was he alone who succeeded in ascending to the twelfth heaven, where he obtained from Io the three baskets of occult knowledge, a fact that was bitterly resented by Whiro. The latter, as the elder brother (darkness is older than light), objected to such treasure passing to the younger brother.

When about to make the great ascent, Tane went to Tawhirimatea and Huru-te-arangi and asked them for the services of their offspring, the Wind Children, to convey him to the heavens. The multitude of Wind Children assembled from all quarters to bear Tane to the heavens; from far-distant realms, from the great spaces of Tahora-nui-atea they came. They ascended to the upper regions, to arrive at the Cloud House, whence emerged the Cloud Children to join them in brave array. Now came the multitude of Peketua, the Whanau akaaka, the repulsive ones—insects, vermin, winged creatures—sent by Whiro to attack Tane. But the Wind Children guarded Tane; they furiously assailed the emissaries of Whiro, scattered them, and drove them afar.

Having gained possession of the three baskets of divine or esoteric knowledge—that of good, that of evil, and that of ritual—Tane began his descent to this world. He now assumed the name of Tane-i-te-wananga, as representing all knowledge, as being the fountain and source of knowledge. During his descent he was again attacked by the army of Whiro, and here he is alluded to as Tane-te-waiora, for it was Darkness attacking Sunlight. His attendants called upon the personified forms of wind, snow, hail, &c., who swiftly came and defeated the hordes of Whiro. Some of the latter were captured and brought down to earth, among them being Waeroa (mosquito) Namu-poto (sandfly), Naonao (midge), Ro (mantis), Moko-kakariki (green lizard), Pekapeka, Ruru, and Kakapo (all night-birds). Thus Tane returned safely to this world, bringing with him the great boon of knowledge for the benefit of his descendants, the people of the World of Light.

A study of the mythopoetic tales so frequently met with in Maori lore tends to show that such mental concepts are by no means to be classified as ordinary folk-tales. They are not merely metaphorical discourses or light allegorical fables, but often show that much thought has been devoted to the subject of the myth, to endeavour to discover cause or origin. The myth of Rona (the moon) and the tides illustrates this view, and other instances might be mentioned in which the Maori mind has approached near to scientific truth.

At the same time, man in the culture-stage of the Maori would never state baldly that the moon controls the tides. He must at least personify ocean and moon, for this curious faculty is one of the most remarkable and persistent features in the traditions and occult lore of uncultured peoples. We can even see survivals of such conceptions among highly civilized races, and we still cling to a few of the old-time personifications.

Neolithic man adopted this mode of teaching what he held to be primary truths. Having worked out his crude theories of the origin of the earth, of the heavenly bodies, of natural phenomena, of man, and of many other things, his mentality, strangely affected by long ages of contact with nature and by ignorance of natural laws, proceeded to depict all activities as anthropomorphic beings, and hence the Maori myths we have discussed in this paper. Uncultured man handed down his conclusions as prized knowledge to his descendants; he taught his children these myths, as we teach ours the moral lessons contained in Aesop's fables and in fairy-tales.

A. C. Parker struck at the root of personification when he wrote, "The primitive mind, believing all things the result of some intelligence, personifies and deifies the causes of effects, and thus has arisen the multiplicity of gods and guardian spirits." Thus we have the many manifestations of the activities of Tane, the sun god and fertilizer. Even sunlight is personified in Tane-te-waiora, and in an old song we find the following:—

Ko te ata i marama,
Marama te ata i Hotunuku,
E, ko Tane-te-waiora . . . e.

(Fair dawned the morn,
Bright was the morn at Hotunuku,
Behold! it is Tane-te-waiora.)

Explanatory myths teem in Maori lore, and are a characteristic feature of the peculiar plane of culture to which he had attained. The Maori was a mystic by nature. He ever felt that he was part of a living world in which nothing is truly inanimate. He looked upon Mother Earth as the nourisher of mankind, her offspring; his outlook upon life and upon his surroundings differed much from ours; he possessed a feeling of kinship with nature, and a curious form of mental vitality, utterly unknown to the dweller by city streets.

The curious practice of attributing sex to things that possess none is very noticeable in Maori myths, and we ourselves have retained some survivals of this habit. The Maori held very singular beliefs as to the protective and destructive powers of sex, beliefs that seem to be also held by certain races of India. Animatism is marked by mental concepts of a very strange nature, which in many instances are most difficult to understand; of this fact many illustrations might be given.

These peculiarities of Maori mentality have the effect of making genuine old traditions, recitals, poems, and speeches of much interest, simply because they were reflected in the language of the people. The mythopoetic concepts passed into the common tongue; hence such matter as mentioned above teemed with allusions to personifications, with metaphor and allegory, with aphorisms and occult expressions. Here we encounter in a living language the figurative expressions and quaint sayings in which is preserved the mentality of uncultured man. Here are the fossilized thoughts of long-gone peoples, of past ages, being uttered by persons of our own day.

The better-class Maori was ever careful to acquire a knowledge of tribal history, of myth, tribal aphorisms and poetry, in order to adorn and point his speech. These folk were born orators, most punctilious in their utterance, and their formal speeches were marked by rhythm, by peculiar modes of diction, and by archaic and poetical expressions.

When Whare-matangi took leave cf his mother, Uru-te-kakara, at Kawhia, in setting forth to search for his father, he said to her, "Farewell! Grieve not for me. Should I survive, then the sea-spray will assuredly return me to your side. Two nights hence, look you to the south; should the gleam of Venus be plainly seen, it will be my token to you that I have safely reached my destination. If you see it not, then know that Aitua has struck me down, by the hand of man or by Maikiroa. Then do you send me kindly greeting by means of the *kura awatea*,* that I may be comforted by it in Rarohenga" (the spirit world).

When Ngarue and his wife were separated, and he departed for Taranaki, he said to her, "Farewell, the breast-clinging spouse! Shame gnaws at me like unto the gnawing of the Ocean Maid into the flanks of the Earth Mother. It is like a fire burning within me. Even my love for you pales before it. Farewell! Remain at your home with your elders. Think not of me, though I will ever greet the mists that hang over Parininihi and conceal you from me. And now the swift-running stream can never return to its source. Farewell! The gnawing of affection is a grievous affliction, but by Te Ihorangi was Mahuika destroyed. Farewell! In the summer of our days we part as the Dawn Maid parted from the Sun God."

In these notes we have endeavoured to explain the Maori genius for personification, and to throw some light on his modes of thought. For

* The *kura awatea* is the solar halo. The Maori believed that certain persons possessed the power to produce this phenomenon, and that they utilized it in signalling to a distance.

the Maori lived in a world to which we have no access; we emerged from that world many centuries ago, to enter a new and very different sphere.

The Maori had a loving regard for the earth, for was not Papa, the Earth Mother, the mother of mankind? Far above him he saw Rangi, the Sky Parent, upon whose breast the Whanau Marama, the Children of Light, were arranged by Tane the Fertilizer, who traverses the head of Rangi accompanied by Tane-te-waiora, the cheering sunlight. The moon was to him Hina-keha, Pale Hina, she who follows in the wake of the sun god, and, in times of stress, becomes Hina-uri, or Darkened Hina. In the transient comet he recognized Auahi-tu-roa, he who brought fire to mankind; and in Maru he resolved celestial phenomena into a protecting deity and a war god. When a meteor darted across the heavens he knew that Tamarau was active; and he saw in the brilliant rainbow Uenuku spent with his long, hopeless search for the Mist Maiden. When the chill winds of winter smote him he knew that Pārāweranui was abroad; when the heaving breast of the Ocean Maid troubled his rude craft he knew that the Whanau Puhi were gambolling on Mahora-nui-atea; when the golden trail of Tane gleamed athwart placid seas he knew that the Wind Children had retired to their haven. Far overhead he beheld the many-coloured battalions of Tukapua and the Cloud Maid, as they hurried forth from the Cloud House, harassed by Tawhirimatea. When Mahuika assailed in fiery wrath the offspring of Tane-mahuta he saw the countless legions of Te Ihorangi darting to their rescue, while Mahuika found fair haven within Hine-kaikomako. In the ceaseless contest between Parawhenuamea and Rakahore he saw the origin of Hine-tuakirikiri (the Gravel Maid), whose multitudes protect the body of the Earth Mother from the wrath of the Ocean Maid, and of whom it was said, "*He ope na Hine-tuakirikiri e kore e taea te tatau*" (A troop of the Gravel Maid cannot be numbered). Yet another stubborn defender of the Earth Mother was Hine-one, and all footsore travellers welcomed the advent of the Sand Maid.

Even so the Maori of yore traversed the path of life, the life he gained from the Earth Mother and from Tane. As he passed down that path he was protected by the offspring of the primal parents, by anthropomorphic personifications, and by the spirits of his dead forbears. When the path became faint as he neared its end, when Whiro and Maikinui destroyed his body, when his spirit traversed the Broad Way of Tane that leads to the spirit world, it was then that the Dawn Maid fulfilled her vow made in the days when the world was young, and protected her children who sought refuge within her realm.

And Tane the eternal, who saw the birth of man, guides his spirit down the Golden Way, and knows that the end is well.

Art. II.—*Old Redoubts, Blockhouses, and Stockades of the Wellington District.*

By Elsdon Best, F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 21st September, 1920; received by Editor, 21st September, 1920; issued separately, 27th June, 1921.*]

Plates I, II.

The amount of interest displayed by Wellington folk in the story of the settlement of the district is exceedingly small, and very few possess any knowledge of the anxious times passed here by early settlers during the Maori disturbances of the "forties" of last century, and, in a lesser degree, some fifteen years later. Probably no man could locate the sites of all the blockhouses, stockades, and redoubts erected in this district in the early days, hence it has been deemed advisable to put together the following notes pertaining to those posts. The stockade-sites marked on Collinson's little map are approximate only, but fortunately the writer was enabled to fix them definitely ere the old generation of settlers in the Porirua district passed away.

Wellington Redoubts, etc., of the "Forties."

The general feeling of uneasiness and apprehension that followed the Wairau massacre led to the erection of two defensive positions in Wellington —one on the Thorndon Flat, as it was called formerly, and one at Te Aro, on the north side of Manners Street. The former was situated near the junction of Mulgrave and Pipitea Streets, and was known as "Clifford's Redoubt" and "Clifford's Battery" among the settlers, but appears as "Thorndon Fort" in official documents. Mundy calls it "Clifford's Stockade," but that name was usually applied to the post at Johnson's Clearing, now known as Johnsonville.

In the *New Zealand Journal* of the 1st March, 1844, appears a report of the Committee of Public Safety, of Wellington, appointed at the public meeting held on the 19th June, 1843. Among other items of interest in this report occurs the following: "Your committee have also to report that a battery has been erected on Clay Hill, under the superintendence of Captain W. M. Smith, R.A., and three guns placed therein. Another battery on Thorndon Flat was in progress at the period of the arrival of the military from Auckland, but has not been proceeded with since."

Clay Hill was the name of the bluff headland, known otherwise as "Clay Point" and "Windy Point," above the junction of Lambton Quay and Willis Street. Its native name was Kai-upoko.

In the same *Journal* of the 6th January, 1844, containing Wellington news up to the end of July, 1843, appears a statement that at 9 o'clock on Sunday, the 2nd July, 400 Wellington Volunteers mustered for inspection on Thorndon Flat. At a meeting of the military sub-committee on the 6th July, there were present Major Durie (president), Captain Sharp, Major Baker, Major Hornbrook, and Dr. Dorset. "It was resolved that a public notice be issued calling upon all parties to assemble on Thorndon Flat on

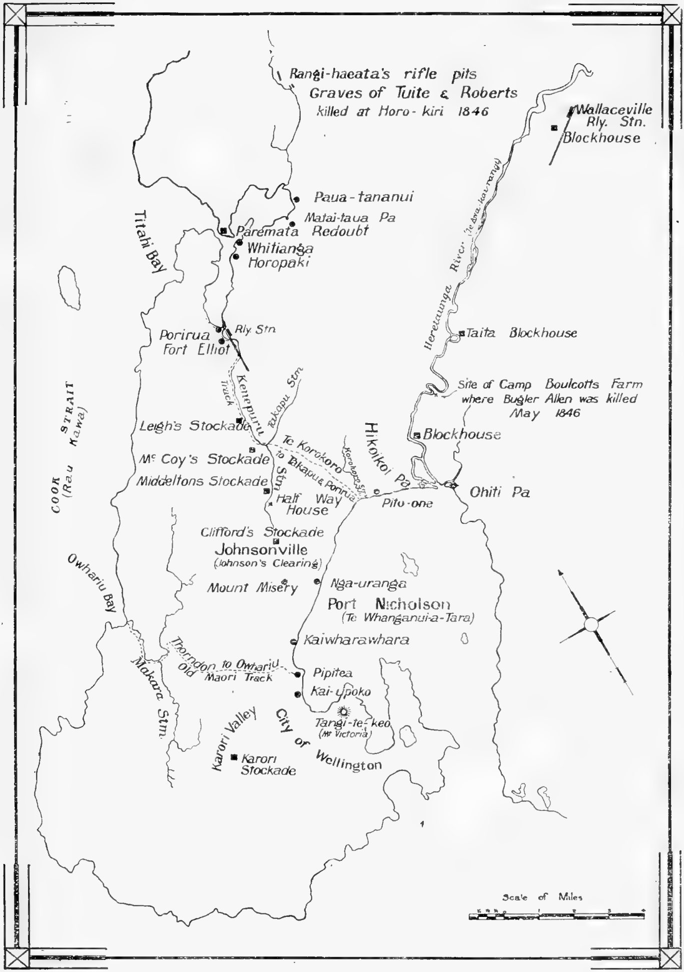

Fig. 1.—Map showing blockhouses and stockades of the Wellington district.

Monday morning next at 9 o'clock, provided with spade and pickaxe, to assist at the erection of the battery now in progress, the completion of which has been retarded by the late unfavourable weather."

The following is a copy of district orders issued in May, 1845 :—

WELLINGTON MILITIA.—DISTRICT ORDERS.

Secretary's Office, Wellington, May 26, 1845.

BY virtue of a commission issued by His Excellency the Governor of New Zealand, dated April 10, 1845, appointing me Major in command of the Wellington Battalion of Militia, I hereby assume command of the troops stationed in the southern districts of New Zealand.

Captain Russel, of the 58th Regiment, will take charge of and direct the detail of the garrison of Wellington.

Captain Wakefield will take charge of and direct the detail of the Wellington Battalion of Militia.

Captain Baker will take charge of and direct the detail of the Mounted Volunteer Corps when organized.

Lieutenant Rush, of the 58th Regiment, will hold the local rank of Captain in this division of the colony, to bear date the 10th April, 1845.

His Excellency the Governor having been pleased to appoint the undermentioned gentlemen to commissions in the Wellington Battalion of Militia, they are posted to companies as follows :—

No. I Company : Captain William Wakefield, Lieutenant Charles Sharp, Ensign Nathaniel Levin.

No. II Company : Captain David Stark Durie, Lieutenant Hugh Ross, Ensign George Hunter.

No. III Company : Captain George Compton, Lieutenant James Watt, Ensign Edward Abbott.

No. IV Company : Captain John Dorset, Lieutenant Robert Park, Ensign George Moore ; Ensign Samuel Edward Grimston to be Aide-de-Camp to the Major commanding.

Captain Arthur Edward Macdonogh, Adjutant. Quartermaster, Alfred Hornbrook.

On the alarm being given, the troops will assemble at the following places :—

The detachment of the 58th Regiment will fall back upon Thorndon Fort.

No. 1 Company of Militia will assemble at Thorndon Fort.

The detachment of the 96th Regiment will fall in under arms at the Barracks, Te Aro, when they will be joined by No. 2 Company.

No. 3 Company will proceed to Fort Richmond, on the Hutt, and join the detachment of the 58th Regiment stationed there, under the command of Captain Rush.

No. 4 Company and the Cavalry will assemble in front of Thorndon Fort.

The Captains of Nos. 1 and 2 Companies will enrol the names of any volunteers who are desirous of giving their aid in case of emergency, and station them within the forts of Thorndon and Te Aro, for their defence, to render as many men of their companies as possible available to resist any attack that may be made upon the town.

The companies of the Militia stationed in the town of Wellington will patrol every morning from 5 o'clock till 7 o'clock a.m. No. 1 in the district from Thorndon Flat to the station of the 58th Regiment ; No. 4 from Kumutoto Stream to Thorndon Flat ; No. 2 from Te Aro Flat to Kumutoto Stream.

These patrols will consist of a non-commissioned officer and four men, and will move in the rear of the town.

The detachments of the 58th and 96th Regiments will protect the flanks, and patrol at the same hours, the former in the direction of Wade's Town, the latter towards the signal-station and Evans Bay.

The Cavalry Corps, when formed, will patrol the roads leading to Karori, Porirua, and Petoni.

A guard of the Militia consisting of a sergeant, corporal, and twelve men will mount daily at Thorndon Fort. The companies of Militia will assemble at their private parades for exercise every morning at 8 o'clock, and 4 in the afternoon, until further orders.

Definite instructions have not yet been received relative to the pay of the Militia, but for the present it will be the same as the non-commissioned officers and privates of the line. Those working at the batteries between the hours of drill will be allowed 10d. a day extra.

The Militia volunteer for three months, or 28 days.

(Signed) M. RICHMOND, Major Commanding.

In the *New Zealand Journal* of the 10th October, 1846, giving Wellington news up to the 27th May, is the following: "An address has been issued by Major Richmond stating that, in the event of any alarm, two guns will be fired. The guns at Thorndon Fort have been put in order and placed in charge of a gunner from Her Majesty's ship 'Calliope.' The carriages of the two guns at the head of the bay will also, by direction of Captain Stanley, be repaired by the carpenters of the 'Calliope,' and the guns will be rendered fit for service."

Colonel Mundy, who was in Wellington in 1847, wrote: "On the plain of Thorndon is an old field-work called Clifford's Stockade, mounting a few guns . . . . and intended as a place of refuge in case of an attack. With a little repair and deepening of the ditch this trifling earthen fortalice might be made quite efficient against a *coup de main;* and, by a very simple contrivance, which may perhaps have never occurred to an engineer, or other defender of a fortified post, might be rendered impregnable against bare-footed savages—namely, by throwing into the ditch all the broken bottles which, in a short period, have been so lavishly emptied by the Company's colonists!"

The above writer has another entry, as follows: "January 18. Inspection of the 65th Regiment on Thorndon Flat, an excellent parade-ground, like an English village green. It is pleasant to see the truly British appearance of the troops of this country—no pale faces, no dried-up frames. Here was a corps 900 strong, including detachments, so increased individually in bulk and healthiness of aspect since I saw them a year ago at Sydney, after a long voyage from England, that it was difficult to believe them the same body of men."

Te Aro Fort.

In Mr. Brees' illustration showing the old Wesleyan Chapel in Manners Street appears a part of the earthworks of the redoubt at Te Aro, which was situated on the north side of Manners Street, opposite the above chapel. Brees remarks, "The house occupied by the late Mr. Brewer is on the right of the road, and the large trench and mound which were formed immediately after the Wairau massacre, for inclosing certain spots as places of refuge in case of Wellington being attacked by the natives." The illustration shows a bullock team and dray proceeding along Manners Street.

Barracks.

In the *New Zealand Journal* of the 15th January, 1848, giving Wellington news up to the 14th August, 1847, appears a short item from the *Wellington Independent*, as follows: "The mechanics and artisans employed in the erection of the new barracks lately completed at Mount Cook were on Monday evening regaled with a substantial supper by the contractor, Mr. Mills. The evening was very pleasantly spent. We have much pleasure in noticing this event, because the buildings have given great satisfaction, and reflect credit upon all engaged in their construction."

The Thorndon Barracks were situated on the eastern side of the old Queen's Head Hotel, where Fitzherbert Terrace now is. They have long disappeared, but two of the four cottages built for the officers at the junction of Park Street and Grant Road, eastern side of Park Street, are still standing. The wood-trails on the hillside above Park Street, where the soldiers used to throw the wood down, are also still in existence.

The Thorndon Barracks witnessed a lively scene during the visit of the Duke of Edinburgh to Wellington in 1869, when a party of Maori performed a war-dance on the flat. They were armed with Enfields that were kept in store there

Karori Stockade.

The site of this post has been fixed on the map. It was erected on Mr. Chapman's land at Karori in the "forties," as a rallying-place and refuge for the surrounding settlers. It was erected under the supervision of Mr. A. C. Strode, on the high ground south of the main road and about opposite the English Church. It was apparently never utilized as a refuge.

Colonel Mundy wrote of Karori in 1847, "Here are several hundred acres partially cleared, and the remains of a stockade built for the defence of the rural community."

Hutt Posts of the "Forties."

*Fort Richmond.**

This was the principal defensive post in the Hutt district during the troubled "forties," and was situated near the old bridge, which was somewhat down-stream from the present bridge.

Brees tells us that Fort Richmond "was constructed under the direction of Captain Compton, an enterprising settler of the Hutt. It is planned on the model of those in the United States of America to guard against incursions of the Indians. The stockade is arranged in the form of a square of 95 ft., with towers of defence, or blockhouses, at two of the opposite angles, which command the bridge and river on both sides. It is composed of slabs of wood 9 ft. 6 in. high, and 5 in. to 6 in. thick, and is musket-proof. One of the blockhouses is 15 ft., and the other 12 ft. square. The fort was erected at a cost of £124, independent of the value of the timber, which was presented by Mr. Compton, and voluntary labour to the amount of £54 10s. is included in the above statement of the cost.

"The excitement which was felt at the Hutt when a party of the 58th Regiment took up their quarters in the fortress on the morning of the 24th April, 1845, will not soon be forgotten. The settlers having brought all their energies to their assistance in the erection of the stockade, had just completed it on the evening of the previous day (Sunday), when an attack was expected from the natives. The settlers accordingly determined to hold possession until the arrival of the military, which took place at about 3 o'clock in the morning, amid the acclamations of the settlers."

This post was named after Major Richmond, who was then in command of the district. A woodcut of the fort appeared in an early number of the *Wellington Independent* (now known as the *New Zealand Times*). A contemporary remarks of those crude woodcuts, "They are apparently the work of no trained artist. The ground is black and the delineation white, reversing the usual process." Brees gives a good illustration of the fortress.

Wellington papers of October, 1846, state that "We are informed that the late flood in the Hutt has done considerable damage in the district. The south-western corner of Fort Richmond, where a detachment of the 58th Regiment is stationed, has been thrown down." Ere long the river had swallowed the site of Fort Richmond, which fortunately was no longer needed.

Colonel Mundy, in *Our Antipodes*, made the following remark on Fort Richmond: "It is a small baby-house kind of fortress built of timber, with a couple of carronades on corner turrets, one of which, impinging on the river, has been carried away by a freshet." This writer visited the Hutt in 1847.

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* Not shown on map, but situated on the opposite side of the river to the blockhouse above Hikoikoi *pa*.

Boulcott's Farm Post.

At this place the troops were camped in tents and farm buildings without any protection, hence we have no defensive works on which to remark. The attack of the 16th May, 1846, was the natural sequence of establishing this singular form of military post. The site of it was near the spot marked on the map issued by the Lands Department, and entitled, "Wellington Country District: showing Native Names."

The Taita Post.

As this place is always called "Taitai," which, according to Mr. Buck, a surveyor, of Hutt, is its correct name, our early settlers must have formed their own ideas of how it should be spelt. The name of Nainai appears to have suffered in a similar way.

The *Wellington Spectator* of the 28th February, 1846, remarks, "The stockade and barracks to be erected in the Hutt district will be 90 ft. square, and will be composed of trees 12 in. in diameter placed closely together and loopholed all round; the stockade is to be splinter-proof. When completed it will be capable of accommodating eighty men and two officers. The site fixed upon for the stockade is near Mr. Mason's house, or rather beyond the present encampment. It is intended to have it completed in a month's time."

The post was, however, established a considerable distance above Mr. Mason's place, its site being on the western side of the present hotel at Taita. A local paper remarked in May, 1846, after the attack on Boulcott's Farm (see *New Zealand Journal* of the 10th October, 1846), "After getting rid of the Maoris on the Hutt, His Excellency decided on building a blockhouse, and maintaining a post of a hundred men somewhere about Mason's section, considerably in advance of the picquets surprised by the natives (*i.e.*, Boulcott's Farm). Instead of this being done, the Superintendent and his coadjutors objected to the amount of the tenders for building the blockhouse, and, the Governor yielding to them, the soldiers fell back to Boulcott's barn, where they were attacked."

Shortly after the above appeared we find the following in a local paper (see *New Zealand Journal*, 21st November, 1846): "The troops and the native allies in the Hutt have been forming an entrenched camp at Taita in the shape of two squares connected at an angle of each, and having a communication from one to the other."

It would appear, however, that a number of Militia were stationed at Taita when the attack on Boulcott's Farm took place, 16th May, 1846.

In Captain Collinson's report we find several statements concerning this post: "The flat part of the Hutt Valley is about eight miles long and two broad, covered with forest. About two miles up it the New Zealand Company's road crosses the river; here a small stockade called Fort Richmond had been erected some time before, and was occupied by a party of 58th under Lieutenant Rush. Two miles farther on was a settler's house called Boulcott's, in a clearing of some twenty acres, and two miles farther was another house called the Taita." (See Plate I.)

Collinson tells us that Maori depredations caused the Governor to take action: "He proclaimed martial law, and (under the usual fiction of considering the natives as rebels) he sent a herald to inform them of it, and at the same time ordered the Taita farm to be occupied by a company of the 96th. . . . In March, 1846, there were three detachments occupying this little valley, fifty men at Fort Richmond, fifty men at Boulcott's, and about a dozen militia at the Taita." Wellington papers of October, 1846, reported, "A sergeant and ten men of the Hutt Militia have been kept on by His Honour Major Richmond, and stationed at the Taita, so that the settlers may have some little force to fall back on in case of accident."

Porirua District Military Posts of the "Forties."

Quite a number of military posts were established in the Porirua district. These were to serve three purposes: the protection of settlers, as at Johnsonville; defensible camps for military roadmakers; and, in the case of the Paremata and Paua-tahanui posts, the keeping of a watchful eye on the turbulent Ngati-Toa folk, and to act as an outpost for the defence of the Hutt Valley. Fort Strode seems to have been a small police post, another being situated at Waikanae. All these posts pertained to the lively "forties"; in the disturbed times of the "sixties" no posts were established in this district, though some troopers were stationed for a while at Paua-tahanui.

Clifford's Stockade at Johnsonville.

In the journal kept by Captains Wilmot and Nugent during their walking-tour from Wellington to Auckland, via Taupo, Galatea, and Rotorua, in 1846, occurs the following entry: "March 17, 1846. Started from Wellington in company with the Reverend G. on our road to Whanganui. At about 11 a.m. arrived at Johnson's Clearing on the Porirua Road, where about forty of the Volunteer Militia were stationed, under the command of Captain Clifford, and were constructing a stockade as a protection to the few settlers in the neighbourhood. The road thus far is good; afterwards there is a mere bush path to Jackson's Ferry."

The *Spectator* of the 7th March, 1846, remarks, "On Thursday His Excellency, attended by a guard of thirty men under Major Last, proceeded on the Porirua Road to examine the stockade erecting under the direction of C. Clifford, Esq., and returned to town again in the evening." Other statements in local papers of that month inform us that the Porirua settlers had been armed and placed under the command of Mr. Clifford, under whose direction a stockade had been commenced on Mr. Johnson's section. The site was a hillock on the north side of Ames's accommodation-house at Johnsonville, east of the main road and railway, and on the south side of the road running eastward to the old Petherick farm. We are told that this post was "for the defence of the settlers, and for the purpose of preventing any predatory incursions of the natives, and a company of sixty men has been formed for the protection of the district." For some time sentries were kept on Sentry Hill and Mount Misery to guard against a surprise by Maori. Lieutenant L. R. Elliott, of the 99th Regiment, was in charge of Clifford's Stockade in October, 1846.

Middleton's Stockade.

When the military roadmakers pushed on beyond Johnsonville each of their camps was surrounded by a stockade, in case of any attack being made by Maori. The men also carried their arms every day they proceeded to work. It is not stated whether they worked under covering-parties or not, as we did in the Taranaki District in later years.

The first defensive post or camp north of Johnsonville was Middleton's Stockade, named after Ensign F. Middleton, of the 58th Regiment; it was situated on Section 26, west of the main road and about half a mile north

Stockade at the Taita. Pencil sketch by W. Swainson, 17th October, 184—.

Fig. 1.—Remains of Paremata Blockhouse still standing in 1920

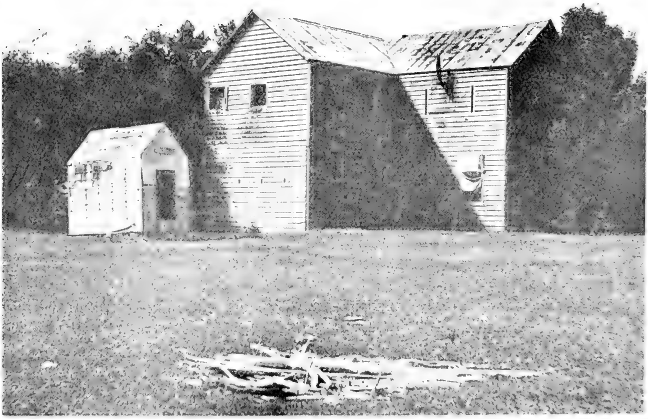


Fig. 2.—Old blockhouse near Wallaceville, built in 1860–61. Photo by J. McDonald, 1916, taken from a point near the bastion, and within the area originally stockaded. The timber lying in the foreground covers the mouth of the well.

of the old Half-way House. It stood on the spur just above the road-line at the corner and rock-cut formerly known as "Pyebald's Corner," "Byass's Corner," and "Gibraltar Corner." This post was built and occupied by men of the 58th Regiment. Each of these stockades from Johnsonville to the Ferry (or Jackson's Ferry), just north of the Porirua Railway-station, was named after the officer in charge of the post.

McCoy's Stockade.

Named after Lieutenant F. R. McCoy, of the 65th Regiment. It was situated on Section 36, on the eastern side of the main road, about where the house of the late Mr. James Taylor stands, on the left bank of the Kenepuru Stream, just below its junction with the Takapu Creek.

Leigh's Stockade.

Also known as "Fort Leigh." Named after Lieutenant C. E. Leigh, 99th Regiment. It was situated on the west side of the road, about where the northern boundary-line of Section 41 cuts the road. The short road extending past the school is a part of the road-line as originally surveyed.

Elliott's Stockade.

Also known as "Fort Elliott." The original stockade stood on the flat on the left bank of the Kenepuru Stream, about 7 or 8 chains south of the hotel (now closed) near Porirua Railway-station. Late in 1846 flood-waters overflowed this flat and rendered the post untenable, destroying 4,000 rounds of ball cartridge. A new stockade was built on the bluff or low hill on the western side of the road, Section 62—a much better site.

In October, 1846, two officers and twenty-four men of the 58th Regiment and two non-commissioned officers and thirty-four men of the 99th Regiment were stationed here under Captain A. H. Russell (father of the late Sir William Russell, and grandfather of the present General Russell who served in the Great War) and Ensign F. Middleton.

Paremata Redoubt.

This post consisted of a stone blockhouse (or barrack, as it was usually called) surrounded by a stockade. It was situated at Paremata proper, at Porirua Harbour. The name of "Paremata" applies properly only to the flat north of the railway-bridge; the railway folk are to blame for having transferred the name to the railway-station across the water. The station should have been named "Whitianga" or "Horopaki," both names of places within a few chains of the station. The remains of this stone blockhouse at Paremata are still to be seen at Paremata Point, west of the railway-line (Plate II, fig. 1), and it was here, at the narrow channel between the outer bay and the inner arm, that the first ferry was established at Thoms' whaling-station.

In Collinson's report on the Wellington Military District (published in the papers of the Corps of Royal Engineers, 1855) appears the following: "On April 8 [1846] 220 men under Major Last were sent round to Porirua, and, after lying a week under Mana Island from stress of weather, they landed and pitched their tents on Paremata Point." The *Wellington Independent* of the 15th April, 1846, mentions this movement. On landing at the point tents were erected, and a large *whare* near Thoms' whaling-station was also occupied. Men were set to work to form a trench and rampart defence, of which some signs may still be seen. The building of the blockhouse was a slow affair. Wellington papers of October, 1846, stated that "The first stone of this building was laid on Friday, the 23rd instant, by Captain Armstrong, the officer in command at Porirua. As usual on such occasions, various coins of the present reign were deposited in the stone." The *Spectator* of the 14th August, 1847, remarks, "Last Saturday [7th] the new stone barracks at Porirua were delivered over by Mr. Wilson, contractor to the Ordnance Department."

A plan of this post made by V. D. McManaway in 1852 (fig. 2) shows the blockhouse almost surrounded by a five-angled stockade, the water-front being left open. Within the stockaded enclosure are shown a number of huts, including a sergeant's hut, three men's huts, a hospital, guard-room, and commissariat. A well is also marked inside the enclosure, while outside are the canteen, bakery, and two other huts.

The walls of the blockhouse were built of undressed stones laid in cement. Many are waterworn boulders apparently obtained from a pit near by, and a few bricks are worked into the walls. The portions of wall still standing are about 30 in. in thickness and up to 10 ft. in height. The dimensions

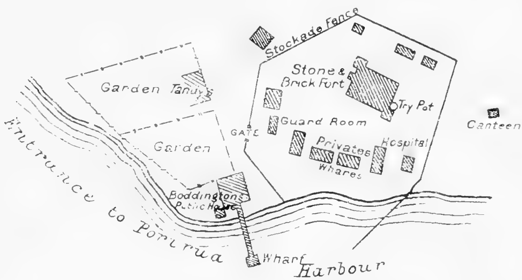


Fig. 2.—Plan of Paremata Redoubt.

of the building are about 60 ft. by 36 ft. inside, and the ground-floor was divided into two rooms. The men's quarters were in the upper story, to which access was gained by means of an outside stairway. The place is only about 35 yards from high-water mark. The earthquake of 1848 so shattered the upper parts that the men were moved out into huts, and the shake of 1855 brought down the upper story. The post had been abandoned before the latter date. Turrets had been built on it, apparently to accommodate cannon of sorts, but the first shot fired at a passing canoe manned by hostiles so shook the fabric that the gun was not used again. Powers tells us that the stockade was a very inferior one.

The *Wellington Spectator* of the 27th May, 1846, gives the strength of the force stationed at Paremata as follows: 58th Regiment—seventy-eight men, under Captain Laye and Lieutenant Pedder; 99th Regiment—seventy-four men, under Captain Armstrong and Lieutenant Elliott; Royal Artillery—nine men, under Lieutenant the Hon. A. Yelverton; also twenty-five Royal Marines from H.M.S. "Calliope," under Lieutenant Fosbrooke.

*Paua-tahanui Post.**

This post was established at the Matai-taua *pa* at Paua-tahanui after its evacuation by the hostile Maori on the approach of the force of

* Mis-spelt "Paua-tananui" on map.

Militia and Maori auxiliaries from the Hutt in August, 1846. This force occupied the *pa* on the 1st August, Governor Grey arriving there in the afternoon of the same day, accompanied by Captain Stanley, of the "Calliope."

The post was situated on the spur on which the church stands at Paua-tahanui, just above the creek, and above the bridge. A rude sketch of the Maori *pa* appeared in a Wellington paper of that time, but the reproduction of the stockade is decidedly eccentric. A sketch in the writer's possession is much more reliable. The name Matai-taua is one of the few local names of which we know the origin. This *pa* was built by Te Rangihaeata when he retired from Motu-karaka some months before. When the Imperial troops advanced from Paremata fortress to join the Militia and Maori contingent in the advance up the Horokiri Valley Lieutenant De Winton occupied the *pa* as a military post. On the 10th August he was reinforced by a detachment of police under Sub-Inspector Strode. In October, 1846, we find that the post was garrisoned by three officers and one hundred men of the 65th Regiment. These officers were Captain R. Newenham, Lieutenant T. F. Turner, and Assistant Surgeon T. E. White.

In 1848 Captain Russell and a detachment of the 58th occupied the post. They were engaged in roadmaking. The post was finally abandoned in 1850. Apparently the 58th advanced to this post in 1847, for a traveller passing down the coast in that year describes it as follows:—

"The strong *pa* of Pawhatanui (?) belonging to Rangihaeata, Rauparaha's fighting-man, had been seized the year before by our forces, and was now occupied by a detachment of the 58th. I stopped at the blacksmith's outside the *pa* to have the horse shod, before taking him on the hard metalled road into Wellington. During the process an officer happened to pass. We entered into conversation, and the result was that Captain R., the officer in command of the detachment (for he it was), invited me to pass the night at the *pa*. Mounting the hill on which it stood, we entered the gate.

"The strong palisade, about 15 ft. high, which surrounded the original *pa*, remained undisturbed, but nearly the entire space within was now occupied by neat wooden huts, painted blue and shingled. Captain R., with his wife, a lieutenant and the assistant surgeon, with their wives, and an ensign, formed the society of the *pa*, and a very lively and agreeable society it was. The ladies were all young and pretty, and on the best terms with each other; Mrs. R., with her frank gaiety, being the life and soul of the little party. As for the officers, they did not, with the exception of Captain R., get through their time so easily—in fact they were mortally bored. What, indeed, had they to do? The doctor, in that provokingly salubrious climate, had no patients to cure, and the subalterns, since the Maori war was over, had none but routine duties to perform, which on detachment service are usually light enough. There was no hunting, and nothing to shoot but parrots, pigeons, and tuis. However, they did what they could; they fished and boated, pulled down almost daily to Paremata Point, where there was a detachment of the 65th, to compare notes with the major and the ensign, the latter of whom ingeniously contrived to kill a good many hours in the education of a talking tui, and laid schemes for obtaining leave to go to Wellington, which was another London or Paris to an unfortunate subaltern buried in the bush at Pawhatanui."

*Fort Strode.**

In Wakefield's *Handbook*, published in 1848, is a short description of the eastern or Paua-tahanui arm of Porirua Harbour, in which occurs the statement, "Two stockades, one of which is called Fort Strode, at different points of this north arm, have been occupied by small military detachments."

One of these posts was that described above; the other, Fort Strode, named after Sub-Inspector A. C. Strode, of the Police Force, was situated on the terrace-like point of Motu-karaka, on the northern shore of this eastern arm of the harbour. The earthworks of the post are still to be seen near the point, which on some old maps is marked "Police Point," on account of some police having been stationed there, under, I believe, Mr. Tandy. This post was built on the site of the position occupied by Te Rangihaeata after he left Taupo (Plimmerton) and prior to his removal to Paua-tahanui. His sojourn at Motu-karaka was rendered uncomfortable by young McKillop, a midshipman of H.M.S. "Calliope" (afterwards McKillop Pasha), who mounted a gun on the long-boat of the "Tyne" (wrecked shortly before at Island Bay), and strolled up and down the harbour bombarding hapless hostiles, and puncturing the atmosphere with cannon-balls.

In those days of the "forties" the ferry charge from Paremata to Jackson's Ferry was 1s. 6d., to Paua-tahanui the same, to Fort Strode 9d., and to Cooper's, at Whitireia, 9d.

We have now enumerated all the posts established in the Wellington District in the "forties," and explained their situations. Other details and remarks concerning some of them, as Fort Richmond, Paremata, and Paua-tahanui, are not given here, not being necessary to a paper that is designed merely to draw attention to these places of interest. Further notes on some of them were published in a series of papers on "Porirua and They Who Settled it" in the *Canterbury Times* of 1914.

Native Disturbances of the "Sixties."

Two Blockhouses erected in the Hutt Valley in 1860–61.

When these troubles arose in the land public uneasiness caused the erection of two blockhouses in the Hutt Valley, one at McHardy's clearing, Upper Hutt district, and the other near the Hutt Bridge, where the Post-office now stands. The latter has disappeared, but the former still stands (1918). The old post at the Taita seems to have disappeared about twenty years ago.

The *Spectator* of the 21st March, 1860, gives an account of the balloting for the first draft of the Militia at Mount Cook Barracks in the presence of Major Trafford.

Old Blockhouse at Upper Hutt.

Half-hidden by tree-growth, this old refuge of sixty years ago stands lone and unknown in a paddock half a mile from the Wallaceville Railway-station, in the Upper Hutt district, some twenty miles from Wellington City. Of the few who know of its existence some have curiously erroneous ideas as to its origin and age. It was built in the latter part of the year 1860 as a refuge and rallying-place for the settlers of the district, in case of a Maori raid; for at that time many of the Maori of the Otaki district were hostile to Europeans, and the King flag was hoisted in the village

* Not shown on map, but situated on the point immediately west of Paua-tahanui, north-east of Paremata.

at the Roman Catholic end of the settlement. The Wairarapa Maori were also disturbed, and some of the settlers in that district had asked that blockhouses be erected there, though curiously enough the sheep-run men, the most isolated and exposed of the settlers, did not sign the petition. The Wairarapa Maori strongly objected to soldiers being sent to their district, and, as a matter of fact, none were sent.

Rumours of Maori raids in 1860 led to the erection of two blockhouses near Wellington, the one herein described and another near the bridge at the Lower Hutt. A number of Volunteer corps were also formed, and these became numerous in the land. The blockhouses were not actually utilized as refuges, simply because those raids never came off. The Wairarapa Maori never became openly hostile. They probably remembered the answer given by a local chief to Te Rangihaeata in 1846, when the latter wanted Wairarapa to join him in a raid on Wellington—"*Kei a wai he tahurangi maku?*" (With whom is a *tahurangi* for me?) *Tahurangi* was the Maori name of the old-fashioned red blankets. The wise chief knew that to slay the pakeha would be to cut off the supply of European products, hence the red blanket saved Wellington. The memory of those old-time fears and dangers has passed away now, and no one worries about Maori raids.

The following is taken from the *New Zealand Spectator*, of Wellington, for the 5th September, 1860:—

Engineer's Office, Lower Hutt, 18th August, 1860.

SEALED tenders in duplicate will be received at this office until Wednesday at noon of the 5th September next for the erection of

STOCKADE AND BLOCKHOUSE

at the Upper Hutt, on McHardy's Clearing, according to plans and specifications No. 1 and 2.

Further particulars can be obtained upon application to Corporal Tapp, Royal Engineers, at this office.

Persons may tender for either Plan No. 1 and No. 2, or both. The lowest tender will not necessarily be accepted of.

W. RAWSON TRAFFORD,
Commanding Wellington Militia and Volunteers.

The defences consisted of a stockade and trench, with a two-storied blockhouse in one corner. The stockade, which has long been pulled down, was 9 ft. high and bullet-proof, as described below, though its form of loop-holes is not given. The blockhouse projected outside two faces of the stockade so as to act as a flanking angle, the opposite corner being provided with a bastion as shown on the plan: thus each covered two curtains or faces. The northern and western curtains were each commanded by eight loopholes in the blockhouse, four on each floor. The western and southern sides of the stockaded area still show a parapet on the outer side of the fosse, or trench. Presumably the stockade occupied this low parapet, while the defenders would occupy the fosse inside it.

The space enclosed inside the trench, is 30 yards east and west, and somewhat more north and south. The measurements given in the report would doubtless be those of the line of stockade. The trenches now contain a considerable amount of debris, but were probably $2\frac{1}{2}$ ft. or 3 ft. deep originally, the width being about 5 ft. at the bottom. The spoil from these trenches was evidently used to form the parapet, of which, however, we now see no sign on the north and east sides. The entrance to the enclosure was probably at the side of the blockhouse where for a space of 18 ft. no signs of a trench are to be seen.

The blockhouse is in a good state of preservation, the timber sound and still showing in places the marks of the circular saw ; it was probably cut in Cruickshank's mill, the first to be erected in this vicinity, which produced some fine totara timber, The ground floor is divided into two rooms, the larger one containing the staircase, as also a small room in the south-west corner, like the sergeant's cubby-hole in a military barrack-room. Four sides of the ground floor present loopholed walls, the two interior walls being blank, save for the doorway and two windows as shown. There are twenty-four loopholes, as marked, not including three higher up to be occupied by persons stationed on the staircase. These loopholes are rectangular, formed with 1 in. timber, with the smaller end outward, the inner and larger orifice being 8 in. by 6 in. Some are still plugged with the original tompions—solid blocks of timber. The walls are flush-lined with 1 in. boards, and the outside weatherboarded with the same ; studs, 6 in. The interior space is filled with fine gravel.

The upper floor is in one room, and is pierced with loopholes all round, on all six faces. The southern end has but two loopholes, but the two windows there are probably modern and not a part of the original plan. The west and north faces have each eight loopholes. The two interior walls have three each, two long vertical ones and a small square one between them. Two of these appear in the illustration. Not being a disciple of Vauban, the writer is unable to explain why these elongated loopholes should appear in two walls only, and those both interior faces. On the outer side these loopholes are 36 in. by 3 in., but the inner part is wider.

The blockhouse is built on piles, and roofed with corrugated iron ; height of walls, 18 ft.

The magazine was a small building, 9 ft. by 5 ft. in size, originally lined, and probably with gravel-filled walls. Outside the blockhouse is a small ditch of unknown use, for presumably the stockade did not extend along outside the north and west sides of the blockhouse. The place seems to have been used as a residence at some time, and a stove has been used in the upper floor. Again, the place seems to have been utilized as a chicken-ranch at no distant period.

The well was covered over with timber, as it appears in the photograph (Plate II, fig. 2). The bastion shows no signs of having contained any small flanking blockhouse, such as we constructed in Taranaki as late as the " seventies." From the trench outside the bastion a covered drain runs to a stream-channel, evidently designed to carry off storm-waters from the trench. A part of the outer scarp of the trench at the south corner of the bastion has been neatly faced with stones, reminding one of the Koru *pa* at Oakura.

No trace of a parapet is seen on the eastern and northern faces of the defence ; the interior of the defended area is level ground, which extends far out on all sides.

(An outpost of singular form was erected at Taita in 1846, and was occupied by Militia for some time. The following appeared in the *Wellington Independent* at the time : " The troops and native allies in the Hutt have been forming an entrenched camp at Taita, in the shape of two squares connected at an angle of each, and having a communication from one to the other." The main post of that period was Fort Richmond, at the Bridge, Lower Hutt.)

The *Australian and New Zealand Gazette* of the 17th October, 1860, contains the following : " The natives in the Wellington district still continue quiet, but the settlers are, as they ought to be, on the alert. The

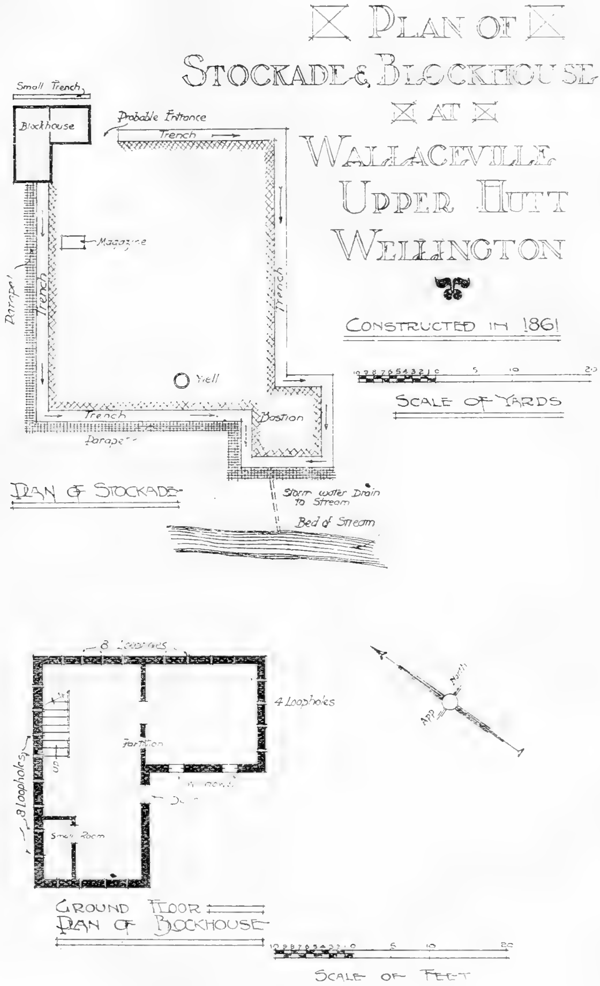

PLAN OF
STOCKADE & BLOCKHOUSE
AT
WALLACEVILLE
UPPER HUTT
WELLINGTON
CONSTRUCTED IN 1861
SCALE OF YARDS
Small Trench
Blockhouse
Probable Entrance
Trench
Magazine
Parapet
Well
Bastion
PLAN OF STOCKADE
Storm water Drain to Stream
Bed of Stream
4 Loopholes
8 Loopholes
Partition
Up
Small Room
North
GROUND FLOOR
PLAN OF BLOCKHOUSE
SCALE OF FEET

FIG. 3.

Militia has been called out both in Wellington and Whanganui, all the disposable rifles have been distributed, and two stockades are being erected in the Hutt district."

The same publication in its issue of the 24th November, 1860, giving Wellington news up to the 7th September, quotes the following from the *Wellington Independent:* "A stockade is about to be erected at the Upper Hutt, and the one now erecting at the Lower Hutt is rapidly progressing. Recently, at the request of several gentlemen of the Hutt, the contractor supplied them with a target made the exact thickness of the sides of the stockades and filled with screened gravel, which was carted to a suitable place under the superintendence of Captain Carlyon, Lieutenant Ludlam, and Corporal Tapp, of the Royal Engineers. The firing commenced at 120 yards, shortening the distance until within five paces, when several rounds were fired from three different descriptions of rifles, likewise from one of the percussion muskets. On examination of the target the result proved very satisfactory, sixteen having struck the centre, but not one had passed through, the balls flattening as soon as they come in contact with the gravel, thus proving the efficiency of the present works."

"A memorial for the erection of stockades has been sent to the Governor from about sixty of the residents in the small-farm neighbourhood of the Wairarapa. It is worthy of note that none of the sheep-farmers whose homesteads are scattered over the valley, and whose property would have to be abandoned should an outbreak occur, have consented to sign it."

The Hutt Stockade.

The following particulars of the blockhouse and stockade erected at the Lower Hutt at the same time is culled from the *Spectator* :—

"Through the courtesy of Corporal Tapp, of the Royal Engineers, who has been sent down to superintend the works, we have been favoured with an inspection of the plan for the stockade and blockhouse to be erected at the Hutt. The site selected is a paddock opposite Jillet's Hotel, known as Plowman's land. The stockade will be 95 ft. square, with walls 9 ft. high, rendered bullet-proof to 6 ft. by the interstice between the inside and outside planking being filled with shingle. The blockhouse, which will be in the south-west corner, the nearest the bridge, will be two stories high, with galvanized-iron roof, and rendered bullet-proof throughout by the same means as that used for the stockade. Its dimensions will be 30 ft. by 30 ft., with outside flanks of 15 ft., with loopholes on all sides and in both stories. In the opposite or north-east corner will be corresponding flanks or loopholes. The magazine will be 8 ft. by 4 ft., by 7 ft. high. The blockhouse will be built so as to protect the Wairarapa and Waiwhetu Roads, the bridge, and the ferry. Mr. W. Taylor's tender, £725, has been accepted, and the works will be commenced next week, the contract time for their completion being three months from the acceptance of the tender."

In this extract we see what the nature of the stockade was at the Upper Hutt, the two being constructed on the same plan. Some of the loopholes are plainly seen, while those blocked with tompions are scarcely discernible.

ART. III.—*The First New Zealand Navy; with some Episodes of the Maori War in connection with the British Navy.*

By HERBERT BAILLIE.

[*Read before the Wellington Philosophical Society, 21st October, 1919; received by Editor, 21st September, 1920; issued separately, 27th June, 1921.*]

Plates III–VI.

THE early volumes of the *Illustrated London News* contain many illustrations of New Zealand scenes and incidents. I was particularly interested in those shown in the issue of the 30th January, 1864, among which was one of "the gunboat 'Pioneer' at anchor off Meremere, on the Waikato, reconnoitring the native position." On looking into the subject of New Zealand's first navy I found that New Zealand had about that time quite an imposing fleet, which was manned from ships of the British Navy then on the station. On further search I found that the colony possessed a gunboat as far back as 1846. In the early days of settlement many requests had been made to the Mother-country to provide the colony with one or two armed vessels, but without success. It has been difficult to piece together the story of New Zealand's first navy from newspaper and official records and personal narratives, the censor having apparently been at work even in those far-off days.

An official statement of "Revenue and Expenditure for 1846" contains the item, "Purchase, &c., gunboat for Porirua Harbour, £100 17s. 11d." A newspaper records the information that H.M.S. "Calliope's" pinnace and two whaleboats had been sent to Porirua, and in a later issue it is mentioned that the "Tyne's" long-boat had been lengthened for service. The "Tyne" was a barque which had ended her voyage from London to Wellington on the rocks off Sinclair Head, Cook Strait, on the 3rd July, 1845. McKillop in his *Reminiscences* says, "A ship's boat had been purchased and converted into a gunboat by the carpenters of the 'Calliope,' mounting a 12-pounder carronade." A brass gun was also placed aboard. (Plate III, fig. 2.) The "Calliope" took the boat to Porirua on the 11th July, 1846. Midshipman McKillop was installed in command. He says that he secured the addition of six more bluejackets and two gunners lent by the officer in command of the Royal Artillery detachment then stationed at Wellington. McKillop came into contact with the Maori at the Pauatahanui head of the harbour on the 17th July; shots were exchanged, but, as he had "taken the precaution of lashing the men's beds up in their hammocks and fastening them round the boat, making a bullet-proof breastwork, which afforded great protection to the crew," no damage was sustained, except that the brass gun burst at the first shot. For meritorious work at Porirua Midshipman McKillop received great praise from Lieut.-Governor Grey, and was promoted to be mate of H.M.S. "Driver."

The gunboat was used for some time at Porirua on patrol duty, and was then taken early in 1847 to Wanganui, where it was commanded by Lieutenant Edward Holmes, H.M.S. "Calliope," who was assisted by Naval Cadet H. E. Crozier, of the same ship. Crozier accidentally wounded a native chief with a pistol, and this was the direct cause of the Gilfillan murders. The natives demanded the surrender of the youth, which, of course, was refused. Crozier was replaced by Midshipman John Carnegie. During the months of April and May, 1847, good work was done by the gunboat. On the 19th May, in consequence of the gunboat being injured from its own firing, Lieutenant Holmes moved his 12-pounder on board the "Governor Grey" (Plate IV, fig. 1), a Wanganui-built schooner of 35 tons, from whose unbarricaded deck he continued to fight until the enemy retired.

Captain J. H. Laye, 58th Regiment, who commanded the forces at that time, reported to the Governor, "To Lieutenant Holmes I am exceedingly obliged; the efficiency of the gunboat under his command (which was exposed to the fire of the enemy the whole of the day), his alertness with her at all times, and cordial co-operation, I am only too happy to bear testimony to."

In a despatch from Wanganui dated the 21st February, 1848, Major Wyatt, O.C., states, "The repairs to the gunboat are progressing."

On the outbreak of hostilities in the Taranaki Province in 1860 the Government advertised for two vessels suitable for gunboat service. In April the schooner "Ruby," 24 tons, recently launched from a shipbuilder's yard, was purchased by the Defence authorities, renamed "Caroline" (Plate IV, fig. 2), and armed with a 32-pounder gun, and a supply of ammunition from H.M.S. "Elk." The cost of the schooner was £630; the cost of stores, fittings, and the cannon, £300. Mr. Smyth, of H.M.S. "Niger," who had distinguished himself at the attack on Waireka, near New Plymouth, was appointed to the charge of the gunboat. He hoisted the pennant on the 14th April, 1860, and sailed from Auckland for Manukau on the 17th April. Mr. Hannibal Marks, "an old, experienced, and dauntless seaman, who knew every nook and inlet of the coast," was appointed pilot and sailing-master, being later appointed to command. The vessel acted as guard-ship on the Manukau Harbour, also being used as a despatch-boat between that port and New Plymouth. Later, she was transferred to Auckland, where she was chiefly used as a despatch-boat. I can find no record of her being engaged in any action. Her commission ended on the 12th October, 1863, and she was sold out of the service, the purchaser being Captain Davidson. Her name was changed back to "Ruby," and for many years she traded between Wellington and Kaikoura. She was wrecked off Jackson Head in 1879.

An urgent call for help had been sent to Australia, and in reply the Government of Victoria had lent its warship, the steam-sloop "Victoria," Captain Norman, which arrived at New Plymouth on the 3rd August, 1860, bringing Major-General Pratt, C.B., Commander of the Forces in Australia, and his staff. General Pratt took command of the troops in Taranaki until the arrival of Lieut.-General Cameron in May, 1861, when he returned to Australia in the "Victoria." The "Victoria" also brought a detachment of troops from Australia during this period, and was engaged on the coast on various duties, including the transferring of refugees from New Plymouth to other ports. Officers and men from this vessel took part in some of the Taranaki land engagements.

On the 28th March, 1860, Captain Peter Cracroft, H.M.S. "Niger," with a force of sixty men and a 24-pounder rocket-tube, landed and captured the Maori pa at Waireka, Taranaki, incidentally relieving a party of Volunteers who were in difficulties. This is the action in which Seaman William Odgers won the first Victoria Cross to be awarded for service in New Zealand. He was the first man to enter the pa, and he hauled down the Maori flag. He was promoted to be a warrant officer by the Admiralty on the 26th June, 1860, and the Cross was presented to him on parade at Devonport, England, July, 1862. Lieutenant Blake, who, with some men of the "Niger," took an active part in the military operations, was promoted to be commander for his services, later taking command of H.M.S. "Falcon" on the New Zealand station. The "Niger" had shelled the Warea Pa on the 20th March.

A Naval Brigade under Captain (later Commodore) F. Beauchamp Seymour, afterwards Lord Alcester, was stationed at Waitara, where Captain Seymour was wounded, June, 1860, at the attack on the Puketakauere Pa. The brigade, which was in service 1860–61, was composed of men and officers from H.M. ships "Niger," "Pelorus," "Cordelia," "Iris," "Elk," and the Victorian steam-sloop "Victoria."

In 1862 the Government purchased the paddle-steamer "Avon" for £2,000. This steamer, which was 60 ft. in length, 14 horse-power, 27 tons register, and drawing 3 ft. of water, had been brought from England in sections and put together at Lyttelton in 1861. She had been engaged in the trade between Lyttelton, Heathcote, and Kaiapoi. On the 22nd November she left Lyttelton in charge of Lieutenant Easther with a crew of fifteen men from H.M.S. "Harrier," in tow of that vessel. Lieutenant Easther retained command until the close of the Waikato War. Mr. Ellis, who is still living (1920) in Auckland, was engineer. The vessels arrived on the 26th November at Onehunga, where the "Avon" was refitted and armoured for service on the Waikato River. She assisted in the rescue of survivors from the wreck of H.M.S. "Orpheus," on the Manukau bar, 7th February, 1863, the men being transferred from the steamer "Wonga Wonga," which happened to be crossing the bar at the time of the disaster.

The "Avon" was towed to the Waikato Heads on the 25th July, 1863, by H.M.S. "Eclipse," Commander Richard C. Mayne (Plate V, fig. 1). Thirty men were transferred from the "Eclipse," and Commander Mayne took the "Avon" up the river to the Bluff—a little below where Mercer now stands. On the 6th August Captain Sullivan, H.M.S. "Harrier," senior naval officer in New Zealand, took the vessel on a reconnaissance as far as Meremere, where the Maori opened fire, which, on completion of observations, was replied to from the "Avon's" 12-pounder Armstrong gun and a 12-pounder rocket-tube.

While the "Avon" was being fitted at Onehunga four large barges were brought overland from Auckland. These were also armoured with an iron-plate covering, and pierced for rifles and sweeps, or oars, this work being done under the superintendence of Captain Mercer, R.A., who was later killed at Rangiriri.

The "Avon" was on service during the course of the Waikato War. On the 18th February, 1864, through striking a snag in the Waipa River, she became partly submerged. She was used for a time as a coal-hulk at Port Waikato, which in those days was a busy place, with building and repairing shops. Later the "Avon" was renamed "Clyde," and was occupied in mercantile trading in the run between Tamaki and the Thames. In 1876 her paddles were dismantled and twin screws substituted. She was broken up in Auckland about 1883.

In 1860 a small paddle-steamer, the "Tasmanian Maid," 53 tons register, 36 horse-power, which had been trading between Nelson, Wairau, and Wellington, was sent over by the Nelson people to bring the women and children from New Plymouth if necessary. She was then used as a despatch-boat between New Plymouth, Waitara, and Onehunga. In 1862 she was engaged in trade from Auckland to Coromandel, and about Auckland Harbour. In June, 1863, she was purchased by the Government for £4,000. She was renamed "Sandfly," and armoured, being also armed with two 12-pounder Armstrong guns. Lieutenant Hunt, H.M.S. "Harrier," hoisted the pennant on the 23rd June, 1863, and his crew consisted of twenty-two men from the warships. On the 12th October Captain Marks, of the gunboat "Caroline," was transferred to the "Sandfly," while Lieutenant Hunt was transferred to the paddle-steamer "Lady Barkly," which had been purchased by the Government and partially plated, when it was decided that she was unfit for service, as intended, on the Waikato River. She was used for transport work in and from the Manukau Harbour. The "Lady Barkly" is still (1920) running on the coast as a screw-steamer under the name "Hina." The "Sandfly" was stationed on the east coast of the North Island, her headquarters being Auckland. She took part in the blockade of the Firth of Thames and the Tauranga campaign. She captured on the 31st October the cutter "Eclair," a vessel of about 20 tons, owned by the Maori, and loaded with provisions. In 1865 the "Sandfly" was sold by the Government, after a short service about Cook Strait transporting troops to Wanganui, and doing a little survey work for the Cook Strait submarine cable. The new owners changed her name back to "Tasmanian Maid," and she was wrecked off New Plymouth on the 16th January, 1868.

In 1863 the Imperial Commissariat Department purchased the 80-horse-power steamer "Alexandra" for transport work. She cost £13,000, and was also wrecked somewhere near New Plymouth, 9th August, 1865. In 1863 the Government owned a sailing gunboat, "Midnight," but I have not been able to trace her commission, except that she appears to have been on service on the east coast, north of Auckland.

In a memorandum dated 20th October, 1863, the Minister of Defence stated, "Towards the end of 1862 the Government determined to place a small steamer on the Waikato, and after some inquiry the 'Avon' was purchased for the purpose. Her draught of water is too great to be available as is desirable; but, notwithstanding this disadvantage, the vessel has been of great service. The importance of having a suitable steamer for the navigation of the Waikato determined the Government to have such a vessel constructed in Sydney, and after many delays and much anxiety the gunboat 'Pioneer' (Plate VI, fig. 1) has been obtained—a vessel, it is believed, well adapted for the purpose." The "Pioneer" was launched from the shipyard of the Australian Steam Navigation Company, Pyrmont, Sydney, on the 16th July, 1863, having been under construction for a period of about seventeen weeks, the superintending engineer of the work being Mr. T. Macarthur, of the company's staff. A report in a local paper, the *Empire*, says, "Yesterday morning there was launched from the A.S.N. Co.'s patent slip, Pyrmont, a rifle gunboat for the New Zealand Government, and intended for the service of the inland waters of the Waikato district. She is intended to carry 300 men, on a light draft of water. Her dimensions are 140 ft. in length, 20 ft. beam, 8 ft. 6 in. depth of hold, and draws only 2 ft. 6 in. of water. She will be propelled by an overhanging stern wheel, 12 ft. diameter, 7 ft. broad, driven by two engines, each 30 horse-power. She is constructed of $\frac{3}{8}$ in. iron, which is pierced for rifles, and which will render her ball-proof. She is fitted with watertight

FIG. 1.—Putataka, Port Waikato. From a sketch by S. Percy Smith.

FIG. 2.—The "Calliope" gunboat. From a sketch by John A. Gilfillan.

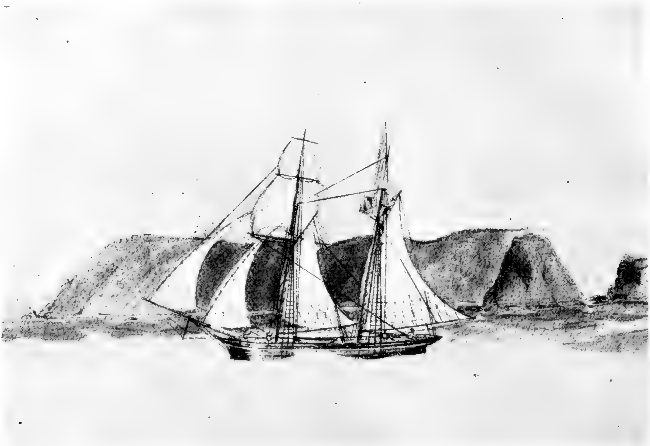


FIG. 1.—The "Governor Grey." From a painting by Major Heaphy.

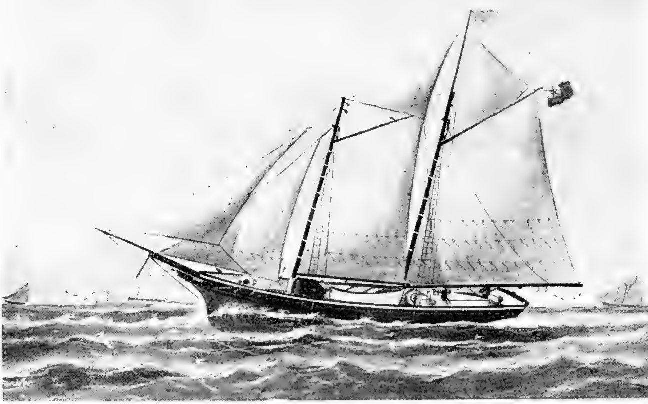


FIG. 2.—The "Caroline." From a painting by W. Forster.

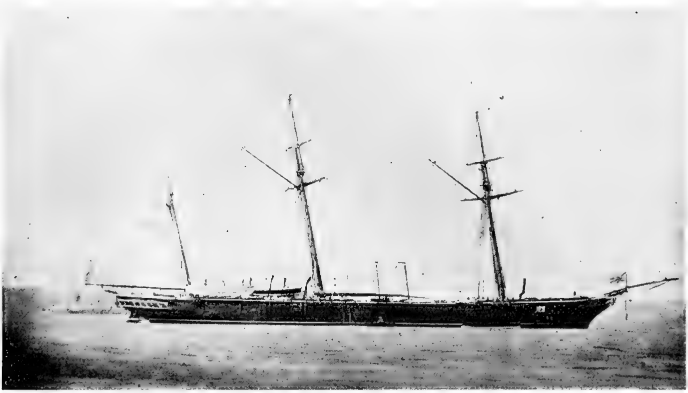


FIG. 1.—H.M.S. "Eclipse." From a photograph supplied by Admiral Sir E. F. Fremantle, G.C.B.

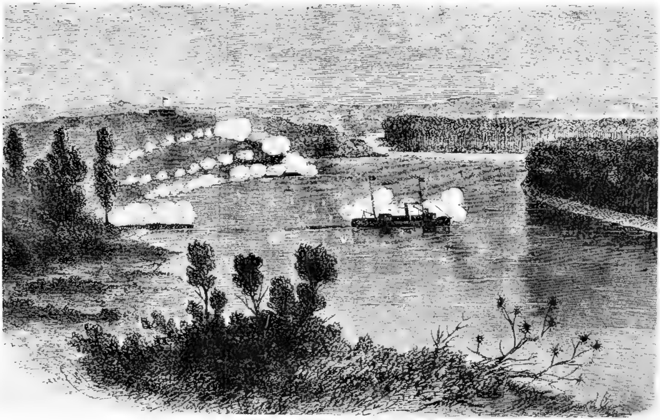


FIG. 2.—The "Pioneer," off Meremere

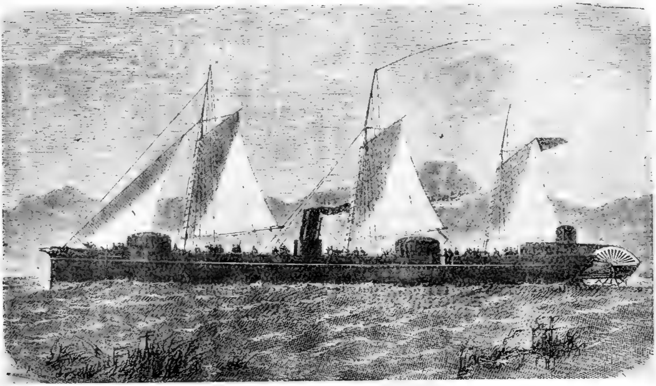


Fig. 1.—The "Pioneer." The mainmast was removed when the boat was in use on the Waikato.

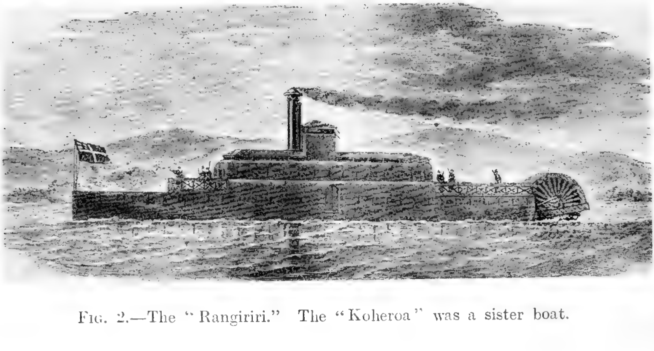


Fig. 2.—The "Rangiriri." The "Koheroa" was a sister boat.

compartments. The boilers were placed 54 ft. forward of the engines for the purpose of keeping the vessel on an even keel." The *Empire* of the 15th September further reports, "On the vessel's trial trip her speed was tested from Fort Denison to Bradley's Heads, a distance of 1 mile and 150 yards A smart N.E. breeze prevailed, but with this disadvantage the distance was run down in 8 minutes 12 seconds, and up in 6 minutes 53 seconds, giving a speed of nearly 9 knots, with 32 revolutions per minute, with 60 lb. on pressure of gauge, and a very small consumption of coal. Her speed exceeded the builder's expectations by one mile per hour. She is fitted with two sliding keels—one forward, one aft. The officers' cabins are situated aft, and the soldiers' apartments forward; they are very large and lofty. She has a flush deck, on which are placed two cupolas, 12 ft. in diameter and 8 ft. high, each pierced for rifles and 24-pounder howitzers. The commander's station was in a turret above the engine-room, which was also shot-proof and placed aft." She was provided with space for the storage of 20 tons of coal, and it is interesting to note that while on the Waikato she used local coal, being the first steamer to do so. The Hon. (later Sir) Francis Dillon Bell, a member of the Ministry, represented the New Zealand Government on the occasion of the "Pioneer's" trial. For the trip to New Zealand the stern wheel was removed, and three masts provided to carry sail. The cost of construction was £9,500.

After shipping a supply of ammunition, consisting of 60 cases shot and shell, 600 cartridges for 24-pounders, 1,000 tubes, 10,000 Terry's rifle cartridges, 12,000 caps, and 18,000 revolver-cartridges, the "Pioneer," in tow of H.M.S. "Eclipse," left Sydney on the 22nd September, reaching Onehunga on the 3rd October, after a rough trip. The officers attached to the vessel for the trip were Lieutenant G. R. Breton, late of H.M.S. "Iris"; Lieutenant O'Callaghan, H.M.S. "Miranda"; and Mr. Jeffrey, engineer; with a crew of twenty-five men. On the 24th October the "Pioneer," with two companies of seamen from H.M.S. "Curaçoa," was towed by H.M.S. "Eclipse" to the Waikato. At the same time the four armoured barges, or gunboats, were also taken to the river. While on active service each of the gunboats was in charge of an officer from H.M.S. "Curaçoa." I am informed by Admiral Hammick (then a sub-lieutenant), who was in charge of one, which was named the "Ant," that one was commanded by Midshipman C. S. Hunt, who had been saved from H.M.S. "Orpheus" when that vessel was wrecked on the Manukau bar; another was in charge of Midshipman F. Hudson. The fourth, which was named the "Midge," was commanded by Midshipman Foljambe. Mr. Foljambe in his *Three Years on the Australian Station* (1868) tells us that the boat was armed with a 12-pounder gun and a 4·4 in. brass Cohorn mortar, and carried a complement of seven men. These boats were used in the different operations on the Waikato and its branches, and also in carrying stores. Mr. Foljambe was the father of the late Governor-General of New Zealand, Lord Liverpool.

On the 29th October the "Pioneer," piloted by Mr. Chandeler, and flying the broad pennant of Commodore Sir William Wiseman ("Curaçoa"), after landing at Whangamarino, which commanded the Maori position at Meremere, two 40-pounder Armstrong guns, brought by the "Curaçoa" from Sydney, conveyed Lieut.-General Cameron, commander of the troops in New Zealand, on a reconnaissance. (Plate V, fig. 2.) Shots were exchanged, but no damage was sustained by the vessel, which returned to headquarters. On the 31st October the "Pioneer" again proceeded up the river as far as Rangiriri, the Maori stronghold. A spot about six miles above Meremere was selected as a landing-place for a force of 640 men and twenty-one officers, with two 12-pounder Armstrong guns This force was embarked on the "Pioneer" on the 1st November, and landed without opposition During the afternoon it was found that the Maori had abandoned their position at Meremere, which was then occupied by a party of 250 seamen, under Commander Mayne ("Eclipse"), and 250 men of the 12th and 14th Regiments, under Colonel Austin, from Koheroa. This force was reinforced next day by detachments from the 12th, 14th, 18th, and 70th Regiments, amounting to 500 men.

On the 20th November General Cameron, with a force of 860 men, attacked Rangiriri. To assist in the operations an additional 300 men of the 40th Regiment were embarked on the steamers, to be landed at a selected point, so that they might make an attack on the rear of the main line of the Maori entrenchments while the main body attacked in front. Owing to the wind and current the "Pioneer" and "Avon," with two of the gunboats, were not able to reach the landing-place decided upon. After a preliminary barrage by the Royal Artillery 12-pounders, under Captain Mercer, and the naval 6-pounder, under Lieutenant Alexander ("Curaçoa"), the main body attacked the main line of entrenchments and drove the enemy to the centre redoubt, while the party of the 40th Regiment, who had been landed sufficiently near to reach their position, were able to pour a heavy fire on a body of Maori, who were driven from their position and fled towards the Waikare Lake, where a number of them were drowned. The centre redoubt, still holding out against the troops, was attacked by a party of thirty-six men of the Royal Artillery, under Captain Mercer, who was mortally wounded, then by a party of ninety seamen under Commander Mayne, who was wounded. Both attempts were unsuccessful, as was another by a party of seamen under Commander Phillimore ("Curaçoa"), who used hand-grenades. As it was now nearly dark, the General decided to wait until daylight, when it was found that the white flag had been hoisted, and 183 Maori surrendered. Midshipman Watkins ("Curaçoa") and five men of the Naval Brigade were killed; while, in addition to Commander Mayne, Lieutenants Downs ("Miranda") and Hotham ("Curaçoa") (afterwards Admiral Sir C. F. Hotham) and five men were wounded.

In a letter from Ngaruawahia dated the 4th December Wiremu Tamehana (William Thompson), the Maori leader, said that he had lost all his guns and powder. "It is your side alone which is still in arms—that is to say, the steamer which is at work in the Waikato, making pas as it goes on; when they finish one, they come a little farther and make another. Now, then, let the steamer stay away; do not let it come hither. That is all." But, as the Maori king's flag had been hoisted at Ngaruawahia in the first place, it was decided that the Queen's flag should fly there.

On the 2nd December General Cameron moved on from Rangiriri. As the outlets from Lake Waikare were not fordable, the troops, with their tents and baggage, were conveyed up the river in boats manned by seamen of the Royal Navy, under Commander Phillimore. The following day the troops again moved on, and encamped abreast of the island of Taipori. Here General Cameron was delayed, waiting for provisions, until the 7th, when he moved the camp about five miles farther up the river, and met the "Pioneer," which had safely passed the last shoal below Ngaruawahia. Next day he went with Commodore Wiseman in the "Pioneer" to Ngaruawahia, which he found to be deserted. He immediately returned to the camp, and, after embarking 500 men of the 40th and 60th Regiments, again proceeded up the river, and landed at Ngaruawahia, where he established headquarters. On the 26th December 300 men of the 50th Regiment left Onehunga on the transport "Alexandra" and the chartered steamer "Kangaroo" for Raglan. On the 28th, 250 men of the Waikato Militia, under Colonel Haultain, embarked on the steamer "Lady Barkly" for the same destination.

The memorandum of the Defence Minister, dated the 20th October, 1863, stated, "But so strongly has the necessity been felt for providing means for commanding the navigation of this important artery of the country, and for preparing means of communication with the military settlers to be located in the Waikato country, and of transporting the necessary supplies, that two smaller steamboats of very light draft of water have been ordered to be constructed in Sydney. These vessels are being constructed of iron. They will be brought from Sydney in sections, on board a vessel laden with coal, direct to the Waikato River, and put together at the Waikato Heads. These two boats are also specially designed of great power, so as to be used as tugs, and thus provide means of transporting supplies up the river."

These two boats were named "Koheroa" and "Rangiriri," probably after the two actions fought on the Waikato. (Plate VI, fig. 2.) The builders were Messrs. P. Russell and Co. A Sydney newspaper, in describing one of the boats, said, "This boat, which can easily turn in the space of a little more than her own length, may follow the bendings of such a river as the Waikato in its narrowest part, and may either be used as a steam-tug, towing flats for the conveyance of troops, or may be armed with a gun at each of the singular-looking portholes, which are closed with folding doors, in the middle of the lower deck; while the bulwarks on each side are pierced with twenty or thirty loopholes for rifle shooting." The "Koheroa" was built in less than six weeks from the time the contract was received from Mr. James Stewart, C.E., who had been sent to Sydney by the New Zealand Government to superintend the construction. The sections of the "Koheroa" were brought from Sydney to Port Waikato by the steamer "Beautiful Star." The first bolt was riveted on the 4th January, 1864, and the vessel was launched on the 15th. I can find no record of these boats being engaged in hostilities, but they were used for transport work for some time.

By the end of January, 1864, General Cameron's headquarters had been moved to Te Rore, on the River Waipa, from which, on the 20th February, with a force that included a naval detachment of 149 men and ten officers, he moved across the Mangapiko River to Te Awamutu, where headquarters were established. During the last few days of this campaign (February, 1864), while the "Avon" was patrolling the river, a shot reached the vessel and killed Lieutenant Mitchell, H.M.S. "Esk."

From Ngaruawahia Commodore Wiseman and a party of naval and military officers went up the Horotiu River a distance of twelve miles, then transferred to the "Koheroa," and, proceeding twenty-two miles farther on (to near the site of the present town of Cambridge), located the Maori position, and returned. This incident ends the story of the British Navy on the Waikato River, though the steamers were used for some time longer on transport duty. Colonial crews were placed on board, and the Naval Brigade's operations were transferred to the Tauranga district.

General Cameron transferred his headquarters to Tauranga on the 21st April, 1864. Reinforcements, which had been sent from Auckland on

H.M.S. "Harrier" and "Esk," arrived at Tauranga on the 26th April. On the morning of the 27th the Maori had fired heavily on Fort Colville, but they were shelled out of their position by H.M.S. "Falcon" and the colonial gunboat "Sandfly." Captain Jenkins ("Miranda") took charge of the "Sandfly," which with the "Falcon" pursued the Maori who were retreating along the beach. Two 12-pounder Armstrong guns had been placed aboard the "Sandfly"; one, from the "Falcon," was manned by "Miranda" men, and the other, from the "Esk," was manned by men from that ship. Both ships shelled the whares at Otamarakau. At 3 p.m. firing ceased, as the enemy had finally disappeared. Captain Hannibal Marks, of the "Sandfly," and Senior Lieutenant Hope, in command of the "Falcon," were mentioned in despatches for "zeal and exertion." The gunners from the "Miranda" and "Esk" were mentioned for the "extraordinary precision of their fire from the 12-pounder Armstrongs."

On the 29th April General Cameron made the attack on Gate Pa, with a force of 1,700 of all ranks, including a Naval Brigade of four field officers, six captains, seven subalterns, thirty-six sergeants, five drummers, 371 rank and file. One hundred and fifty seamen and marines under Commander Hay ("Harrier"), and an equal number of the 43rd Regiment under Lieut.-Colonel Booth, formed the assaulting party. Commander Hay and Lieut.-Colonel Booth fell mortally wounded. Captain Hamilton ("Esk") was killed. The casualties of the Naval Brigade were: Killed or mortally wounded: "Curaçoa"—Lieutenant Hill and one man; "Miranda"—one man; "Esk"—Captain Hamilton and three men; "Harrier"—Commander Hay and three men; "Eclipse"—one man. Wounded: "Curaçoa"—five men; "Miranda"—Lieutenant Hammick and eight men; "Esk"—Lieutenant Duff and ten men; "Harrier"—four men. Total dead, 12; wounded, 29. Most of the wounded cases were classed as "severe" or "very severe."

For bravery in carrying Commander Hay, when wounded, off the field, Samuel Mitchell, captain of foretop, and captain's coxswain, was awarded the Victoria Cross, which was presented to him by Sir J. Young, Governor of New South Wales, in Sydney in October.

On the 21st June Colonel Greer, commanding the Tauranga district, attacked the enemy at Te Ranga, and while this attack was being made a naval force from the "Esk" and the "Harrier" was landed for the protection of the camp. Lieutenant Hotham was mentioned in despatches.

Lieut.-General Sir D. A. Cameron left Auckland in January, 1865, for Wanganui on H.M.S. "Falcon," calling at New Plymouth *en route.* He arrived at Wanganui on the 20th January, and on the 5th February moved camp to Waitotara, one and a half miles from the mouth of the river. The paddle-steamer "Gundagai" entered the river during the evening, bringing provisions for several days. On the 16th February General Cameron marched to the Patea River, which had been entered by the "Gundagai" and "Sandfly" the day before. The General stated in his report, "They crossed under the most favourable circumstances; but as the latter ["Sandfly"] had not more than a foot to spare at high water, it will not be prudent to bring her into the river again."

This covers, as far as I can discover, the operations of our first naval adventures. The vessels seem to have done good work, and all that was expected of them. It is to be hoped that the "Calliope's" gunboat, the schooner "Caroline," the paddle-steamers "Avon" and "Sandfly," and the river-steamers "Pioneer," "Koheroa," and "Rangiriri," and the men of the British Navy who manned them, will not be forgotten in our histories.

ART. IV.—*Notes on a Geological Excursion to Lake Tekapo.*

By R. SPEIGHT, M.A., M.Sc., F.G.S., F.N.Z.Inst., Curator of the Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 7th July, 1920; received by Editor, 31st December, 1920; issued separately, 27th June, 1921.*]

DURING the Easter recess of the present year the author paid a visit of several days' duration to the country lying to the east and north of Lake Tekapo, in the Mackenzie country, the visit being primarily to determine the stratigraphical relations of the coal reported to occur in Coal River, and its bearing on the origin of the Mackenzie intermontane basin. The question of the origin of this basin, the greatest in the alpine region of Canterbury, was discussed to some extent by Kitson and Thiele (1910, p. 431), when these authors concluded that it was of structural origin, a conclusion largely based on the observations of McKay on the Tertiary sedimentaries which occur near Lake Ohau and in the lower part of the area. This lower part, however, they do not appear to have visited; while the structural origin of the upper part in the vicinity of Lakes Pukaki and Tekapo, which they did examine, was stated as a probability, without giving distinct evidence. Largely influenced by the great weight of Captain Hutton's opinion, they concluded that the tectonic movements which initiated its formation dated from pre-Cainozoic times; that a depression of the land took place in mid-Cainozoic times, and that the sea then invaded the valleys and deposited marine sediments; that the area was raised at the close of the Cainozoic era with some slight deformation, and that the resulting surface was modified by glacier erosion and deposition. This is a brief summary of the position as far as the origin of the basin is concerned.

Since their paper appeared there has been a general swing of mature geological opinion in the direction of the hypothesis that the chief structural movements in the alpine region of the South Island took place in late Jurassic or early Cretaceous times, when the Alps were raised as a folded mountain-chain and during a subsequent period of stillstand of the land a peneplain was formed as the result of prolonged subaerial erosion; that on lowering this surface below sea-level a more or less continuous veneer of Tertiary marine sedimentaries was laid down on it; and that at the close of the Tertiary era an epeirogenic movement ensued, with attendant faulting, warping, and, in some cases, of folding of the beds, which resulted in the formation of an elevated tract known as the Southern Alps. Included in this are several remarkable intermontane basins, of which the Mackenzie country is one. The second hypothesis is the one favoured by the author, and the visit to the district under consideration was made in order to ascertain if the facts furnished by it fitted in with this hypothesis.

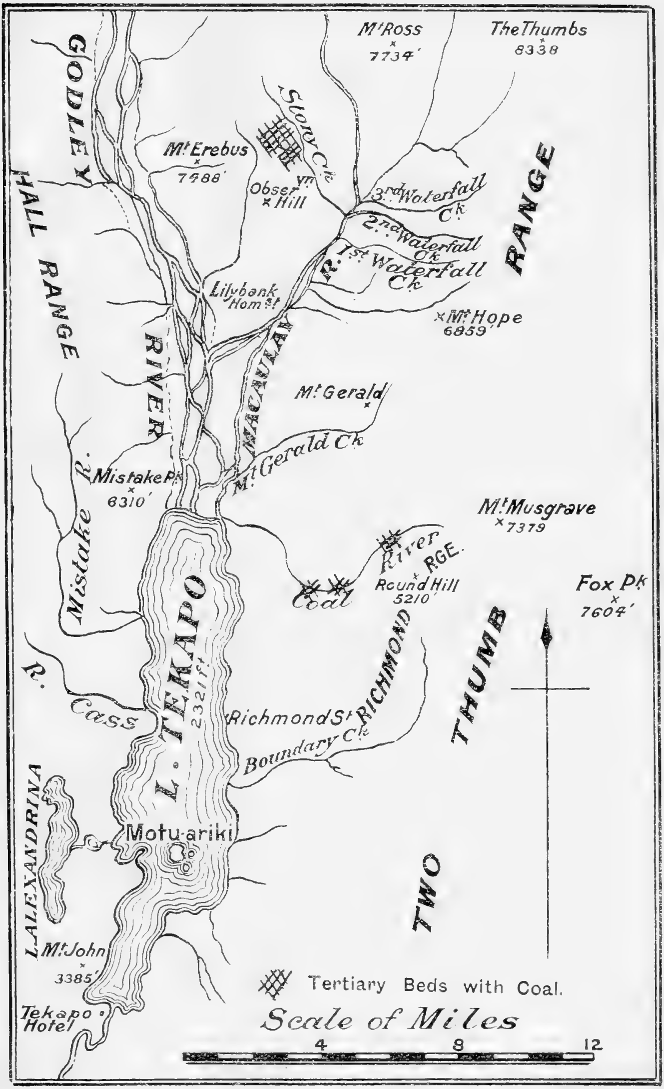
General Physiography. (See map.)

The district under special consideration lies to the north-east and north of Lake Tekapo, which occupies the most easterly of the three main valleys leading from the highest section of the Southern Alps out on to the sloping plain region of the Mackenzie country, which owes its formation largely to the aggrading action of the great rivers which formerly flowed from the fronts of glaciers issuing from those valleys. The basin is bounded on the east by the Two Thumb Range, which branches off the main divide of the Southern Alps in the vicinity of McClure Peak (8,192 ft.), and runs south without a break until it reaches the Ashwick Saddle and Burke's Pass, whence it continues southward as the Hunters Hills. The range is highest at its northern end, where it is dominated by the great mass of Mount d'Archiac (9,279 ft.); but high peaks are found farther south, such as Mount Chevalier (7,910 ft.), the Thumbs (8,338 ft.), and Fox's Peak (7,604 ft.); while for long distances it is over 7,000 ft., and rarely sinks below 6,000 ft. It thus forms a thoroughly effective divide between the north-eastern part of the Mackenzie basin and the valleys of the Rangitata and Opihi, which lie to the east. From this range important ridges stretch down towards Lake Tekapo, such as the Sibbald Range, which divides the Godley Valley from that of the Macaulay, with Mounts Sibbald (9,181 ft.) and Erebus as its leading peaks, and the Richmond Range, which reaches south-west towards the middle of the eastern shore of Lake Tekapo. To the south of the Macaulay lies Mount Gerald, which, though not very high, is a noteworthy feature of the landscape.

The chief rivers feeding the lake are the Godley and the Macaulay, the former rising in the main divide and the latter draining the country between the Sibbald Range and the Two Thumb Range. On the western side of the lake the chief streams are the Cass River and Mistake River; while on the eastern side the most important streams are Coal River and Boundary Creek, both of which flow first of all south-west and then west. The former follows along the northern flank of the Richmond Range and enters the lake at its extreme north-eastern corner, while the latter follows along the southern side of the range and enters the lake about the middle of the eastern shore.

The surface of Lake Tekapo is 2,321 ft. above sea-level, and it is therefore the highest of the great lakes of New Zealand. It has a length of about fifteen miles and a breadth of about three and a half in its widest part, and is somewhat quadrangular in shape. Its general surroundings are monotonous, and the country is now treeless except for the plantations in the neighbourhood of station-homesteads. The shores, too, are flat and wanting in bold features Only on the western side, in the vicinity of Mount John and the Mistake Range, do hills closely approach the lake; and in these cases they rise precipitously from the water's edge, and exhibit all the features of valley-walls whose bases have been sapped back by lateral glacial erosion.

On the eastern side the country rises gradually from just above lake-level to the foot of the spurs from the Two Thumb Range, such as Mount Gerald and the Richmond Range; and the profile of these slopes is evidently carried down to the bed of the lake, so that it has not the form of a true glacial trough, but rather of a widely open groove or depression. The lake is thus somewhat shallow—387 ft. was the maximum depth obtained by Ayson—and two small ice-scoured islands with outlying reefs near the lower end of the lake emphasize the fact that the solid bottom does not lie far below a large area of the water.


Mt Ross
7734'
The Thumbs
8338
GODLEY
Stony Ck
Mt Erebus
7488'
Obser vn Hill
3rd Waterfall Ck
2nd Waterfall Ck
1st Waterfall Ck
RANGE
HALL RANGE
Lilybank Homst
Mt Hope
6859'
RIVER
MACAULAY R.
Mt Gerald
Mt Gerald Ck
Mistake Pk
6310'
Mt Musgrave
7379
Mistake R.
River
RGE.
Round Hill
5210'
Coal
Fox Pk
7604'
L. TEKAPO
2321 ft
RICHMOND
THUMB
Cass R.
Richmond St
Boundary Ck
L. ALEXANDRINA
Motu-ariki
TWO
Mt John
3385'
Tekapo Hotel
Tertiary Beds with Coal.
Scale of Miles
4
8
12

The whole country in the vicinity of Lake Tekapo has been heavily glaciated. Extensive areas of the lower levels are masked by a veneer of moraine; large travelled blocks everywhere dot the landscape, and some are exposed, partially submerged, along the shores of the lake. Owing to the completeness of this covering, exposures of rock *in situ* are rare below the steep slopes of the mountains. Scoured and grooved surfaces and smoothed landscapes are visible at higher levels. Numerous shelves of comparatively small elevation are characteristically developed as the valley widens out, especially on the section between Coal River and the Macaulay. These are strongly reminiscent of those to be seen near the Potts River in the Rangitata Valley, and near Lake Heron in the valley of the Upper Ashburton. In these cases the type of sculpture is associated with the erosion of a valley which has been at one time filled with non-resistant Tertiary sediments. Farther up-stream, however, a modified form of this sculpture is apparent where the ice has overridden the end of the spur between the Macaulay and the main valley, the rock being entirely greywacke, so that it is not dependent altogether on the presence of easily eroded rocks. A feature similar to this is recorded by Park (1909, p. 19) as occurring near Ben More, in the Wakatipu district. In this case, however, he attributes the feature entirely to glacier erosion, whereas the Tekapo occurrence seems partly due to erosion and partly to the deposit of morainic matter on the shelves so formed.

The extreme freshness of the evidence of ice-action suggests that the retreat of the ice was comparatively recent, a fact which is emphasized by the modifications of the valley-sides. The youthful stage of the drainage of some of the tributary creeks, too, with their deep, narrow, rock-bound gorges incised into the abraded surfaces, so smooth by contrast, strongly supports the hypothesis that the ice has but recently retreated from this region. This feature is specially well exhibited in the Waterfall Creeks, which enter the Macaulay from the east, just at the point where it is emerging from the rocky precipitous country on to the down area which lies on the flank of Mount Gerald.

One somewhat surprising feature is the absence of halting-stages in the retreat. There are no terminal moraines apart from the great one at the foot of the lake, and the coating of angular material seems to be somewhat thin. It is as if the ice disappeared simultaneously from long stretches of the valley and dropped the covering of moraine which then masked its surface. This loose material would be rapidly occupied by plants from the adjoining open spaces, so that the formation of a plant covering should not lag long behind the disappearance of the ice. The rapidity with which a bare shingle river-bed is covered with vegetation shows that no objection can be raised to the hypothesis of a recent rapid retreat of the ice on the ground that plants would not have had time or opportunity to spread and establish themselves on the glacier-swept areas. The evidence of rapid retreat with few or no halting-places is observable in the valleys of the other main rivers of Canterbury, especially the Rakaia and the Waimakariri.

On the higher country the usual forms resulting from glacial sculpture are to be seen, notably corries in all stages of complete and arrested development and of destruction by present-day ice and frost. The cirques, originally heading them after the retreat of the ice, are attacked by these agencies, the clear-cut walls disappear, the hollows becoming filled with debris. Especially is this the case when they are partially filled with snow. Rocks roll down its frozen surface, especially in winter, and accumulate at the lower margins of the hollows, simulating terminal moraines of the glaciers which once filled them.

A most beautifully developed corrie, fully a mile broad, occurs at the head of Stony Creek, a western tributary of the Macaulay. This is headed by a well-marked amphitheatre or cirque with steep rock walls; at their base are hollows now occupied by small ponds or swamps, the remains of old corrie lakes. The lower part of the basin was once filled by a deposit of Tertiary sands and clays with coal, but a great part of these has been removed, so that now there is a double basin inside the limits of the corrie. On the lower side, too, below the spot where the coal has disappeared, there is the characteristic rock barrier, breached at one point, and through this opening, in a deep narrow notch, the stream draining the basin now flows. Before the coal-measures had been removed it must have presented a thoroughly typical example of a coomb or corrie.

STRATIGRAPHY.

The great mass of the mountains of this region consist of greywackes, argillites, and slates of the Maitai series, to which may be assigned a Trias-Jura age. This time classification is based almost entirely on the similarity of the lithological character of the rocks to those with undoubtedly Trias-Jura fossils. This is, however, supported by the author's finding a fragment of dark-coloured argillite in the high country between the Godley and Macaulay Rivers which shows the unmistakable sculpture of *Monotis salinaria*. Not only the primary and secondary ribs occur, but also the peculiar and regular cross-sculpturing, so that the author has no reasonable doubt but that it belongs to that important Triassic fossil, and the find thus confirms the age of the beds as deducted from their lithological character. The finding of this fossil, and other finds reported lately from Arthur's Pass and the Hawdon River, suggest a wide extension of rocks of this age over the mountain region of Canterbury; but it must not be inferred that all the rocks of that area are of the same age. The presence of heavy bands of conglomerate containing pebbles of greywacke, in close proximity to beds with these fossils and in apparent conformable relations, suggests that there is an older set of beds in the region of similar lithological character which have furnished these pebbles, and therefore lying unconformably under it. The contention of Hutton and others that two distinct series of rocks occur in the mountains of Canterbury is apparently correct, but much more field-work will have to be done before they are definitely separated.

On the east side of Lake Tekapo, especially in the Richmond Range, the rocks show a submetamorphic facies; and slaty shales with a somewhat lustrous surface occur, and in all probability they grade into the true phyllites exposed near Fairlie on the flanks of the Hunters Hills and in the Kakahu Gorge, which resemble closely the phyllites of that belt of Otago east of the schists. I have been informed by Mr. Pringle, owner of Richmond Station, on Lake Tekapo, that marble occurs just over the divide to the east of the lake, on the Rangitata slope; and if the identification of the rock is correct it means that the metamorphic belt extends much farther north than has been recorded previously. Much less is known of the geological features of the western side of the Rangitata Valley than of any part of Canterbury, so that the occurrence of marble may well have escaped observation. The beds to the north and east of Tekapo have, according to the observations of the author, a general north-and-south strike, with directions west of north occurring freely.

Two exposures of Tertiaries are recorded for the first time from this district—(1) that in Coal River, and (2) that occurring on the western side of the Macaulay River on the Sibbald Range.

(1.) *Coal River.*—Exposures of sands and clays with coal occur in several places in the deep gorge which Coal River has incised in the down country to the north-east of the lake, and chiefly in the vicinity of the right-angle bend which the stream makes as it leaves the Richmond Range and runs straight to the north-eastern corner of the lake. The exposures, five in number, occur in places along the two miles of gorge stretching both above and below the bend, but they are so masked by moraine that they cannot be traced away from the stream, and the relations of the individual outcrops to each other are obscure. The exposure lowest in the course of the stream is distant about three miles from the road-crossing. Here are exposed greyish-white sands of uncertain thickness, capped by gravels, brownish owing to the presence of iron-oxide, which are apparently unconformable; above them lies morainic matter.

On the north side of the river, at the bend, occur sands and sandy clays weathering white or stained brown. The strike is appaiently N. 10° W., and the dip to the east 35°, but there is some doubt about this observation. On the south side of the river, about 100 yards up-stream, are sandy clays with carbonaceous shales; and farther up still, at the mouth of a small creek coming from the Richmond Range, there is a patch of much-slipped country showing sands and sandy clays, some with distinct greenish tint.

After the intervention of a barrier of greywacke, capped in places by white sands, similar beds to those just mentioned occur nearly a mile up-stream on the south side. The following sequence occurs here, in ascending order: (1) White sandy clay, 4 ft.; (2) clays with reddish tinge, 8 ft.; (3) impure lignite, with carbonaceous shale, 2 ft. 6 in.; (4) argillaceous sands, stained brown in the lower part, yellow above, 15 ft.; (5) whitish sands, thickness uncertain. These are capped by brownish gravels, which may be conformable, but the exposure is so limited that it cannot be determined for certain These are succeeded unconformably by moraine.

The strike of the beds is north, with a dip to the east of 45°. This patch of sedimentaries has a fault-contact on the south-east margin with the older beds, the fault running north-east and south-west, and its continuation may account for the presence of the beds in the bend of the creek, as their south-eastern border has the same line as the fault. This patch owes its preservation, in all probability, to having been faulted down, and having thus been preserved from erosive agents. How far it extends under the morainic material to the north and south of the river is quite uncertain, but brown gravels similar to those occurring near the stream are exposed farther north on the western slope of Mount Gerald, which suggests a continuation of the beds in that direction.

(2.) *Stony Creek Beds.*—These beds lie on the floor of a corrie on the western side of the Macaulay Valley, which is drained by Stony Creek. They lie about 4,000 ft. above the sea. There are two occurrences, separated by a barrier of greywacke. The lower one consists of the following beds, in ascending order: (1) White argillaceous sand; (2) greenish sandy clay; (3) brown coal, 2 ft. 6 in. thick, striking north and south, and dipping west 35° (the coal contains pieces of ambrite); (4) whitish sand, with yellow stain; (5) white sand, very fine in grain, with small amount of clay; (6) grey sandy clay.

The country is much slipped and the deposit comparatively thin, so that the true relations of the beds are uncertain, and their enumeration is in all probability quite incomplete. This is emphasized by the fact that pebbles of quartz, like those from the quartz drifts of Otago, occur in other parts of the basin, but they were not noticed in the series given above.

About 200 ft. higher in elevation there is another outlier of uncertain size, consisting of several seams of coal. This has a pitchy lustre, conchoidal fracture, blackish-brown colour, and contains numerous pieces of ambrite. Several of the seams are 2 ft. in thickness, and may be more. They are interstratified with carbonaceous shales, and lie on green sandy clays, which in turn lie on greywacke. The whole thickness of the beds is at least 100 ft., and may be much more, as the surface is masked by debris. The strike is north-east, and the dip north-west about 35°. It was just below this occurrence that the fragment of rock was found showing the sculpture of *Monotis*. The greywacke here strikes north-west.

These two patches are evidently the remnants of a much larger deposit which filled a considerable part of the cirque, the great size of which is evidently due to the fact that it was an area of easily eroded beds. The remnant is a very small one, and is rapidly disappearing. This observation is confirmed by the experience of Mr. Pringle, who accompanied us on our visit to the spot and stated that since he last saw it, some twenty years ago, the floor of the basin had completely changed and a great deal of the beds containing coal had disappeared. In the great snow winter of 1895 he had packed down half a ton of this coal for use at the Lilybank Station when supplies were short owing to the break in communication, and he said that it burnt excellently. If it were not in such a remote locality no doubt the deposit would have been used up long ago.

On both sides of the Macaulay between this and the lake are extensive deposits of brownish gravels antedating the glaciation. The pebbles are chiefly greywacke, but quartz is also an occasional constituent, although no quartz-bearing rocks are now found in the locality. These are evidently remnants of a much more widely extended sheet which has been swept away by glaciation.

In none of these occurrences of Tertiary sediments were any marine fossils found which might definitely prove that the beds themselves were of marine origin. They resemble very closely the deposits described by McKay (1882, p. 62) as occurring in the lower part of the Mackenzie country near Lake Ohau and in the Wharekuri basin, and classified by him as "Pareora," or of Lower Miocene age. As far as the deposits at Wharekuri are concerned, considerable doubt has been thrown on McKay's account by both Park (1905, p. 499) and Marshall (1915, p. 380)—which is unfortunate, seeing that the Wharekuri basin is in the same river-valley as the Mackenzie basin, and the explanation of the origin of one might support that of the other. However, the deposits laid down in the basins of Central Otago, as described by Hutton (1875, p. 64) and Park (1906, pp. 15–19, and 1908, pp. 31–33), are so similar that a common origin is suggested. Hutton (*loc. cit.*, p. 64) notes the similarity of the Otago deposits to those at Lake Ohau, and thus incidentally confirms the resemblance of the Tekapo beds to those of Central Otago. He classifies the latter as of Pliocene age.

There is thus a possibility that the beds occurring in the Tekapo district are of Pliocene age, though it is possible that the age of the Otago lacustrine (so called) beds has not been definitely determined up to the present, and that this opinion may have to be revised.

McKay was correct in suggesting (1884, p. 62) that considerable areas of his Pareora gravels and clays underlay the moraine which covered a considerable area of the plains, seeing that remnants of this deposit have now been located near their upper margin. Up to the present the valley of the Tasman River has yielded no positive evidence of the existence of these beds, but the character of the slopes about Braemar is such that similar Tertiaries might be located beneath them.

There is thus direct evidence of the structural origin of the basin, apart from that suggested by its form; but the special point left to consider is the date at which it took on this form—that is, whether it antedates or postdates the time of deposition of the beds contained therein.

Hutton (1875, p. 64) was firmly convinced that the areas were basin-shaped before the deposits were laid down in them—that is, they were of pre-Pliocene origin—just as he maintained that the Canterbury intermounts were pre-Tertiary (1885, p. 91). In this he was followed by McKay (1884, pp. 76–81) and by Park (1905, p. 523; 1906, p. 9; 1908, pp. 17 *et seq.*), who restated his position in his *Geology of New Zealand* (1910, pp. 141–44). The latter evidently dates the formation of his block-mountain system of Otago and the Wharekuri basin to pre-Pliocene times, although he gives in numerous places instances of the beds concerned having been involved in faults and other deformations which may well have originated or have been attendant features of the formation of the basins.

On the other hand, Marshall (1915, pp. 380–81) has expressed the opinion that some of the basins, such as that at Wharekuri, were formed after the deposition of the Tertiary sediments, and that the landscape as it now exists has no resemblance whatsoever to the form of the surface when deposition was going on. This opinion has been strongly supported by Cotton (1916, pp. 316–17, and 1917, pp. 249 *et seq.*), who points out that the evidence for the basins being filled with lacustrine sediments is extremely slight, and that they were subjected to deformational movements after deposition, and that the dominant surface-features result from the faulting-down of blocks covered with a non-resistant veneer of Tertiary sediments which were preserved in the low-lying basins resulting from this faulting, whereas on the higher elevations it was completely or almost completely removed by erosive agents. In this paper, too, he endorses the statement that the upper course of the Waitaki River occupies a broad tectonic depression, and apparently accepts Kitson and Thiele's explanation of its origin, although this conflicts somewhat with his explanation of the origin of the basins of Central Otago.

The most important piece of geological evidence, apart from the physiographical, is that furnished by the character of the deposits themselves. There is a widespread absence of coarse sediments in the basal beds of the basin—sediments suggesting a mature topography and the absence of high land in the vicinity of the area of deposit; and if this contention is correct the landscape must have been entirely different from what it is now. It is inconceivable that sediments could have been laid down in basin-shaped hollows as at present existing without, in some parts of the area, coarse conglomerates forming an important element in the lower members of the series. Again, the presence of numerous quartz pebbles in conglomerates like those in the Macaulay Valley, evidently strangers to the district, cannot be easily explained unless the drainage directions were considerably different at the time of deposition from what they are at present. These geological features are not explained on the hypothesis that the "lake-basins" were formed before they were loaded up with sediments.

Again, the height at which these sediments occur in the Tekapo region is most striking. In Coal River they are 3,500 ft. above sea-level, and in Stony Creek 4,200 ft.—that is, 2,700 ft. above the floor of the lake. These deposits, especially the latter, could not have been deposited were the form of the Mackenzie basin at all like that at present existing. If the basin had been filled up to this level it would imply the removal of an enormous amount of material by glacier erosion subsequent to deposition, and this amount is too great to have been removed without leaving more than two slight traces of its former presence in the Tekapo area, even if we grant that glaciers have great powers of erosion. Some remnants other than those would be present, tucked away in some sheltered corner of the mountains out of the line of action of the ice-flood. If warping be called in to modify the form of the basin this argument falls to the ground. It is remarkable, however, that the remnants occur in a region where the mountains are highest.

If due regard be paid to the character of the deposits it will be evident that the Mackenzie country looks rather to Otago for its nearest relatives, though similar areas occur farther north in Canterbury. In these, limestones are a dominant geological feature; whereas in Otago they are almost absent, the occurrence of patches like that at Bob's Cove, on Lake Wakatipu, being quite exceptional. The occasional occurrence of marine shells, however, shows that the sea extended over the area. The presence of conglomerates at the close of the cycle of deposition indicates that fairly high land was in existence at that time; and, as similar gravels are found closing the Tertiary sequence over a great extent of country to the east (*e.g.*, the Kowai* series of North Canterbury) and to the west of the Alps, as described in various bulletins of the Geological Survey, it is reasonable to think that the movements which resulted in the final formation of the Alps commenced towards the close of the Pliocene period and continued into the Pleistocene, and therefore that the intermounts date from that time. The final form of the landscape resulted largely from the influence of glaciation on the structural features then formed.

Little evidence of the direction of the axes of deformation is afforded by the Tekapo district. There is nothing to support the contention of Edward Dobson that the orientation of the valley of the Godley was initially determined by tectonic movements, although I came across nothing against it. The axis of the valley, however, seems to correspond with the general strike of the greywackes and associated rocks.

The latest observed deformational movements that the district experienced are on north-east and south-west lines. The strike of the coal-beds in Stony Creek, and also the fault-line which bounds the occurrence in Coal River, have this direction. From the limited and unsatisfactory nature of the exposures in the latter locality the general strike of the beds cannot be accurately determined, but the even and regular slope of the north-west side of the Richmond Range suggests that it corresponds with some fault-line; and, further, if such a line be granted to exist, and its direction

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* NOTE.—I have retained the spelling for this term in the form as applied originally by myself to the series developed in North Canterbury, although Dr. J. A. Thomson has criticized it and replaced it by another spelling in his paper on the "Geology of the Middle Waipara and Weka Pass District" (*Trans. N.Z. Inst.*, vol. 52, p. 334, 1920). The spelling used by me is that originally used by Haast, and is also that in official use for the past thirty years not only for the river, but for the district, now merged into a county. It is that which appears on all recent maps issued by the Survey Department. Further justification is, I think, unnecessary.

be followed into the Rangitata Valley, it is found that the steep tent-sided face of the Ben Macleod Range, which forms the southern boundary of the Forest Creek valley, is in actual alignment with it. This striking surface-feature cannot be accounted for as the result of stream or glacier erosion, but if faulting be granted it would also explain the subdued character of the surface which lies to the south of the Mesopotamia homestead, this having been lowered as a result of the earth-movement, and it would also help to account for the form of the Rangitata intermount. Further, if the line of the north-west face of the Richmond Range be continued to the south-west across Lake Tekapo it will pass along the north flank of the isolated Mount John, and bound the considerable area of flat country which lies between that elevation and the Mistake Range, which may also owe its form to having been faulted down. This is a pure speculation, but the peculiar position of Mount John requires some explanation, and it seems impossible to account for it as the remnant of a spur or extension of the Mistake Range, with the connecting-ridge removed entirely by normal glacial erosion.

In concluding, I should like to express my indebtedness to Mr. James Pringle, of Richmond Station, who not only gave valuable information with regard to the district, but also kindly provided means of transport so that the most was made of the time at my disposal.

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ART. V.—*The Modification of Spur-ends by Glaciation.*

By R. SPEIGHT, M.A., M.Sc., F.G.S., F.N.Z.Inst., Curator of the Canterbury Museum.

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Plates VII–XI.

THE subject of the changes which glaciers exert on the form of stream-valleys is such an interesting one that special aspects are worthy of detailed consideration. It has not, however, been fully considered so far as this country is concerned, although Andrews in his classic paper on the glaciation of south-western New Zealand (1905) has drawn attention to certain forms, such as the total truncation of spurs, and the development of sitting-lion and titan-beehive shapes, as well as the formation of a double slope on the valley-sides and especially on the spur-ends. The present author has pointed out certain other features (1907 and 1911), but observations made during the past few years in the alpine region of the South Island of New Zealand have suggested that still other forms exist. The faceting of spur-ends as a general result of the overdeepening of glaciated valleys and the formation of tributary hanging valleys has been dealt with in various places by W M. Davis, G. K. Gilbert, de Martonne, and others; but apart from this, judging by the literature at my disposal, little has been written. Davis has, however, insisted that the detached knobs on the floors of valleys, either separated from or in close proximity to the valley-walls, are remnants of a pre-glacial land-surface which have escaped destruction. He says (1900, p. 274), "On entering the glaciated valley of the Rhue it is found that the regularly descending spurs of the non-glaciated valleys are represented by irregular knobs and mounds, scoured on their up-stream side and plucked on the down-stream side; and that the cliffs formed where the spurs are cut off are sometimes fully as strong as those which stand on the opposite side of the valley. The spurs generally remain in sufficient strength to require the river to follow its pre-glacial serpentine course around them, but they are sometimes so far destroyed as to allow the river to take a shorter course through what was once the neck of a spur." Again, on page 276 he says, "It is seen that just before the complete obliteration of the spurs some of the remnant knobs may be isolated from the uplands whence these pre-glacial spurs descended. It is out of the question to regard the ruggedness of such knobs as an indication of small change from their pre-glacial form, as has been done by some observers. The ruggedness is really an indication of the manner in which a glacier reduces a larger mass to smaller dimensions by plucking on the down-stream side as well as by scouring on the up-stream side. It is possible that knobs in other glaciated valleys than that of the Rhue may be of this origin; they should then be regarded not as standing almost unchanged and testifying to the incapacity of glacial erosion, but as surviving remnants of much larger masses, standing, like monadnocks above a peneplain, as monuments of the departed greater forms."

The glaciated knobs of the Central Plateau of France that he notes later on hardly come into this category, but on page 288 he refers to rocky knobs seen in abundance about Ambleside and along the ridge separating Thirlmere from St. John's Vale, in the County of Cumberland, in England. In this paper he everywhere emphasizes the potency of glacier erosion, especially in valleys.

In a subsequent paper (1905, pp. 4–5) he again refers to knobs: "The knobs and ledges may be taken to be so-many unfinished pieces of work, which would have been more completely scoured away had the glacial action lasted longer." This point he again emphasized in a paper on "American Studies on Glacial Erosion" (1910, p. 423), and refers to it slightly in the discussion on his account of the glacial features of North Wales (1909), and also in an answer to a question on glacial knobs addressed to him by M. Allorge.

This is a summary of Professor Davis's position as far as I can see from the literature at my disposal. It will be noted, however, that nowhere in the papers I have cited has he illustrated his point by showing the various stages by which a spur actually develops into a field of knobs; and this is somewhat surprising, as the method would be one entirely in keeping with the way in which he so frequently presents a physiographic problem.

I have examined other authorities, such as Hobbs and de Martonne, and find that faceting is everywhere recognized, but no other forms are noted. In the report of the Harriman Expedition to Alaska, G. K Gilbert deals exhaustively with the origin of hanging valleys and faceted spurs, but says little or nothing of any other of the various stages of modification However, I have examined the maps and illustrations and can see little evidence of intermediate forms, with the possible exception in the case of Nunatak Glacier (p. 59, and map), where the Nunatak appears to be a detached knob or end of a reduced spur.

Since there is this absence of statements concerning intermediate forms, I have attempted to supply some evidence as to their occurrence which I have come across during years of intimate acquaintance with the alpine region of the South Island of New Zealand. Incidentally this will be found to support Davis's contention that fields of knobs in the floor of a glaciated valley represent the remnants of spur-ends.

The main effect of ice-action on valley-spurs is due to abrasion, although no doubt plucking is very important at times, and especially in its more mature stages, when the spur-ends have become faceted At this stage, too, the excavating-power of a glacier has a dominating influence on the resulting landscape-form. But the depth of the ice, its velocity, and the time to which the surface has been subject to its action all exert important influences; and, further, the direction in which the tributary valley meets the main valley also controls to some extent in its initial stages the result of ice-action on the spur-ends.

As its dominating influences are those of thickness, velocity, and time, the modification of valleys, and therefore of the spurs running into them, will be different in different parts of the valley, being more pronounced in the upper portions, owing to the fact that these agencies are there at their maximum. Those parts of the valley where the ice is thickest, its velocity greatest, are just those parts which have experienced its action for longest time, and therefore modifications will be carried further than in the lower reaches. It will follow also that the character of the pre-glacial topography will be most easily arrived at by a study at the fringe of the glaciated district,

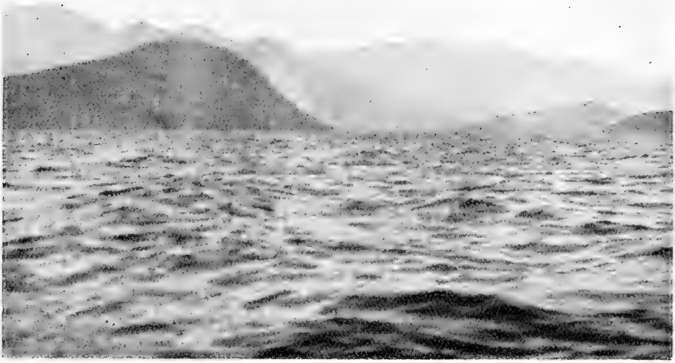


FIG. 1.—Lake Manapouri, looking east, showing notched spurs with islands formed by ice moving across the spur from west to east.

FIG. 2.—Lake Manapouri, looking east, showing islands with characteristic profile, remnants of dissected spurs.

Fig. 1.—Lake Manapouri, looking west. Island in foreground with profile similar to those in Plate VII, figs. 1 and 2, but more rounded. A still more rounded form in the background farther west, it having been more exposed to erosion.

Fig. 2.—Semi-detached knob, Thompson Sound.

where the action has not been intense, owing to the thinness of the ice and the shortness of the period during which the area has been covered. Also, there will be a progression of phenomena, varying in intensity on moving from the outskirts of the glaciated area; and phenomena characterizing the areas where glaciation has been intense, inexplicable in themselves, may be elucidated from the intervening regions where glaciation has been intermediate in its intensity.

The region of the South Island whence most of the instances to be mentioned later are drawn had reached a submature stage in the cycle of erosion before the incidence of the glaciation. Valleys had been cut in an elevated area, and a well-developed stream-system had been established with long spurs trailing down into the main valleys; but the district was one of alpine character, with peaks approaching in elevation, if not exceeding, the present European Alps.

A most interesting case illustrating the nature of the slight modification to which spurs may be subjected on the outskirts of a glaciated area is furnished by Lake Manapouri. The chief complex of spurs entering the basin occupied by the lake reaches down from the north, the spurs running in a north-and-south direction, whereas the direction of the chief ice-stream was from the west, and in its passage eastward it cut across the long trailing ridges of the pre-glacial land-surface. Erosion was most marked in the western reaches of the lake, where the ice was thickest and had acted for a longer time, so that a great trough or hollow was formed, with precipitous sides carried far down below the present surface of the lake (depth 1,458 ft.). Not all of this is to be credited to excavation by glacier-action, but some portion to the damming-back of the water by the morainic bar of the combined Te Anau and Manapouri glaciers. While the ice has profoundly modified the western portion of the lake and removed the spurs of the pre-glacial valley-system, the change in the eastern spurs has been slight, merely cutting them into a series of notches placed one below the other down the backbone of the ridge, all with the same characteristic profile, and continued down to lake-level, where exactly the same landscape-form is reproduced in the islands that dot the lake. (See Plate VII, figs. 1 and 2.) These notches form a kind of stairway with the treads inclined backward so that the level of the tread is lower at the foot of the riser than on the edge of the tread (*cf.* glacial stairway in a valley). The spur has thus been little modified, so that its original form can be restored. The slight modification suggests that the ice, though deep, as is evidenced by the height up the spur to which the series of notches reaches, can have exerted its action for a comparatively short time or it would have produced a profounder impression. Although signs of ice-action are found some twenty miles to the east of these spurs, the period of advance must have been quite short, or the spurs would have been more profoundly modified. Traces of this peculiar landscape-form are to be found on all the spurs to the eastern end of Manapouri where they were likely to be exposed to the full force of the ice-flood, so that it can hardly have been an accidental feature. Still farther eastward the spurs are unmodified. In Plate VIII, fig. 1, which is a view of the lake looking west, there are also signs of the same form, with a more developed knob in the background.

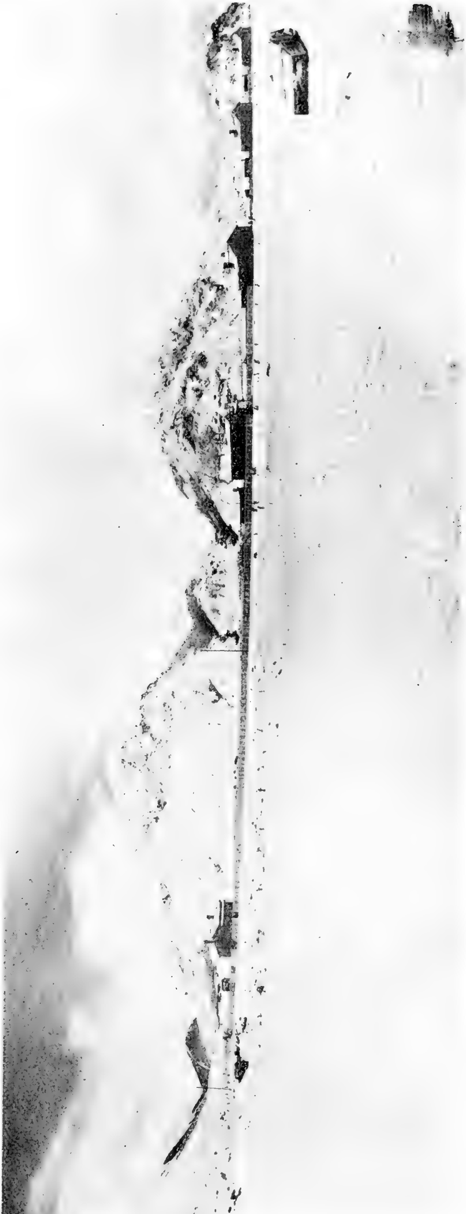
The form of the modified spurs suggests another point. Judging from the shape of the islands which lie off the ends of the spurs, it is clear that before the ice-advance the spurs continued down below the present level of the lake. It therefore negatives the idea that the hollow in which the lake now lies has been entirely due to glacial erosion. In my opinion, the hollow is primarily tectonic, but the surface so formed has been modified by stream-action, succeeded by glaciation, and that now a new cycle of stream erosion has commenced.

The form of the notches cut in these spurs is also characteristic of ice erosion, since glaciers always appear to exert their maximum erosive effect at the base of the valley-sides or shelves along which they move. Thus the notches have the backward slope which results from this mode of action. When this becomes more pronounced and ice-action has been more prolonged, the outstanding portions of the ridge tend to become rounded eminences. If a stairway was attacked further the notches would become a string of knobs, gradually getting higher as the spur is followed upwards. This stage of development is seen in the Waimakariri Valley to the west of the Cass River, where Mount Horrible and Mount Misery owe their rounded form to the great Waimakariri Glacier crossing a spur which runs parallel with the present Cass River and enters the main valley nearly at right angles. (Plate IX.)

The formation of a well-developed series of notches generally occurs where the spur has great length ; but if it is shorter in the pre-glacial stage only one or two notches may be cut, and the resulting form becomes a semi-detached knob or titan beehive noted by Andrews in the Sounds region. (Plate VIII, fig. 2.) This form is typically developed in the Upper Rakaia Valley at Mein's Knob and Jim's Knob, the latter being formed by the Ramsay Glacier passing over the terminal spur of the Butler Range. (Plate X, fig. 1.) Numerous illustrations in all stages of development can be seen in the Upper Waimakariri Valley, especially where the action of the main glacier has not been interfered with by the weight of the ice issuing from a tributary comparable in size to the main stream. When the tributary becomes large the modification of the spur is attributable chiefly to its action, and not to the erosion of the main stream.

From the slight difference in the form of the notches in the higher part of the series as compared with those at floor-level it is evident that all the notches were cut during one period of ice-advance. Had there been more than one ice-flood, reaching various levels, there would have been some difference in the form of the higher members of the series from that of the lower. As the lower members would have experienced more than one ice-flood, their stage of erosion would have been more mature. Also, if the ice had not reached so high in the later floods as in the earlier the exposed notches or knobs at higher levels would show more the effects of subaerial erosion, by rain, frost, &c. For example, if the first flood were the highest, then while the lower levels were being subsequently glaciated the higher and exposed levels would have been differentially modified by subaerial erosion, and glacial erosion of the lower slopes would have been carried to a more mature stage. If the last ice-flood had been the highest, the modification of the higher levels would have been different in that the glacial surface would have been juvenile, while the lower would have been mature. If an intermediate flood had been the highest, a differential modification partaking of both characters would have occurred, depending on the relative importance of the two phases. But the only difference—and that is a very slight one—is that which might have been expected in the lower parts of a glacier, where, under the influence of greater weight of ice, abrasion, plucking, sapping, and other glacial agencies are more intense.

The knobs of the Cass Range show very markedly the modifying effect of frost erosion, as their plant covering is of the scantiest—in marked contrast



Range west of Cass River, Waimakariri Valley, showing partially dismembered spur with rounded knobs.

Fig. 1.—Jim's Knob, Upper Rakaia Valley. A semi-detached knob, showing channel where ice has attacked and cut down the termination of a spur.

Fig. 2.—Ice-cut bench on lower side of Bealey River at its junction with the Waimakariri River.

Fig. 1.—Jumped-up Downs, Upper Rangitata Valley, showing spur reduced to a field of knobs. View taken looking down-stream.

Fig. 2.—Jumped-up Downs, Upper Rangitata Valley, showing spur reduced to a field of knobs. View taken looking up-stream.

to the forest-covered slopes near Manapouri; but it is noteworthy that erosion has reached a similar stage in each individual of the series of knobs, suggesting that they were all formed by the same ice-flood, as is the case of those near Manapouri.

The fact that the series of notches in these spurs has been cut all at the same time suggests that the shelves existing in valleys of the European Alps may, in some cases, have been cut during one period of ice-advance. These are referred to by de Martonne in his *Géographie Physique* (p. 641). After describing the shoulders which are so characteristic of these valleys, and the location of villages on them, he says, "Les replats multiples indiquent que l'érosion des vallées alpines est le résultat d'une série de phases d'érosion glaciaire et d'érosion fluviale alternantes, produisant un enfoncement progressif du thalweg et un encaissement de plus en plus grand de la vallée, malgré les efforts faits par le glacier pour reculer le pied du versant par sapement à chaque période glaciaire!" Although it is dangerous to express an opinion without having seen the locality, it seems possible that these flats and shoulders may—in some cases, at all events—have been formed at one glacial effort, like those at Manapouri.

An important factor which affects the resulting form of the spur-remnant is the angle at which the pre-glacial valley of the tributary meets that of the primary. It will be most convenient to take the simple case when they meet at right angles or nearly so. Good illustrations of this case are furnished by the Bealey and Hawdon Valleys at their junction with that of the Waimakariri. The two tributaries come in from the north, whereas the main stream runs from west to east. The tributary valleys are subequal in size, and the size of the glaciers issuing from them at the height of the glaciation, judging from the present cross-section of the valleys, would be about one-fourth of that of the main stream. As a result of the greater weight of the ice in the main valley, the tributaries were crowded over the shoulder of the spur on the down-stream side of the tributary, with the result that they have both a flattish shelf about 100 ft. above the present floor of the valley and about 200 yards in length, formed by the cutting-down of the end of the spur, so that it terminated in a kind of platform analogous to the wide shore-platforms sometimes seen off a point on a coast-line composed of moderately soft rocks. (See Plate X, fig. 2.) The two spur-ends are so similar in position, shape, and extent that they might easily be mistaken, and photographs taken from the opposite bank of the Waimakariri are almost interchangeable. The similarity in form is no doubt to be attributed to similarity in the conditions under which the spur-ends were reduced by the glaciers as erosive agents.

If erosion proceeds further the shelf is cut down near its proximal end, and the beehive form again results, but it is then flatter than that resulting from the passage of the main stream at right angles over a trailing spur.

If the tributary meets the principal valley at an angle greater than a right angle, as in the case of Harrison Arm and Milford Sound, or the Sinbad Valley with Milford Sound, then the form becomes accentuated. The formation, not of a shelf, but of the couchant-lion shape, takes place, but ultimately this must develop into the beehive form. This form is, of course, subject to profound abrasion, and is liable to be reduced by attack from both sides and also on top, so that it ultimately becomes a mere *roche moutonnée*, standing in the floor of a glacial trough, and apparently without genetic connection with the valley-sides. In most cases, however, such isolated rocks were once connected directly with the valley-sides, the connecting ridges having been completely removed by glacial abrasion. All the different stages in the formation of such isolated rocks from spur-ends can be seen in the valleys of the Southern Alps.

Worthy of special mention are the detached hills which lie in the angle between the Poulter and Esk Rivers near their junction with the Waimakariri. They are the remnants of the spur which once came down between the two former rivers, and whose end was dismembered by the large glaciers which issued from the Poulter Valley and Boundary Creek Valley, crossing it near its termination.

Spurs are eroded on the up-stream side in a somewhat different way. There is no overriding except in the case of the main stream entering a distributory valley, as in the case of the Rakaia branching off into the Lake Heron Valley, or when a glacier crosses the mouth of a tributary valley which is bare of ice. When, however, both are full of ice the end of the spur is modified by an action which is analogous to the whirlpool that forms when two rivers join, as a result of which the end of the spur is ground back below the surface of the glacier, so that it presents a steep face at the angle between the streams.

When the tributary meets the main valley at an angle less than a right angle the spur-ends are cut back, though with less overriding of the end than when the angle is greater. Narrow shelves, somewhat resembling terraces, are the common resultant form. Excellent illustrations of these can be seen at the junction of the Macaulay River with the Godley, and in the angle between the Potts and the Rangitata.

When valleys are subparallel, then there can be little or no truncation of the dividing ridges, but these are dismembered and cut into lengths as the result of lateral corrasion, chiefly by means of small tributary glaciers of the corrie type whose heads ultimately meet and lower the divide. Thus we get the elongated rocky hills which are so frequent in our ice-enlarged intermontane basins, which if submerged would produce elongated islands in parallel or linear arrangement, such as those which add to the scenic beauty of the West Coast Sounds, notably Dusky and Doubtful Sounds.

In the figures given by Davis illustrating partially destroyed spurs, fields of knobs appear to be a common feature. I have noticed occurrences similar to these in places where spurs have been partially destroyed—*e.g.*, in the valley of the Harper River to the north-east of Lake Coleridge ; but the most characteristic occurrence is in the valley of the Rangitata at the place called by the somewhat striking name of the "Jumped-up Downs." (Plate XI, figs. 1 and 2.) This is evidently the residual of a destroyed spur, and its irregular appearance is well described by the name given by the early settlers. Right out in the floor of the Rangitata Valley is an isolated rocky mound in a line with the hummocky area ; this is evidently the remnant of a spur which reached a considerable distance into the wide basin now occupied by the river.

The surface of these hummocks is characteristically worn into smaller *roches moutonnées*, often well striated, forming rounded oval masses with dimple-like hollows in between. When the general surface is flat, as is frequently the case when shelves are formed from the terminations of spurs, shallow rock-bound pools are formed containing the characteristic bog-vegetation of these regions, which passes into peaty masses. Excellent examples of these can be seen on the platforms at the junction of the Bealey River with the Waimakariri, and on the reduced spur-ends farther up-stream opposite the mouth of the Crow River.

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ART. VI.—*Recent Changes in the Terminal Face of the Franz Josef Glacier.*

By R. SPEIGHT, M.A., M.Sc., F.G.S., F.N.Z.Inst., Curator of the Canterbury Museum.

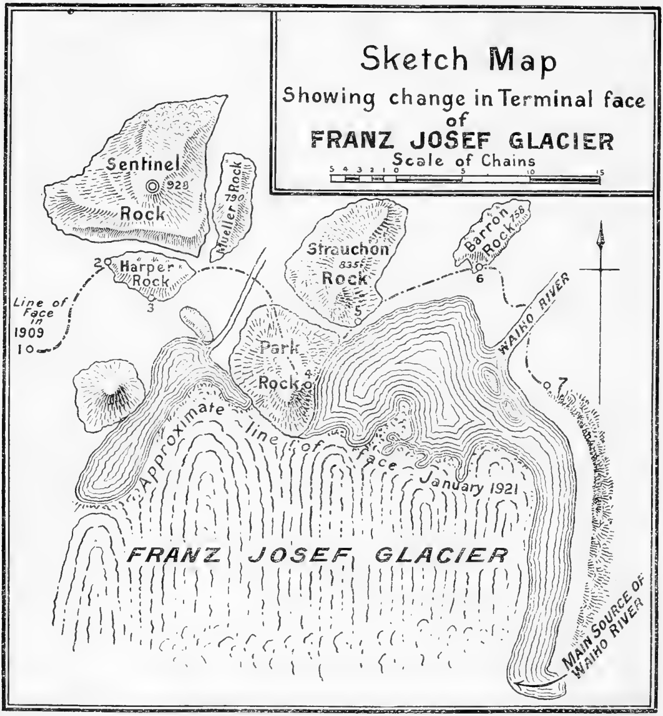
[*Read before the Philosophical Institute of Canterbury, 6th October, 1920; received by Editor, 31st December, 1920; issued separately, 27th June, 1921.*]

Plates XII, XIII.

IN 1909 Dr. J. Mackintosh Bell, then Director of the New Zealand Geological Survey, placed a number of pegs along the face of the Franz Josef Glacier in order to enable its subsequent advance and retreat to be definitely determined. Their position, and other particulars about the glacier, were recorded in a publication issued by the Survey in 1910, entitled "A Geographical Report on the Franz Josef Glacier." Since then Mr. A. Graham, who is guide at the glacier and takes the keenest interest in its varying moods, has from time to time recorded the movements of the face, and a summary of his observations was published by the present author in 1914 under the title, "Recent Changes in the Position of the Terminal Face of the Franz Josef Glacier."* Since the appearance of this record the glacier has rapidly retreated, as will be clear from the observations detailed below; but it is approaching a stage when an advance may be expected, and it is therefore most important that its present features should be placed on record as definitely as possible in order to afford a sound basis for future comparisons. Mr. Graham has most kindly assisted with observations, and a recent visit of the author to the locality (February, 1921) enabled these observations to be confirmed and brought up to date, Mr. Graham rendering most willing and valuable assistance. It is somewhat difficult, however, to get precise records at present, since ponds of water of varied width up to some 100 to 120 metres lie in front of the greater part of the face and prevent close approach to it except by means of a boat, which was not available; and, further,

* *Trans. N.Z. Inst.*, vol. 47, pp. 353–54, 1915.

these ponds cover extensive areas of submerged ice lying in position, so that the precise location of the end of the ice is almost impossible. Nevertheless, the observations conclusively prove that there has been a marked retreat of the ice since 1914, and still more since 1909. In this account reference will be made to each of the pegs in turn, and the characteristics of the face in its vicinity recorded as accurately as possible; and for the purposes of ready comparison all measurements will be recorded in metres. As the general trend of the front of the glacier is approximately



east and west, the line in which measurements were made from the pegs was north and south, unless special reasons occurred for deviating from this direction. It should also be mentioned at this stage that the principal part of the Waiho River now runs from the eastern side of the glacier, and that lying in front of its western edge is a complex of *roches moutonnées*, evidently the remains of a spur of the pre-glacial valley, destroyed as described in a paper published elsewhere in this volume (see p. 47). The solid barrier presented by these rocks has no doubt caused the stream to discharge near the eastern side where the lip of the obstruction is lower.

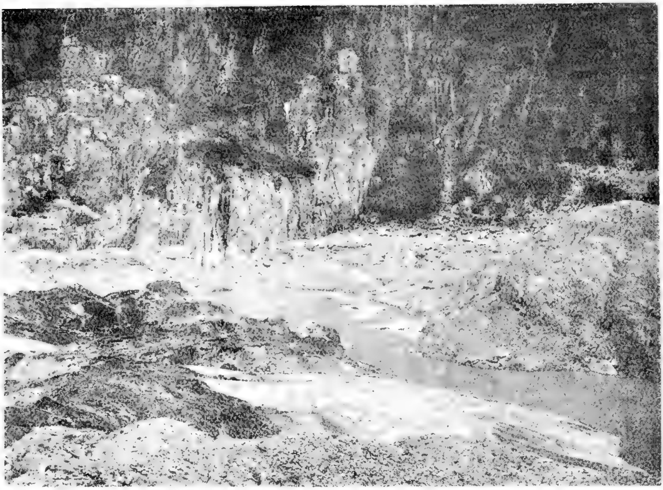


Fig. 1.—Ice-front viewed from Park Rock, looking south-west, showing pond with ice continuing down below water-level. Freshly exposed *roche moutonnée* on right.

Fig. 2.—General view of glacier, looking south from Park Rock, showing overthrust upper layers in foreground and advancing pulse in background; Roberts Point on the extreme left top corner.

Fig. 1.—View looking east from Park Rock, showing part of pond fronting ice in the foreground, with collapsed glacier ice to the right. Peg No. 7 is situated on the rock-edge to the left of the picture, at a height of 200 ft. above the river. The Waiho River runs along the foot of the slope over ground from which the ice has retired since 1909.

Fig. 2.—View from peg No. 7, looking south, showing source of the Waiho River, and slightly advancing ice to the left; advancing pulse in the background.

The circumstances of the ice in the front of each peg will now be taken in turn, the chief features and points of interest being recorded on the map.

Peg No. 1.—This was placed on solid rock on the western side of the valley, but it is now covered with moraine, and its precise location is impossible without detailed survey. In 1909 the ice was 1 metre from the peg; it is now 279 metres distant, the measurement being made approximately parallel with the valley-wall to the point where the ice meets it. The face is here quite low, but immediately to the east the pool of water fronting the glacier commences, and the face is higher, sometimes overhanging; farther east the face again becomes low. The pool is about 60 metres broad on its western margin. The rapid retreat of this part of the face was mentioned in the records issued in 1914, as Mr. Graham then noted that the river had cut a wide gap between the ice and the western wall of the valley. The movement has apparently been much accelerated since the last observation.

Peg No. 2.—It was not found possible to determine the distance of the face from this peg in a satisfactory manner—first, on account of the pool, about 50 metres wide, fronting the glacier, and, secondly, because the ice in its retreat has exposed a large rock about 30 metres in height above the level of the water. The pool now washes the southern face of this rock. This rock was not exposed in 1914, so that its appearance and situation give some idea of the great distance the ice has retreated and the change in the condition of the face. (See Plate XII, fig. 1.)

Peg No. 3.—This is situated on Harper Rock. When originally placed the peg was at the ice-face. In 1912 it was 15 metres away, in 1914 it was 37 metres, and now it is 160 metres distant. The ice is fronted here by water 50 metres wide. (See Plate XII, fig. 1.)

The trend of the ice-front along the stretch just dealt with is slightly east of north, and running in a line with Strauchon Rock. Between Harper Rock and Park Rock another smaller rock has been exposed, and all three present a face towards the glacier not suggested by the map attached to Bell's account. The southern faces of all three are in approximate alignment, the direction running E. 30° S., and being determined by the dominant joint-planes traversing the schist of which the rocks are entirely composed. They all present a steep face to the south, and do not exhibit the effects of glacier erosion to a marked degree, there being a tendency to split both along the foliation-planes and also the joint-planes, so that any glacial smoothing originally existing has disappeared as the slabs have flaked off.

A low tongue of ice runs from the glacier into the pool (Plate XII, fig. 1), between the large new exposed rock in front of peg No. 2 and Park Rock, but ice occurs in position under the water of the pool, so that it extends farther forward at this part of the face than elsewhere. The end of this tongue is almost due west of peg No. 4, on Park Rock. The edge of the pool reaches the south-west side of the rock, but the pool narrows to a point, and there is a small stream issuing from it immediately to the west of Park Rock. The southern face of Park Rock is reached by the ice, but the rock has a much greater extent to the south-south-east and south-west than is suggested by Bell's map.

Peg No. 4.—This is on Park Rock. When originally placed it was surrounded by ice except to the northward. In 1912 the ice was 23 metres away, in 1914 it was 58 metres, whereas it is now 100 metres distant. The face is also low, but the upper layers show signs of being pushed over differentially. (See Plate XII, fig. 2.)

Opposite Strauchon and Barron Rocks there is a good expanse of water, and the edge of the ice reaching down into it is low and irregular, presenting embayments such as occur on a drowned coast-line, and no doubt the ice extends forward below water-level. For these reasons it was not considered advisable to measure the distance of the face from pegs Nos. 5 and 6, but the retreat from the line of the ice-front indicated on Bell's map certainly exceeds 160 metres, since the farthest exposed ice is at present almost due east of peg No. 4, on Park Rock. The whole of this portion of the face affords evidence of collapse, and the upper layers of ice show shear-planes and have evidently been pushed over the lower layers, an effect certainly due to differential movements; but whether this is to be attributed to the collapse of the glacier or to a definite thrust forward of the upper layers of ice is quite uncertain. This phenomenon seems to be more pronounced as Park Rock is approached. (See Plate XIII, fig. 1.)

By far the greatest volume of water issuing from the glacier runs out of the north-east side of the pool which fronts the ice east of Park Rock, but a very considerable stream issues from close to the eastern side of the glacier and runs along between the ice and the wall of the valley for over 400 metres. In this part of the face the retreat has been most marked of all, as the measurements clearly show.

Peg No. 7 was initially placed 2 metres from the ice; by 1912 it was 14 metres away, by 1914 it was 24 metres, and now it is as much as 456 metres distant from the peg to where the ice abuts against the eastern valley-wall near river-level. The front is very high, over 20 metres in this section, and there is evidence of a small advance, since the ice is crowding over lichen-covered rock at the side. This advance may be of local character and therefore of little importance, but it may be symptomatic of a pronounced forward movement which is impending (See Plate XIII, fig. 2.)

It will be evident from the foregoing records that the minimum retreat of the face since 1909 has been 100 metres, and the maximum 456 metres, and after making all due allowance for the form of the face the average retreat of the front of the glacier is found to be approximately 180 metres.

As noted previously, there are evidences of approaching advance. A pulse indicating a marked rise in the ice is strongly developed about half a mile (800 metres) up the glacier, and the ice is pushing over the moss-covered glaciated rock-surfaces of the valley-walls at Roberts Point and Cape Defiance, still farther up. (Plate XIII, figs. 1, 2.) If the rate of movements of the glacier be that determined by Bell—viz., from 1 ft. to 2 ft. (0·3 to 0·6 metres) per day—this pulse should reach the terminal face in from three to five years. If the rate of movement is faster, as it probably is, the space of time will be correspondingly reduced, and it may be reduced still more as the oncoming wave affects the ice immediately in advance of it. A similar pulse is observed in the neighbouring Fox Glacier, and Mr. Graham intends to place a mark in a good position on the Chancellor Ridge near the glacier so that the rise of the ice-level may be correctly determined.

Mr. Graham has also made observations to arrive at the rate of flow. Selected morainic blocks lying on the surface of the ice below Roberts Point have shown an average movement of 3 ft. (1 metre approximately) per day during a period of 200 days, and it is likely that at the base of the first ice-fall the rate is much faster. Observations have been made since November, 1920, but the results are not yet available.

An interesting point to consider is the possibility of periodicity in advance and retreat. My first experience of the glacier was in the year 1905, when it was advancing. It was also advancing in 1909 when Bell made his observations, and was retreating in 1912. I cannot determine the precise year when this retreat commenced, but it had probably set in during 1910, and has continued since that date, so that it has been falling back for approximately eleven years. One cannot predict at present when this retreat will end, or what the total length of the cycle is likely to be.

There are one or two other points to which brief allusion may be made. First, the angle of the shear-planes near the present terminal face, especially those near the eastern front of the glacier, suggests that a great thickness of ice, probably to be measured in hundreds of feet, exists behind the rock bar which stretches from the western wall of the valley towards the present mouth of the Waiho between Barron Rock and peg No. 7. If, therefore, the glacier should retreat farther, the lake along its face will probably increase in size, and it will furnish a suggestion of what usually happens as the ice retreats from a rock bar across a valley. Such conditions must have occurred in the Rakaia, Wilberforce, and Waimakariri Valleys when the ice commenced to retreat towards the heads of the valleys from the barrier near the plains in late Pleistocene times.

An examination of the rock-surface recently exposed does not suggest that glaciers have any marked power of erosion near their ends even when advancing, slight abrasion being all that was noted on the *roches moutonnées* recently exposed before the terminal face; but, of course, this does not negative their power to erode their beds where the ice is thicker.

The presence of an apparent wave of high ice might have been credited to the influence of an irregular bottom during a period of ice-decline, analogous to the effect of obstructions in the bed of a river, masked as they frequently are at high water, were there not definite proof that ice is actually rising relative to the rocks at the side. In any case, the thickness of the ice is very great even in times of lower level; all the same, there is some suggestion in the alternating stretches of ice-fall with more gently inclined surface, shown not only in this glacier but in the Fox as well, that if the ice were removed the valley-floor would exhibit in a perfect form the characteristic stairway developed in glaciated regions—as, for example, those in Deep Cove and other valleys at the heads of the sounds of the west coast of Otago.

In conclusion, I have to express my indebtedness to Mr. Graham for much valuable information and for ready help. He has promised to continue observations and to take photographs of the face from already-selected positions on Park Rock at the same time each year, so that changes in the character and position of the terminal face can be accurately recorded. It is important that they be taken during the same month of the year, so as to eliminate any error due to variation between the summer and winter heat.

Art. VII.—*Notes on the Geology of the Patea District.*

By P. G. Morgan, M.A., F.G.S., Director of the Geological Survey of New Zealand.

[*Read before the Wellington Philosophical Society, 27th October, 1920; received by Editor, 10th December, 1920; issued separately, 27th June, 1921.*]

Previous Investigations.

Mr. John Buchanan, in a paper read before the Wellington Philosophical Society in September, 1869 (2),* mentioned the blue clay of Patea, which he placed in the Wanganui beds, but expressed a doubt as to this being its right position. It might, he thought, belong to a somewhat older formation.

In January, 1884, Professor F. W. Hutton, accompanied by Mr. S. H. Drew, of Wanganui, spent a day in the neighbourhood of Patea. In a paper on the Wanganui system (3), he writes (p. 340),—

"On the sea-coast at Patea, south of the mouth of the river, blue clay with fossils passes up gradually into a blue micaceous sandy clay, apparently unfossiliferous. Upon this lies about 12 ft. of yellow sand; then cemented gravel 4 ft. thick, followed by grey sands, and then red and yellow sands. The upper beds form the cliff, and, not being very accessible, I did not examine them closely, but I could find no fossils in the tumbled blocks. The sequence is remarkably like that at Wanganui. The yellow sand is distinctly separated from the blue micaceous clay upon which it rests, but without any appearance of unconformity. The number of species obtained from the blue clay is twenty-six, of which 77 per cent. are Recent. Three species of Pareora shells, not known from any other part of the Wanganui system, have been found in the blue clay at Patea. They are *Oliva neozelanica*, *Struthiolaria cingulata*, and a species of *Cucullaea* (fragments)."

In 1886 Professor James Park, at that time a member of the Geological Survey staff, examined the coast-line from Kai-iwi to Patea (see 4, pp. 26, 55, 56, 57, &c.). He states that there are evidences of the existence of a submerged forest between Wanganui and Patea, and describes a "drift formation" which "extends as a maritime belt from the Ruahine Range to the foot of Mount Egmont." This formation is well exposed in the cliffs between Wanganui and Patea (4, p. 59; see also 7, p. 414). From the blue clays exposed near the mouth of the Patea River Park obtained the following fossils: *Malletia australis* Q. & G. (listed as *Solenella australis* Zittel), *Atrina zelandica* (Gray), *Nucula nitidula* A. Adams, *Struthiolaria cingulata* Zittel, and fish-scales.

* This and other numbers enclosed in brackets refer to list of literature at end of paper.

Mr. W. Gibson, of the Geological Survey, visited Patea in September, 1914, with the object of reporting on the ironsand deposits of the district. His report (6) describes only the beach and dune-sands.

In 1917 Dr. J. A. Thomson published a paper (7) on the "Hawera Series," in which he makes reference to the geology of Patea. The Hawera series, he states, is well exposed in the cliffs between Wanganui and Hawera. The mudstone or claystone (papa) forming the lower part of the sea-cliff at Hawera is "probably about the same age as the Patea blue clays, which are placed by Park below the *Ostrea ingens* bed of Waitotara. It is certainly older than Castlecliffian, and is probably Waitotaran."

The observations lately published by Marshall and Murdoch (10) on the fossils collected by them at Wanganui, Kai-iwi, Nukumaru, Waipipi, &c., have an important bearing on the age of the Patea blue clays.

Last October the writer paid a brief visit to Patea, and made observations which are embodied in the following pages.

PHYSIOGRAPHIC FEATURES.

The district surrounding Patea forms part of that decidedly complex feature generally termed the Wanganui coastal plain, which, viewed broadly, may be said to extend along the south-west coast of the North Island from Paraparaumu in south Wellington to Opunake in Taranaki, and inland to the slopes of Mount Ruapehu, while if Mount Egmont and the adjoining volcanic ranges were removed the whole of Taranaki might be included in the plain. The inland portion of the area just defined is for the most part maturely dissected, and exhibits numerous irregular ridges of approximately equal height in adjoining localities, separated by deep, narrow valleys. The coastal belt, in marked contrast to the inland region, as a rule has a nearly flat surface, sloping uniformly and gently towards the sea, where it is usually, at least from Wanganui north-westwards, ended by dune-capped cliffs of considerable height. Inland of Hawera there are one or two well-marked marine terraces ("raised beaches").

The principal streams north of the Manawatu River have cut deep, rather narrow, steep-sided valleys in the soft rocks of the coastal area, one result of which is that the railway from Wellington to New Plymouth has to descend into and ascend out of each valley by a more or less steep grade. The inland hills, as a rule, do not descend gently to the nearly flat coastal belt, but rise with some abruptness from its inner margin. Thus the surface of the coastal belt and the plane joining the tops of the inland hills and ridges are distinctly unconformable. Hence the Wanganui coastal plain (*sensu lato*) really consists of an ancient well-dissected coastal plain bordered on its seaward side by a younger less-dissected coastal plain.

The physiography of the area immediately surrounding Patea does not differ from that of other parts of the coastal belt between Wanganui and Hawera. The gently sloping coastal plain, as elsewhere, ends in dune-capped cliffs, here about 100 ft. high. The Patea River flows at grade through the plain in a deep relatively narrow valley with cliffed sides. A mile from the sea the river is slightly entrenched in the valley-bottom, so that the small flats on either side are above ordinary flood-level. This seems to indicate recent slight elevation of the land; but, as there also seems to have been a slight depression in recent times, as shown by a submerged forest at the mouth of the Waitotara River, another explanation of the entrenchment seems desirable. This may be found in the fact that during the Recent period the sea, as shown by the cliff, has cut away several miles of land, thus shortening the course of the Patea River, and allowing it to deepen its channel for some distance above its present mouth.

Geology.

The stratigraphical geology of the Patea district is very simple. Almost horizontally-bedded claystones, known in geological literature as the Patea blue clays, are unconformably overlain by beds of gravel and sand belonging to Thomson's Hawera series. A small patch of gravel and sand forming a low hill in the Patea Valley east of the town bridge is probably quite distinct from the Hawera beds. Sand and silt form the surface of a low-lying flat near the mouth of the Patea River. Of more importance are the iron-bearing dune-sands that cap the sea-cliffs and extend for some distance back from their margin.

Patea Blue Clays, &c.

The Patea claystones are of the type which throughout New Zealand is popularly called "papa." Like the Wanganui clays, they contain a considerable amount of fine micaceous sand, which, according to the view expressed by Marshall and Murdoch in their paper on the Tertiary rocks of the Wanganui district (10, p. 118), was probably derived from the granites of north-west Nelson. Some layers consist almost entirely of fine sand, and in places these may be crowded with shells. The claystones are exposed only along the coast-line and in the Patea Valley, where, as previously mentioned, they form cliffs on either side. A thin bed of limestone outcrops on both sides of the Patea Valley between Kakaramea Railway-station and Pirinoa Pa. This is probably at a lower horizon than the Nukumaru limestone.

During his visit to Patea last October the writer collected the following fossils from shelly layers in the sea-cliff half a mile to a mile north-west of the mouth of the Patea. The identifications have been made by Mr. John Marwick. Living species are marked by an asterisk :—

Ancilla sp.
Crepidula gregaria Sow.
Dentalium solidum Hutt.
**Glycymeris laticostata* (Q. & G.)
Lucinida levifoliata Marsh. & Murd.
Miltha sp.
Ostrea sp.
Phalium fibratum Marsh. & Murd.
Polinices huttoni Iher.
Terebra sp.
**Verconella mandarina* (Duclos)
Verconella cf. *nodosa* (Mart.)
**Spisula ordinaria* (E. A. Smith)

In addition to the above the writer saw, but did not collect, *Voluta* sp., *Flabellum* sp., and plant-remains of various kinds. At one place worm-casts such as are commonly called "fucoids" were exceedingly abundant.

At the brickworks quarry, on the south side of the Patea River, near the bridge leading to the town, *Atrina* sp.—perhaps *A. zelandica* (Gray)—was collected.

As already mentioned, the cliffs east of the Patea River were examined by Hutton in 1884. He states that twenty-six species of Mollusca were collected from the blue clays, of which 77 per cent. were Recent (3, p. 340). His Wanganui lists mention the following twenty-five species, twenty of which are Recent, as indicated by a prefixed asterisk :—

**Verconella nodosa* (Mart.)
Olivella neozelanica (Hutt.)
**Ancilla australis* (Sow.)
**Ancilla depressa* (Sow.)
**Voluta arabica* Mart.
**Terebra tristis* Desh.
**Natica zelandica* Q. & G.
Polinices ovatus (Hutt.)
**Cerithidea bicarinata* (Gray)
Struthiolaria cingulata Zitt.
**Calyptraea maculata* (Q. & G.)
**Crepidula costata* (Sow.)
**Crepidula monoxyla* (Less.)
Dentalium solidum Hutt.
**Mactra discors* Gray
**Mactra ovata* (Gray)
**Mactra scalpellum* Reeve
**Zenatia acinaces* Q. & G.
**Gari lineolata* (Gray)
**Chione mesodesma* (Q. & G.), or perhaps *C. marshalli* Cossmann
**Dosinia anus* (Phil.)
**Dosinia subrosea* (Gray)
**Divaricella cumingi* (Ad. & Ang.)
Cucullaea attenuata (?) Hutt.
**Glycymeris laticostata* (Q. & G.)

Hutton's names have been revised so as to correspond with modern nomenclature, and some changes in the specific names have been made on the authority of Suter. In his paper on the Pliocene Mollusca of New Zealand, published in the *Macleay Memorial Volume* (1893), Hutton gives a list of Wanganuian Mollusca which broadly is the same as that published by him in 1886, but, besides making changes in nomenclature, he omits eight of the Patea records. It is hardly necessary to go into details. Hutton's lists, whichever may be taken, show a high percentage of Recent species as compared with Marshall and Murdoch's Waipipi list, and differ still more in this respect from the list of fossils collected by the writer west of Patea. If all the fossil records are combined, a total of thirty-four identified species is obtained, of which twenty-five, or 73 per cent., are Recent.

Since there is reason to believe that the Patea claystones are at least as old as the Waipipi beds, as shown by stratigraphical considerations, as well as by the occurrence of a species of *Cucullaea* (*C. attenuata* ?), *Dentalium solidum*, *Phalium fibratum*, and *Miltha* sp., it seems likely that several of the shells identified by Hutton and Park as belonging to species still living really represented extinct species. Be this as it may, the Patea beds clearly belong to the lower part of the Wanganuian formation—that is, to the stage called "Waitotaran" by Thomson. By restricting the definition of "Waitotaran" it would be possible to introduce a third stage into the Wanganuian, and into this the Patea claystones would no doubt fall.

Hawera Series.

As developed near Patea the Hawera series appears to be typically 30 ft. to 40 ft. in thickness. The lower layers consist of beach-worn peebles mixed with much sand; the upper layers are almost wholly sand, which in places is nearly black owing to titaniferous magnetite being present in large quantity. Current-bedding is everywhere very noticeable, and some of the black sand appears to be wind-blown. Along the sea-coast the Hawera beds form the top of the cliff, and therefore cannot be closely examined. On the sides of the Patea Valley their contact with the Waitotaran beds is clearly marked by a sudden change from steep grassy slopes above to claystone cliffs below, and by numerous small springs. At one or two places near Patea, road-cuttings allow the Hawera beds and their contact with the Waitotaran claystones to be closely studied. For example, on the Wanganui road, about a mile from Patea Railway-station, brown weathered claystone (Waitotaran) is overlain by a thin layer of gravel, above which comes 15 ft. of pebbly sand and 4 ft. or 5 ft. of loamy subsoil and soil. The seepage from these beds supplies a water-trough. On a branch road up a small valley south of the railway-station Waitotaran claystone is seen to be overlain by 30 ft. or 40 ft. of sand, mostly dark-coloured, the lower layers of which contain many pebbles of greywacke and numerous fragments of claystone. Another water-trough indicates a permanent water-seepage from the base of these beds.

Thomson (7, p. 416) explains the Hawera beds as having been deposited upon a wave-eroded surface of the Wanganuian beds during an advance of the sea. The writer's observations, though entirely supporting most of Thomson's statements, lead rather to the conclusion that the Hawera beds were formed wholly or mainly at a somewhat later stage—namely, during the subsequent retreat of the sea, caused by land-elevation.

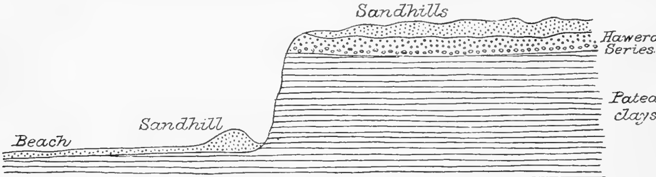
As has been shown by Thomson, the Hawera series is unconformable to the Wanganuian formation. Since the Upper Wanganuian or Castlecliffian is of Upper Pliocene age, the Hawera series falls into the Pleistocene. No shells were seen in it at Patea, but at Hawera Thomson collected a large number of Recent species from a shell-bed at the base of the series.

The Hawera beds, as pointed out by Thomson, give rise to a rich soil of great importance to the agriculturist.

Post-Hawera Deposits.

In the small valley south of the Patea town bridge there is a low hill formed of fine gravel and sand, similar in appearance to the gravel and sand of the Hawera series. Since this hill is far below the general level of the Hawera series, one must suppose that the material of which it is composed represents a rewash of the Hawera series.

The ferriferous sand-dunes capping the cliffs have already been mentioned several times. The material of which they are formed has probably been partly derived from the Hawera beds (as suggested by Thomson), and



Section West of Mouth of Patea River.

partly from an ancient belt of dunes formed on the old coast-line immediately after the last elevation of the land had ceased. The prevailing wind is probably from the south-west,* and hence as the sea attacked the land, and cliffing advanced, the bulk of the ancient dune-sand was blown inland. Wind-action is strong at the cliff-edge, and keeps it clear of loose sand. Although some sand falls or is blown over the cliff, this loss is more than counterbalanced by sand derived from the Hawera series. R. Pharazyn, in 1870 (1, pp. 158–60), explained the present dune-sands on top of the cliffs along the shore of the Wanganui Bight as the remnant of a wide belt formed before cliffing began, but the idea that the sand was blown inland as the cliffs advanced was not clearly expressed in his paper.

* In summer there is a frequent sea breeze.

The observations made by Thomson (7, pp. 415–16) and by the present writer support the view that the ironsand of the dunes is mainly derived from the Hawera series. The rich ironsand deposit found on the beach between tide-marks west of the mouth of the Patea River may also be ascribed mainly to material derived from the Hawera series—that is, for the most part it represents a concentration of the material that falls or is blown over the cliffs.

Probably owing to the construction of moles at the mouth of the Patea River, material is at present accumulating on the beach immediately to the west of that river. Consequently cliff-erosion by the sea in this locality has ceased, and a narrow strip of sandhills, perhaps half a mile long, has formed close to the base of the cliffs, as illustrated by the annexed section.

Geological History—General Remarks.

The geological history of the coastal belt extending from Wanganui to Hawera has been described by Thomson in his paper on the Hawera series, and some of his statements are almost necessarily repeated in the following paragraphs. At the end of the Castlecliffian stage (Upper Pliocene) the whole of the Wanganui coastal plain (*sensu lato*) was elevated, not uniformly, but with gentle flexures which, on the whole, produced dips towards the southward. At Wanganui the uplift was not great, perhaps only 400 ft. to 500 ft.; but if Marshall and Murdoch's data (10, pp. 118–19, 127) be accepted it must have been nearly 2,500 ft. at Nukumaru, and not far short of 4,000 ft. at Waipipi. At Patea and Hawera the elevation was not less than at Waipipi, and inland, as a rule, must have been much greater. Owing to the soft nature of the Wanganuian rocks, erosion proceeded rapidly, and when elevation ceased the land was no doubt maturely dissected. Slow depression followed, and the sea, as it advanced over the land, eroded and swept away all material above its own level, thus forming a plane of marine denudation. The great amount of previous erosion and the softness of the rocks enabled it to accomplish this task without difficulty. The plane of denudation, it is fairly obvious, was not horizontal, but had a gentle seaward slope. Inland from Hawera, as previously stated, it is terraced, but in most localities it has the one uniform slope to the foot of the inland hills. Depression ceased when the land was roughly 600 ft. below its present level, and elevation began, apparently almost without delay. During the retreat of the sea the sediments deposited during the previous advance, or the greater part of them, were reassorted, and in great measure swept away. The residue, with new material brought down by the rivers of that time, forms the Hawera series. It is a remarkable fact, perhaps more consistent with Thomson's explanation of their origin than with the writer's, that the Hawera beds seem to have been deposited almost uniformly over the whole of the coastal belt from Hawera to Turakina. Towards Marton they disappear, and their place is taken by fluviatile gravels; but the country between Marton and the coast has not yet been examined in order to ascertain whether they continue along the present sea-coast towards the mouth of the Rangitikei River.

Elevation continued till the land was somewhat higher than at present, for there is evidence of recent slight depression at Patea, Waitotara, and Wanganui (Park and Thomson). At the last-named place the depression may have been considerable. A paper by Henry Hill (5) on artesian wells at Wanganui gives data that to some extent support this view.

The marine sand and gravel forming the low hill in the small valley near the Patea brickworks presumably represent a rewash of the Hawera beds deposited during a brief period of depression. Probably there were other occasional minor oscillations during the last uplift, but there is no evidence of prolonged periods of standstill.

The marine planation of a wide belt of the Wanganuian beds is a remarkable fact, which has a bearing on the geological history of other parts of New Zealand. Had the upward and downward movements of the Wanganui beds been uniform, the eroded surface would have been almost or quite parallel to the bedding-planes, more especially if there had been a hard stratum of, say, limestone just below the level of the sea at the time of greatest depression. In that case the Hawera series would have been deposited on the Wanganuian without any visible unconformity, and a contact similar to that of the Amuri limestone and the Weka Pass stone in North Canterbury would have resulted.

According to Thompson's view of the origin of the Hawera beds, their upper surface must be wave-planed; and this statement holds good in the main, even if the present writer's hypothesis of their deposition during a negative movement of the strand be correct. The planation is not confined to the area between Hawera and Turakina, but may be traced north-westward beyond Cape Egmont, and southward, with some interruption, to Otaki, and finally to the immediate neighbourhood of Wellington. The gently sloping lowland at the foot of Mount Egmont extending from Hawera to Cape Egmont and thence northward to the Kaitake Range has been wave-smoothed in the late Pleistocene. In places numerous small conical hills of volcanic origin, formed almost in Recent times, stud its surface, but evidence of planation by the sea remains. In the Shannon district, and elsewhere south of the Manawatu River, aeolian sandstones, probably younger than Castlecliffian, appear to have been planed by wave-action, an interpretation of their topography partly supported by Adkin's account (9; see also his paper of 1911), but opposed to Cotton's views (8). At present only small portions of the Wanganui coastal plain have been examined in detail by geologists. These examinations have been made independently by various workers, at various times, and for various objects. Some divergence of opinion is therefore to be expected, but this will doubtless be eliminated when the results of detailed surveys over wide areas are available.

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ART. VIII.—*The Geological History of Eastern Marlborough.*

By Professor JAMES PARK, F.G.S., F.N.Z.Inst.

[*Read before the Otago Institute, 9th November, 1920; received by Editor, 31st December, 1920; issued separately, 27th June, 1921.*]

CONTENTS.

INTRODUCTION.

IN two papers, published in 1917 and 1919, Dr. J. Allan Thomson champions the views of Dr. C. A. Cotton (1913, 1914A, and 1914B) as to the genesis of the physiographic features of eastern Marlborough and origin of the so-called post-Miocene conglomerate. In the last of these papers he restates at great length the observations of McKay made in 1886, 1890, and 1892, and the opinions of Cotton, and disagrees with my view that the post-Miocene conglomerate is morainic. With the zeal of an advocate he contends that my "hypothesis involves the formation of the great Clarence and other faults in the late Notopleistocene, and is quite untenable." Why untenable? Geophysicists recognize that the crust of the earth will be subject to tensional stresses, fracturing, and faulting so long as the denudation of mountain-chains and the piling-up of sediments on the sea-floor continue.

The view I have always maintained is that the Clarence fault is of considerable antiquity, and that the involvement of the glacial and older strata was caused by a revival of movement along the old fault-plane. Great faults are of slow growth.

As if doubtful of warranty for his extreme pronouncement, Thomson adds, "In any case, the evidence for the fluviatile origin of the lower beds of the series is overwhelming." But even if partly fluviatile, this would not invalidate my view that the great conglomerate is morainic. There are moraines and moraines. The morainic matter carried on the back of a glacier invariably consists of a tumbled pile of angular blocks of rock. In such a deposit fluviatile material is usually absent. Curiously enough, this appears to be the only type of moraine that Thomson recognizes as undeniably glacial. But terminal moraines, of which we have in New Zealand many fine examples, both ancient and modern, are invariably composed of fluviatile drifts mingled to a greater or less extent with tumbled ice-carried blocks.

During the past two years I have attempted to determine the relative proportions of fluviatile drift and tumbled blocks in some well-known terminal moraines in Otago and Southland, and I may say that the task proved more difficult than I anticipated. The results obtained I can only claim to be rude approximations, but they are sufficiently near the truth to demonstrate the conspicuous part played by fluviatile drifts in the structure of such deposits. In all cases the observations were made at points free from re-sorting.

The great Clyde moraine contains about 60 per cent. of silts, sands, and gravels of fluviatile origin; the Queenstown Domain moraine, 55 per cent.; the Kingston moraine, 55 per cent.; the Manapouri moraine, 65 per cent. The Clyde, Kingston, and Manapouri moraines appear to rest on beds of fluviatile drift. I have not yet made a quantitative estimate of the material composing the Tasman terminal moraine, but if my recollection is not at fault I should say that fluviatile drift is conspicuously represented. According to many independent writers, the Pleistocene glacial deposits of Canada and the United States contain a large, or even dominant, proportion of fluviatile material.

A Question of Nomenclature.

Before going further I wish to express my views as to some new names that have been lately suggested by Thomson. In my paper (1905, pp. 497–501) "On the Marine Tertiaries of Otago and Southland" I recognized (*a*) that the main orographical features of New Zealand were determined by an early Cretaceous diastrophic movement that folded and elevated the Juro-Triassic and older formations, and (*b*) that the Upper Cretaceous and Tertiary strata were laid down as "marginal" deposits on a platform that contoured around the early Cretaceous strand. These views I reiterated in 1910 (p. 85). Thomson (1917 p. 407), in a discussion of the younger covering strata, thought it "desirable for many purposes in New Zealand geology to have a name which will embrace them all, a name which will replace the earlier name of 'marginal rocks' used by Park and myself, and the physiographic and structural term of 'covering strata,' when an age significance is intended."

I was the first to describe (1905) the late Cretaceous and Tertiary strata as "marginal," and have no recollection that this term was used by Thomson till many years afterwards. Apart from this, I am in agreement with him that the substitution of a name for my "marginal" strata is desirable. But the term "Notocene," which he has suggested, is inappropriate; and I agree with Marshall (1919, p. 240) that it is unscientific. The suffix "cene" (from *kainos* = recent) is used as the termination of the four epochs into which the Cainozoic era has been divided, and to use it in the structure of a word intended to cover the Upper Cretaceous and the whole of the Cainozoic would be certain to lead to misunderstanding. Moreover, there is nothing *recent* about the Albian and later groups of the Upper Cretaceous, in the sense that "cene" is used in the words Eocene and Miocene. If it had not been previously used in a much narrower sense—that is, as meaning Cretaceo-Eocene—Hector's term "Cretaceo-Tertiary" would be quite satisfactory, but it must also be ruled out on the score of possible confusion.

Following the precedent set by the Geological Survey of India, a native group-name may be appropriately used for the marginal Cretaceo-Pliocene strata of New Zealand. The name I now suggest is "Awatean."*

For the post-Jurassic and pre-Albian N.E.–S.W. orogenic movements that folded and elevated the Juro-Triassic of the main chains I propose to use the term "Rangitatan movement."

* Awatea was the name of the great Polynesian deity who heralded the emergence of the land from the void.

In 1916 Cotton gave the name "Kaikoura movements" to the Pliocene uplift that affected eastern Marlborough. I was the first (1905, pp. 501–2, and 1910, p. 110) to recognize and describe the differential character of this uplift, and should prefer the name "Ruahine movement." In the Ruahine Range the effects of differential axial elevation are better displayed than elsewhere. Moreover, Professor Suess (1909) included the Ruahine Range of New Zealand in his Third Australian Arc of folding, elevation, and vulcanicity, and used the name "Ruahine" as representative of the uplift and vulcanicity of that region. I think the term "Ruahine movement" ought to stand.

SYNOPSIS.

My view is that the folding and elevation of the Juro-Triassic and older rocks took place in the pre-Albian period of the Lower Cretaceous. This orogenic movement, which I have called the "Rangitatan movement," gave birth to the existing N.E.–S.W. axial chains of New Zealand. The folding was accompanied by fracturing, faulting, and subsidence along lines of structural weakness. The climatic conditions were pluvial, and the denudation of the newly uplifted chains was relatively rapid.

During the Albian, while the peneplaining of the mainland was in progress, the sea began to invade the Clarence depression, where it laid down Albian sediments. At the close of the Albian the Cenomanian transgression became general, and soon the sea encroached on the newly formed peneplain, Tahora,* that everywhere fringed the remnants of the main chains. On the surface of this peneplain, and on the Albian beds already deposited in the Clarence depression, sediments were laid down throughout the remainder of the Upper Cretaceous period.

Then followed the Eocene uplift, during which the weak post-Albian beds were removed from the greater part of the uplifted Tahoran peneplain and from the Clarence depression. At the close of the Eocene began the Oamaruian subsidence, during which the great Miocene formation was deposited, in some areas on the slightly eroded surface of the surviving Cretaceous strata, but mainly on the surface of the recently uncovered peneplain.

At the close of the Miocene there began a differential uplift in Otago and Auckland, pivoting on the Napier–Wanganui zone, where the movement still continued downward, this arising from the thrust accompanying the tilting of the ends of the main chains.

Before the advent of the newer Pliocene the Marlborough and north Hawke's Bay areas were raised above sea-level. In the Napier–Wanganui zone the deposition of marine sediments continued till the close of the newer Pliocene, when this region also rose above sea-level.

During the succeeding Pleistocene the alpine chains and the Kaikouras were covered with ice-fields that fed the Clarence glacier, which, in my opinion, formed the great post-Miocene conglomerate.

GEOLOGICAL HISTORY.

In Marlborough we are confronted with geological and physiographic conditions altogether unlike those prevailing along the main axial chain. The Inland Kaikoura and Seaward Kaikoura Mountains are well-defined ranges composed of folded argillites and greywackes of Juro-Triassic age, in

* In Maori, *tahora* = great plains and low-lying maritime lands.

many places intruded by a network of basic, semi-basic, and acidic dykes. The post-Jurassic (or Rangitatan) diastrophic movement that folded the ranges of the main axial divide was also responsible for the folding and elevation of the Kaikoura chains, and the subsequent intrusion of the igneous magmas.

McKay (1886, p. 65) has shown that the rocks composing these chains are arranged in two simple synclinal folds, separated by an anticlinal fold, the crest of which runs parallel with the present course of the Clarence Valley.*

The folding and elevation of the Jurassic and older rocks took place in the pre-Albian stage of the Lower Cretaceous. The denudation of the newly elevated folds of the main divide began immediately, and continued throughout the whole of the Albian, resulting in the base-levelling of the great peneplain elsewhere called Tahora. At this time the Seaward Kaikoura chain existed as an island, or as a long narrow peninsula.

During the progress of the Albian base-levelling of the mainland, Albian sediments were being deposited in the deep, clear waters of the fiord-like Clarence Sound, that separated the Kaikoura chains. After the post-Jurassic folding, and before the Albian, the crown of the Clarence anticline was deformed by powerful faults, the most important of which followed the base of the Inland Kaikoura chain.

The floor of the Clarence Valley is occupied by a sheet of strata many thousand feet in thickness, ranging in age from Lower Utatur (Albian) to newer Pliocene or even Pleistocene. Two unconformities have been recognized in this pile of material. The Lower Utatur strata are followed by the Amuri limestone, which, according to Henry Woods (1917, p. 4), favours the view that the latter is of Tertiary age, since the Upper Utatur (Lower Chalk) beds that normally follow the Lower Utatur in India, Japan, Madagascar, and Zululand are not known to be represented in New Zealand. The second unconformity comes between the Awaterean marine clays and a remarkable deposit which McKay (1886) called the "post-Miocene conglomerate."

The Post-Miocene Conglomerate.

This deposit attains in places a thickness of 600 ft. It is mainly composed of water-worn drift, derived from the Juro-Triassic argillites, greywackes, and associated dyke-rocks that compose the Kaikoura chains, mingled with a confused pell-mell of angular slabs and irregular masses of Amuri limestone, "gray marls," and fossiliferous Awatere (older Pliocene) clay-rock, some of the former of enormous size. Patches of this deposit occur near the Marlborough coast, resting on an eroded surface of the Amuri limestone. But its greatest development is in the Clarence Valley, where it lies on the "grey marls," a clayey formation that conformably follows the Amuri limestone.

McKay in his report on the Cape Campbell district (1876, p. 190) gives a good description of this breccia-conglomerate. He says, "These conglomerates are composed in chief part of well-rounded boulders, but have a large percentage of angular blocks of great size, so that they often present the appearance of old morainic accumulations. A great variety of rocks

* Thomson (1919, p. 305) expresses the opinion that the strikes observed by him would tend to show that a strike west of north is prevalent in at least some parts of the Kaikoura area; and Cotton (1913, p. 244), arguing from the variability of strikes and dip, considers it probable that the older axes of folding make an angle with the general N.E.–S.W. trend of the chains. In my opinion the meagre evidence produced by these writers is not sufficient to invalidate the considered generalizations of McKay.

is represented in these conglomerates, including old slates and sandstones and crystalline rocks from the inland ranges, volcanic rocks belonging to the Amuri group, green sandstone from the 'saurian beds,' and great masses of Amuri limestone, and large blocks of fossiliferous conglomerate containing abundance of Awatere fossils; also blocks of sandy limestone and fine-grained standstones with abundance of Awatere fossils. These beds cannot be less than 200 ft. in thickness, and in places they rise to a height of 850 ft. above the sea. Like the Awatere beds, the conglomerates never pass to the eastward of the Amuri limestone, nor do they reach to the lower grounds on the west side of the range; but, as they are but the remnant of a formation that must once have covered a considerable extent of country, other outliers of them will probably yet be found to the south and west."

Referring to the conglomerates at Heaver's Creek, he says (1886, p. 115), "They are rudely stratified, at places showing that the beds are standing nearly vertical; in the lower part are enormous blocks of Amuri limestone and masses of soft marly strata, which it seems impossible to convey any distance and deposit in the position in which they are found. . . . It is impossible to give any description which will convey a correct idea of the pell-mell manner in which the various materials of this conglomerate-breccia are mixed together." Further on he says some of the masses of Amuri limestone in this deposit at Shades Creek "are of such an extent that at first sight they might be taken for an outcrop of this rock *in situ*."

Relationship of Post-Miocene Conglomerate to Underlying Tertiary Formations.

The stratigraphical succession of the formations represented in eastern Marlborough is:—

(1.) Post-Miocene conglomerate.
(2.) Awatere clay and marly beds.
(3.) "Grey marls."
(4.) Amuri limestone.
(5.) Cretaceous strata.
(6.) Juro-Triassic basement rocks.

Near the coast the conglomerate-breccia rests on the Amuri limestone, and in the Clarence Valley on the "grey marls." It contains angular masses derived from the underlying Cretaceous strata, Amuri limestone, "grey marls," and Awatere beds. McKay (1886 and 1890) and Hector (1886) considered it unconformable to the Awatere beds, a conclusion which I had no difficulty in endorsing in 1910.

Cotton (1910), in a general account of the geology and physiography of eastern Marlborough, expressed the view that the conglomerate-breccia was conformable to the "grey marls," and this opinion appears to be supported by Thomson (1919). If this tumbled and confused deposit is conformable to the "grey marls," the question arises, what has become of the Awatere beds? And in like manner, where it rests on the Amuri limestone, we may ask, what has become of both the "grey marls" and Awatere beds? It may be suggested that the conglomerate-breccia is the equivalent of the Awatere beds; but clearly this is impossible, as large masses of the latter are contained in the conglomerate.

Referring to the difficulty presented by the view of conformity, Thomson (1919) says, "Cotton accounts for the peculiar features of the conglomerate—viz., that it lies conformably on the 'grey marls' but contains materials of all the underlying Notocene [Cretaceous and Tertiary] beds—by assuming that a neighbouring area was differentially elevated to the extent of perhaps as much as 12,000 ft. without seriously disturbing the horizontal attitude of that portion of the Notocene series which, a little later, had the conglomerate deposited upon it." This hypothetic assumption does not make the position easier. By all the criteria of stratigraphical geology, whatever its origin, there must be a time-break between the conglomerate-breccia and the "grey marls."

Involvement of Post-Miocene Conglomerate.

Along the base of the Inland Kaikoura Range the Cretaceous and Tertiary deposits, including the post-Miocene conglomerate, are down-faulted towards the north-west, and appear to plunge below the Juro-Triassic rocks composing that chain.

There is no evidence that the Kaikoura chains were ever reduced to a sea-level peneplain, and all surmises to the contrary are purely hypothetical. At the time the Tahoran peneplain was being base-levelled the Kaikouras existed as ridges, separated by the Clarence Valley, into which the sea during the Albian stage gradually encroached. The advancing sea first formed a basal bed of conglomerate, which is entirely composed of material derived from the neighbouring mountain-walls. As the sea continued its invasion of the Clarence Valley the bed of conglomerate spread slowly landward, forming a deltaic deposit, on the emergent surface of which vegetation grew till destroyed and buried by sediments deposited by the advancing sea.

If the sea advanced from the north-east, as seems to be indicated by the distribution of the Cretaceous strata and Amuri limestone, the conglomerates laid down at the head of the sound should be coeval with the fine marine sediments deposited in the deeper water near the entrance of the sound. As the transgression progressed the conglomerates became everywhere covered with the finer muds and sands of the Upper Utatur.

At the beginning of the Cenomanian the advancing sea overspread the base-levelled Tahoran peneplain and covered it with a sheet of Upper Cretaceous sediments. During the Eocene uplift the newly formed Upper Cretaceous sediments in the Clarence fiord, in north and west Nelson, and throughout Westland, Southland, and south Otago, were completely removed by denudation. Only in north Otago and Canterbury did some remnants escape the general destruction of this period.

The Eocene uplift was followed by slow persistent submergence, during which the Oamaruian and Awatere sediments were deposited. At the close of the Miocene, differential uplift began along the axial chains, accompanied at the north and south by a tilting movement that pivoted about a zone extending from Napier to Wanganui, along which submergence continued till the close of the Pliocene, as witnessed by the newer Pliocene beds on the coasts of Hawke's Bay and Wanganui Bight. The movement was faster along the axial divide than at the east and west coasts, and this generated crustal stresses which found relief by fracturing and faulting, followed by the uplift and tilting of mountain blocks.

There was also, as already indicated, a general tilting of both ends of New Zealand coeval with the axial uplift. This tilt was greatest in Auckland and Otago, and least in the Napier–Wanganui zone. As a consequence of this unequal uplift the youngest marine strata known in Otago and south Canterbury are late Miocene; in Marlborough, older Pliocene; and in the Wanganui and Hawke's Bay areas, newer Pliocene.

NEWER PLIOCENE.

As a further consequence of the pivotal (or differential) elevation, the refrigeration which afterwards culminated in the glaciation of a large part of the South Island and a small part of the North Island began in Otago and Southland as far back as the early Pliocene, and in Marlborough in the late Pliocene. The general advance of the alpine glaciers began in the late Pliocene, and throughout the South Island this was a period of intense fluviatile activity. In the early Pleistocene the high Kaikoura chains were covered with permanent ice-fields that fed the Clarence glacier, the terminal face of which reached the sea at the time of maximum refrigeration.

It was during the early Pleistocene that the Marlborough fluvio-glacial conglomerate was deposited. The piling-up of from 4,000 ft. to 12,000 ft. of sediments and other rocky detritus on the floor of the Clarence Valley disturbed the isostatic condition of the crustal strip lying along the Clarence fault, and as a result of this disturbance there was a revival of movement along the old fault-plane. McKay reported in 1886 that a distinct depression marked the line of the great fault, and this depression was said by the settlers to have been formed by the historic earthquake of 1855, which is also known to have opened gigantic earth-rents in other parts of Marlborough, as well as in Wellington.

I would suggest that it was the overloading of the Clarence segment which caused the Inland Kaikoura chain to creep towards the south-west. This and crustal weakness originated the overthrust which eventually entangled the Cretaceous and Tertiary strata and post-Miocene conglomerate along the course of the Clarence fault. But this suggestion is purely hypothetical and incapable of proof.

CONCLUSION.

Herbert Spencer has laid it down in his *First Principles* that no hypothesis is capable of more than partial proof, and that of two rival hypotheses the one that approaches nearest the truth is that which does least violence to fundamental principles. I venture to think that Cotton's titanic faulting and stupendous walls of weak, unconsolidated sediments (*vide* fig. 2, Cotton, 1913) postulate conditions that appear almost impossible. Moreover, his and Thomson's contention that the post-Miocene conglomerate is conformable to the " grey marls," notwithstanding that it is composed of material derived from all the underlying formations, is opposed to all the canons of stratigraphical geology. The view of conformity did not even suggest itself to Hector, McKay, or myself.

According to Cotton's hypothesis, the faulting was a single catastrophic movement of such magnitude as to expose the Tertiary and Cretaceous strata in a stupendous fault-scarp from the steep face of which blocks and vast slabs of the different beds, under the influence of gravity, fell or slid into the valley below, forming the " pell-mell " so well described by McKay. But the blocks are contained in a matrix of fluviatile drift composed mainly of the basement Juro-Triassic rocks. Evidently the Clarence Valley was already drained by a well-established river-system. It seems incredible that the titanic dislocation required by Cotton's view could have taken place without causing serious disarrangement of the pre-existing drainage-system.

If it be conceivable that the faulting proceeded by a series of catastrophic displacements that exposed in a steep escarpment first the Tertiary and afterwards the Cretaceous strata in the order to their superposition, we should expect to find the Awatere rocks, as the first exposed to shattering and crumbling, predominating in a stratum towards the base of the great conglomerate. Above this stratum there should appear a succession of layers dominated by blocks of "grey marl," Amuri limestone, and Cretaceous rocks, and in the inverse order of their superposition. But the blocks of the different formations do not occur in this orderly succession: they are mingled in a confused jumble. Clearly this conception also fails.

It is generally recognized that all great faults are of slow growth. If the growth of the Clarence fault were slow, the denudation of the newly uplifted covering strata would result in the formation of the slopes normal to weak strata, and there would be no dislocation of the established drainage-system.

The Tertiary strata were laid down on the floor of the sea, and elevated before the process of shattering and denudation began. Surely this uplift and the geographical changes which it brought about must represent a time-break between the post-Miocene conglomerate and the underlying Tertiary strata which figure so conspicuously in its composition.

I do not know of any natural agency other than ice that could transport and leave stranded among fluviatile drifts slab-like masses of soft friable rock ranging from a few feet up to 70 ft. in length; and I can see nothing unreasonable in my suggestion that high chains like the Kaikouras could support ice-fields during the period of Pleistocene maximum refrigeration. I do not suggest that my view is the obvious truth. My contention is that it is a reasonable interpretation of the known facts. The obvious truth may often resemble a truism, which Carlyle has defined as an invention for concealing the real truth. The uplifted hand may obscure a landscape; and a simple truth may be presented in such a manner as to hide a whole gospel.

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ART. IX.—*The Birth and Development of New Zealand.*

By Professor JAMES PARK, F.G.S., F.N.Z.Inst.

[*Read before the New Zealand Science Congress, Palmerston North, 26th January, 1921; received by Editor, 2nd February, 1921; issued separately, 27th June, 1921.*]

THOUGH it contains in its fabric rocks of great antiquity, considered as a geographical unit New Zealand is, geologically speaking, very young. We must ever bear in mind that, though it may be built of stones of great antiquity, a house is not older than its builder. And so it is with New Zealand. Its framework is composed of an extraordinary pile of Palaeozoic and Mesozoic rocks, but it was not till the Cretaceous epoch that these rocks were built up into the mountain-chains and other land-forms familiarly known to us by the geographical name "New Zealand."

The Palaeozoic sediments were derived from the denudation of a land area that formerly occupied the greater part of the Southern Hemisphere. This ancient continent certainly existed throughout the whole of the Palaeozoic era, and eventually became submerged some time in the Mesozoic. Like the larger continents of the present day, this Archaean land was dominated by mountain-chains, tablelands, and plains, and its coasts were deeply indented with bays and estuaries. Though no trace of this Pacific continent now remains, the pile of sediments derived from the wear-and-tear of its surface tells us that it was no arid land, but possessed an abundant rainfall. Moreover, there is evidence that in the Cambrian, Devonian, and Permian epochs its alpine chains were covered with an ice cap from which tongues of ice reached down the mountain-glens towards the sea.

The great rivers which drained the highlands built up mighty deltas along the ancient strands, covering the floor of the seas where New Zealand now stands with sands and muds many thousand feet in thickness. But we must not assume that deposition was continuous in the New Zealand area throughout the whole of the Palaeozoic. No rocks of Devonian or Carboniferous age are known in New Zealand, and from this we infer that during a great hiatus, the exact limits of which are not yet definitely ascertained, there was a cessation of deposition on the floor of the seas covering the area now contained within our borders. The cessation of deposition on a sea-floor may arise from the profound submergence of the land area providing the sediments, or from the uplift of the sea-floor as a consequence of crustal folding or a recession of the sea. By submergence the scene of deposition is shifted landward, and by uplift seaward. The absence of Devonian and Carboniferous rocks leaves a tremendous gap in the geological history of New Zealand, and is ascribed to crustal folding that raised the sea-floor, thereby enlarging the borders of the ancient Palaeozoic continent.

In the late Carboniferous there began a general transgression of the sea that submerged the coastal lands and permitted the deposition of the Permo-Carboniferous Maitai series on the folded rocks of the Silurian and older epochs. The succeeding Permian was an epoch characterized by earth-movement, and the intrusion of granitic and dioritic magmas on a gigantic scale.

The Palaeozoic formations contain an abundant marine fauna that in many respects shows a curious resemblance to the contemporary faunas of Europe and North America; but of the Psilophytales—the rootless and leafless land-plants of pre-Devonian Europe—and of the prolific Carboniferous flora of the greater continents there is no trace in New Zealand. For an explanation of this we must look to the land-movements that brought about the great Devonian-Carboniferous hiatus. And this leads to the surmise that the ancient continent on the shores of which the Palaeozoic sediments of New Zealand were laid down had no direct land connection with the Palaeozoic land areas of the Northern Hemisphere—a surmise further strengthened by the absence of the typical *Glossopteris* flora of the hypothetical Gondwanaland of the South Pacific.

But to return to the New Zealand area. After the cessation of the Permian diastrophic movements already described, normal deposition continued without interruption throughout the Triassic and Jurassic epochs, the sediments being derived from the denudation of the ancient continent, which was now larger in area, having been augmented in size by the addition of the uplifted Palaeozoic rocks of the New Zealand area. The Mesozoic sediments consist mainly of alternating beds of deltaic sands and muds, in places intercalated with marine beds containing a rich assemblage of fossil molluscs that in general facies bears a striking resemblance to the contemporary Mesozoic marine faunas of Europe. It is noteworthy that, though beds of limestone are common in all the Palaeozoic formations, no limestones occur among the Juro-Triassic strata of New Zealand. This circumstance may possibly be ascribed to the prevailing deltaic conditions of deposition, which, as we know, would not favour the growth of limestone-building organisms.

Up till the close of the Jurassic epoch New Zealand had not come into existence, but for a million centuries rocky materials had been accumulating on the site it was destined to occupy. The early Cretaceous witnessed the birth of the new land. At this time there began two syntaxial crustal movements that folded and ridged the Mesozoic and older rocks into great chains. Of these, the Rangitatan, a north-east and south-west movement, produced the main alpine chains, and the Hokonuian the north-west and south-east transverse chains. These movements built up and gave definite form to the framework of New Zealand as we now know it. They were accompanied by rock-shattering and faulting, and the extrusion of igneous magmas, mostly of basic and ultra-basic types. This period of intense crustal movement also brought about the foundering and submergence of the ancient continent that had existed in the south from Archaean times, shedding the materials of which the Palaeozoic and Mesozoic rocks were mainly composed. The disappearance of the parent continent was doubtless a consequence of the process of crustal adjustment, or compensation, arising from the emergence of New Zealand from the floor of the ocean.

The aphorism of Plato that a country is only as old as its mountains contains more than a grain of truth, and in the case of New Zealand is actually true. The mountain-chains came into existence in the early Cretaceous, and it was in that epoch that the real history of New Zealand as a geographical unit began.

The Cretaceous and Tertiary formations are marginal deposits mainly composed of materials derived from the wear-and-tear of the axial chains. The post-Albian history of New Zealand is a chronicle of denudation, submergence, uplift, faultings, vulcanicity, glaciation, and river erosion, all of which have taken an active part in modifying and shaping the topographical forms with which we are familiar.

In the early Cretaceous the foothills, transverse chains, and even the lower parts of the axial chains became worn down to a peneplain that bordered the coast on all sides. When the peneplain became submerged by the mid-Cretaceous transgression of the sea, the area of the dry land was correspondingly diminished. It is probable that the New Zealand of this period was represented by a long narrow island, or by a chain of islands, of moderate relief, deeply indented with bays and sounds, and drained by numerous small streams. The submerged peneplain was now a sea-floor, and on it accumulated the marginal pile of Cretaceous and Tertiary sediments, which as partially consolidated and elevated strata may now be seen fringing many parts of the sea-coast in both Islands, and as down-faulted blocks on the flanks of the alpine chains. When we speak of the marginal pile of Cretaceous and Tertiary strata we do not wish it to be inferred that deposition was continuous. As a matter of fact, we know that it was broken by a considerable hiatus in the early Eocene.

The Cenomanian transgression was preceded by the deposition of deltaic and estuarine silts and muds, on the emergent surface of which there grew a dense jungle vegetation. The vegetable remains were subsequently buried by the sediments laid down by the advancing sea, and afterwards formed the coal-seams of our Upper Cretaceous measures. The Upper Cretaceous strata constitute what is called the Waipara formation.

At the close of the Cretaceous there was a general uplift which lasted well into the Eocene. During this uplift the greater part of the newly formed Cretaceous sediments was removed by denudation, thereby uncovering the pre-Albian peneplain.

Towards the close of the Eocene there took place another transgression of the sea, which was preceded by the deposition of deltaic sediments on the surface of the recently uncovered peneplain. A jungle vegetation flourished for some time on the emergent deltaic flats. Afterwards the marine sediments laid down by the advancing Miocene sea covered and preserved the vegetable remains.

The late Cretaceous and older Tertiary movements were unaccompanied by crustal folding, and as a consequence the stratigraphical break between the Upper Cretaceous and Lower Tertiary formations is generally insignificant. But in New Zealand, as elsewhere, the close of the Cretaceous witnessed momentous faunal changes.

The Miocene coal-measures and the associated marine strata that cover them constitute the well-known Oamaruian formation.

In the central, or Cook Strait, area deposition continued uninterruptedly till the close of the Pliocene, but in the north Auckland region and in that part of the South Island lying to the south of the Trelissick Basin marine strata of Pliocene age are absent. So far as we know, the Tertiary succession of marine strata in the far north and south of New Zealand ended with the deposition of the Awamoan beds, of Upper Miocene age. The Awamoan is the closing member of the great Oamaruian formation as developed in north Auckland, south Canterbury, Otago, and Southland. The abrupt cessation of marine deposition in these parts is, I think, a good reason for considering the Oamaruian a distinct geological unit in the chronological succession of the Tertiary formations.

A cessation of deposition, or even an abrupt faunal change, is merely the expression of a geographical change. The absence of marine Pliocene deposits in the north and south of New Zealand must be regarded as a consequence of a differential elevation that raised the sea-floor in these parts till it became dry land, but did not affect the central region till late in the Pliocene.

At the close of the Pliocene the differential uplift became general throughout the length and breadth of New Zealand, the movement being more rapid along the axis of the main chains than towards the coasts to the east and west. The unequal upward movement raised the marginal cover of Tertiary strata high up on the flanks of the upraised axial chains, and at the same time subjected the rocks composing these chains to stresses that found relief by the formation of powerful faults. The major faults run more or less parallel with the trend of the folded chains. Thus in western Southland and in Otago they run north and south; in Canterbury, Marlborough, Wellington, Hawke's Bay, and south Auckland, north-east and south-west; in eastern Southland, north Nelson, and north Auckland, north-west and south-east.

The ancient peneplain, Tahora, which for a hundred thousand generations had exercised a powerful influence on the arrangement and distribution of the younger formations, now became deeply dissected, and for the most part almost obliterated, by the intense pluvial and glacial erosion of the Pleistocene period. In almost all cases the lines of dissection followed fault-planes, along which the rocks were, as a rule, shattered, and hence incapable of offering an effective resistance to the turbulent mountain-streams and the ponderous advance of the Pleistocene ice-sheet. The dissection of the uplifted peneplain was preceded by the removal from its surface of the covering strata, except along the coast and in the trough-faulted mountain-basins, where they were in some measure protected from the full activities of subaerial denudation.

The Pliocene uplift, elsewhere called the Ruahine movement,* gave the finishing-touches to the structure of New Zealand. The crustal dislocations and faultings which accompanied it determined the lines of the great trunk rivers, already well established in their courses when the Pleistocene refrigeration began. The Pleistocene glaciers descending from the alpine chains ploughed out and deepened the valleys, smoothed the contours of the mountain-slopes, and wore down to rounded hummocks the rocky ridges lying in their path. Before their final retreat they piled up vast moraines that will always remain as imperishable monuments of the iron grip in which in the near past the great Ice King held this now sunny land.

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* See head of p. 67 of this volume.

Art. X.—*Some Tertiary Mollusca, with Descriptions of New Species.*

By P. Marshall, M.A., D.Sc., F.G.S., F.N.Z.Inst., Hector and Hutton Medallist, and R. Murdoch.

[*Read before the Wanganui Philosophical Society, 25th October, 1920; received by Editor, 31st December, 1920; issued separately, 27th June, 1921.*]

Plates XIV–XIX.

Melina zealandica Suter. (Plate XIV, figs. 1, 2.)

M. zealandica Sut., *N.Z. Geol. Sur. Pal. Bull. No. 5:* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 52, p. 136, pl. 9, fig. 21; pl. 10, fig. 20.

Complete valves of this fine species were recently obtained. They are more oblique than appears in our figure of the restored valve, and there is also considerable difference between the young or medium-sized individuals and the large adult form. The latter is here illustrated by the photograph of a right valve, and shows the dorsal margin not markedly oblique to the body of the shell, while in some smaller individuals it is most pronounced and the posterio-ventral area considerably produced. But for the fact that intermediate forms occur and that they are all found together they might well have been regarded as distinct species. There also occurred an imperfect smaller valve, which is clothed with a thick periostracum, almost black.

Adult: Height, 150 mm.; length of hinge, 135 mm.; length of body across adductor-scar, 116 mm.

Locality: On the coast about three miles north of the Waipipi Stream, Waverley. This species also occurs in the Trelissick Basin, and at Target Gully, Oamaru.

Ostrea gudexi Suter. (Plate XV, fig. 1.)

N.Z. Geol. Sur. Pal. Bull. No. 5, p. 71, pl. 8, fig. 2.

Suter's paratypes from Kakahu show a considerable variation in the number of radial ribs; the typical form has seven to eight, others fifteen or more, excluding the small ribs on the posterio-dorsal area. Some specimens which appear to belong to this species have recently been found at Pahi. This (Pahi) form has nineteen to twenty ribs, with an additional five or six much smaller on the depressed posterio-dorsal wing.

Height, 30 mm.; length, 25 mm.

Locality: Pahi. Collected by Marshall. Material, two left valves.

Thracea magna n. sp. (Plate XV, figs. 2, 3.)

Description derived from right valves.

Shell large, oblong, inequilateral, beak at the posterior third, the umbo swollen and prominently curved inwards; the anterior dorsal margin long, slightly curved and declining, the end rounded; posterior dorsal margin short, excavated below the beak, thence almost straight and slightly declining, the end obliquely truncated, basal margin lightly curved, ascending a little more rapidly to the anterior end ; the posterior area is defined by a broad subangular ridge which descends from near the beak to the lower margin of the truncation, a smaller ridge similarly proceeding unites with its dorsal margin. Sculpture consists of fine growth-lines, irregular in places, and more pronounced on the posterior area ; there does not appear to be any radial sculpture. Hinge without teeth, but with a strong inward-projecting lithodesma ; the pallial sinus and adductor impressions obscure, the posterior adductor apparently large and near to the end.

Length, 78 mm. ; height, 49 mm. ; diameter of a single valve, 14 mm. Another valve : length, 68 mm. ; height, 44 mm.

Type to be presented to the Wanganui Museum.

Locality: On the coast about three miles north of the Waipipi Stream, in brown sand and blue sandy clay.

The material consists of two right valves and one left, the latter rather fragmentary. In size it may be compared with *Thracea* sp. H. Woods, *N.Z. Geol. Sur. Bull. No. 4*, p. 34, pl. 19, figs. 4*a*, 4*b*. It shows even greater convexity than that species, and the beak is distinctly more posterior.

Miltha neozelanica n. sp. (Plate XVI, figs. 1, 2, and Plate XVII, fig. 1.)

Shell large, ovately subrotund, compressed, left valve distinctly more compressed than the right ; beaks small, curved forward, and nearer to the anterior end ; immediately in front of the beak is a small triangular area of the margin sharply inflexed to almost half the depth of the hinge-plate ; the anterior dorsal area narrow and inconspicuous, the margin convex, declining, and forming a small distinct angle at the end, from this is a wide uniform curve continued around the ventral margin and terminating in a more pronounced angle at the posterior end ; the posterior dorsal margin convex and regularly declining. On the posterior dorsal area of each valve one or two feeble corrugations following the curve of the margin. Sculpture consists of fine concentric threadlets, somewhat irregular towards the ventral margin, and rather more sharply raised on the posterior dorsal area ; radiate striation is very obscure, indications of it in places only. The hinge-plate wide with two cardinals in each valve, the anterior small, separated by a narrow triangular pit ; laterals consisting of a simple ridge on each side, the posterior almost obsolete ; ligament and resilium deeply inset. Adductors, the posterior small ovate, the anterior large and much elongated, the lower end almost in a line vertical to the beak ; pallial line impressed and distant from the margin, the latter smooth. The disc is more or less punctate and with small raised processes indicating attachment of the mantle ; all valves have a rather broad oblique sulcus on the middle area.

Height, 94 mm. ; length, 91 mm. ; thickness of united valves, 32 mm. A right valve : height, 64 mm. ; length, 68 mm.

Type to be presented to the Wanganui Museum.

Locality : On the coast about three miles north of the Waipipi Stream, in brown sands and in blue sandy clay ; also in the sea-cliff near to the Hawera County metal-pit, Whakina.

In the list of fossils occurring in the Waipipi beds this species is recorded as *Dosinia magna* Hutton (*Trans. N.Z. Inst.*, vol. 52, p. 124, 1920). In large specimens the anterior and posterior angles are more or less obscure.

but in medium-sized examples are very distinct, and frequently the length of the valve exceeds the height.

This is the first record of a species of *Miltha* in New Zealand. Its large size and the fact that the Lucinidae are poorly represented in this country make this occurrence noteworthy.

Miltha dosiniformis n. sp. (Plate XVII, figs. 2, 2A.)

Shell large, solid, subrotund, somewhat compressed, the left valve rather less inflated ; beaks small, a little anterior, and slightly curved forward ; the anterior dorsal area narrow and inconspicuous, the margin slowly declining, uniformly curved around the end and ventral margin ; the posterior dorsal margin slightly convex, declining, lightly angled at its termination, the end subtruncate ; the posterior dorsal area with a well-marked ridge. Sculpture consists of fine concentric threads, somewhat irregularly disposed ; the specimen is slightly eroded, but there does not appear to be any radial sculpture. Valves united and filled with hard matrix.

Height, 78 mm. ; length, 83 mm. ; thickness of united valves, 29 mm. Another example : height, 79 mm. ; length, 81 mm.

Type in the collection of the Geological Survey, Wellington.*

NOTE.—On the card accompanying a specimen it is recorded as "*Dosinia* sp. Age 4 to 6. Locality No. 257. Kawau Island." In addition to the two complete specimens there is a large fragment with the valves partly united and showing the pallial line distant from the margin ; also two smaller fragments of right valves, one of which clearly shows the small deeply inflexed area in front of the beak.

Miltha parki n. sp. (Plate XVII, fig. 3.)

Shell large and solid, ovately subrotund, compressed, the left valve more compressed than the right ; beaks prominent, curved forward, nearer to the anterior end ; excavate in front of the beak with the margin sharply inflexed, thence rounded, the end subangled on meeting the ventral curve ; the posterior dorsal margin convex and declining somewhat sharply, the end apparently slightly angled. The posterior dorsal area faintly indicated. Sculpture consists of fine concentric and radiate threads of about equal strength, producing minute granules. All examples have the valves united and are filled with a hard matrix ; no description of the interior can therefore be given.

Height, 77 mm. ; length, 75 mm. ; thickness of the united valves, 25 mm. ; the diameter of the right valve about one-third greater than that of the left. Other examples : height, 70 mm. ; length, 70 mm. Another : height, 64 mm. ; length, 62 mm.

Type and co-types in the collection of the Geological Survey, Wellington.

Locality : No. 526, Okoko–Waipa–Kawhia Road.

The specimens were collected by Professor Park and listed as *Dosinia* sp. (*Geol. Rep.*, vol. 17, p. 139, 1885).

NOTE.—The three species of *Miltha* described may be distinguished from each other by the following characters :—*M. parki*, by the prominence of the beaks and the radial sculpture : *M. neozelanica*, by the anterior position of the beaks and their marked forward curve ; in large specimens the

* Fig. 2A is from the right valve of the type, prepared by Mr. J. Marwick.

height is greater than the width and the marginal angles obsolete, though in medium-sized individuals the angles are very distinct; the left valve also is invariably much more compressed than the right: and *M. dosiniformis* by the submedian position of the beak, the more equal slope of the dorsal margins, and the more circular marginal contour. The two species are nearly allied, and closely approach *Phacoides* (*Miltha*) *sanctaecrucis* Arnold (*U.S. Geol. Sur. Bull. 396*, pp. 57–58, pl. vi, fig. 6, 1919) from the Coalinga District, California, recorded from Lower to Upper Miocene and perhaps Lower Pliocene.

A fragment of a *Miltha* was obtained by Dr. Thomson from the Mount Donald beds. It is too small to determine definitely, but is certainly very near to *M. neozelanica.*

A species of *Miltha* has recently (1919) been described by M. Doello-Jurado from the Tertiary beds of the Argentine in the Entrerienne formation, classed by von Ihering in the Miocene period.

Couthouyia concinna n. sp. (Plate XVIII, fig. 1.)

Shell minute, fusiform; whorls six, rounded and somewhat abruptly contracted at the sutures, apex minute, the two following whorls with fine spiral and axial threadlets, thence the axial riblets prominent, narrower than the interspaces, in places somewhat irregular and wrinkled, the spiral striae very indistinct, Aperture ovate, outer lip almost uniformly curved, basal lip very slightly produced; columella slightly curved, projecting, and with a small groove separating it from the body-whorl except on the upper third where the peristome is closely united.

Length, 2·6 mm.; width, 1·5 mm.

Type to be presented to the Wanganui Museum.

Locality: Target Gully. Collected by Marshall.

There is a single example only; it is near to the Recent species *C. corrugata* Hedley.

Vermicularia ophiodes n. sp. (Plate XVIII, fig. 2.)

Shell small, apparently solitary, of about seven or eight volutions, which are irregularly and obliquely spirally coiled and attached, with the exception of about one-third of the last coil, which is free and projecting; the apical whorl is broken and there appear to be internal septa, but there is no indication of septa in the terminal free portion; the sutures undulating and in places deep; the dorsal surface of the coils except the last with small somewhat irregularly-rounded pustules, frequently perforate, and between these irregularly granose. Viewed from the base the last coil produces a deep and rather elongated umbilicus, the sculpture is small undulating longitudinal threads, somewhat irregular and distinctly granular in places; the aperture subcircular.

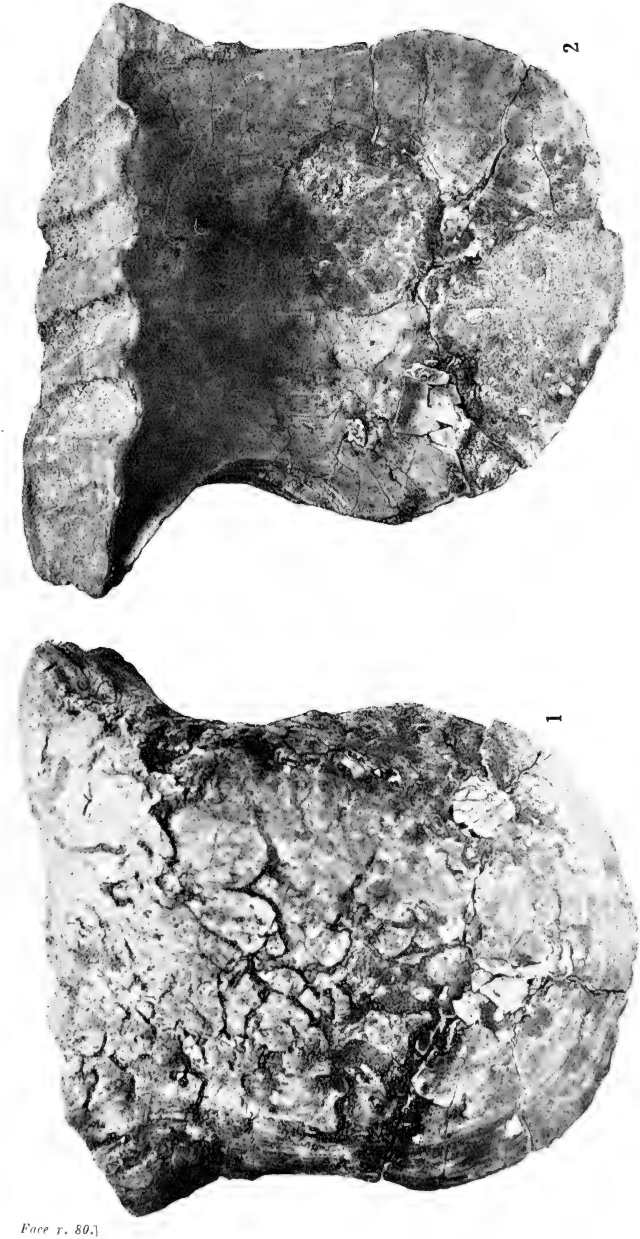
Greatest diameter of shell, 15 mm.; greatest diameter of aperture, 4 mm.

Locality: Target Gully. Collected by Marshall.

Type to be presented to the Wanganui Museum.

Cymatium suteri n. sp. (Plate XVIII, figs. 3, 4.)

Shell small, fusiform, aperture and canal shorter than the spire; whorls six or seven, somewhat rounded, sutures impressed not deep, canal short;



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Figs. 1, 2.—*Melina zealandica* Suter.

1

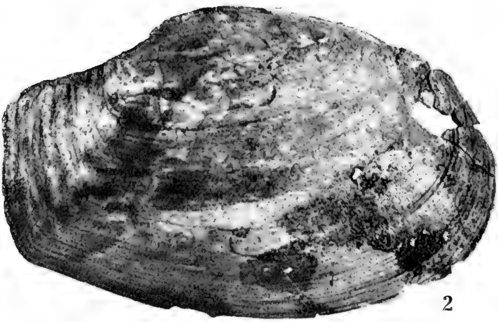

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FIG. 1.—*Ostrea gudexi* Suter. FIGS. 2, 3.—*Thracea magna* n. sp.

FIGS. 1, 2.—*Miltha neozelanica* n. sp.

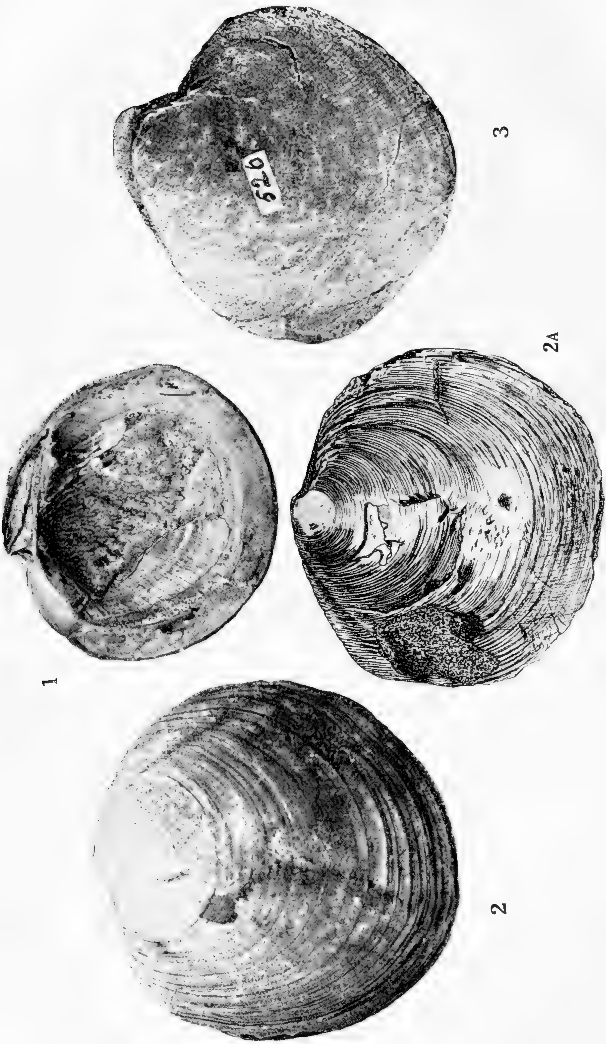

FIG. 1.—*Miltha neozelanica* n. sp. FIGS. 2, 2A.—*Miltha dosiniformis* n. sp. FIG. 3.—*Miltha parki* n. sp.

sculpture consists of axial and spiral cords forming nodules on the crossings; they are equal to or rather wider than the interspaces; on the body-whorl the axials are more distant and less marked especially towards the lip, there are about thirteen on the penultimate whorl, growth-striae are well marked in places and there are several prominent varices; of the spiral cords there are six or seven on the penultimate whorl and fourteen or fifteen on the last, with an occasional minute thread in the grooves, those on the base and canal smaller and crowded, on each whorl the two spirals immediately below the sutures are small and close together. Aperture ovate, slightly oblique, the outer lip with a stout varex, somewhat expanded and with several stout elongated denticles; columella almost straight, smooth, with a stout callus narrowing to the end of the beak, which is slightly twisted.

Length, 13 mm.; width, 6 mm.; length of aperture and canal measured on the angle, 7 mm.

Locality: Waikopiro.

Type in the Wanganui Museum.

This small species came to light in the Suter collection. It is labelled by him "n. sp.," and it is only one of many with which he was unable to deal.

Cymatium pahiense n. sp. (Plate XVIII, fig. 5.)

The specimen is embedded in sandy clay, and the front only is visible.

Shell of medium size, stout, shortly fusiform, aperture longer than the spire; whorls about five or six, the last large and narrowed to the short anterior canal; apex missing, the lower spire-whorls convex, lightly angled above; sutures impressed, apparently not deep; the body-whorl with a prominent varex to the left of the aperture. Sculpture consists of axial and spiral cords, the latter more pronounced and forming rows of small nodules, the separating grooves in width about equal to the cords; on the penultimate whorl there are apparently four or five spiral cords. Aperture slightly oblique and somewhat narrow, the outer lip widely expanded, thick and with ten to a dozen stout lamellae, which curve into the aperture; inner lip with a broadly expanded thin callus not obscuring the spiral sculpture; the columella almost straight, a few small lamellae at the anterior end, four stout rounded plates on the middle area, and immediately above these narrowly and rather deeply excavated, thence curving outward to the lip with the nodular spiral cords continuing into the aperture.

Length, 40 mm.; width, 23 mm.; length of aperture and canal, 25 mm.

Type to be presented to the Wanganui Museum.

Locality: Pahi. Collected by Marshall.

The apical whorls are missing, and therefore the proportional length of the aperture and canal to the total length is not as great as the measurements given above would indicate. It is a somewhat peculiar form, and placing it in *Cymatium* is not altogether satisfactory.

Cypraea sp. (Plate XVIII, fig. 6.)

Specimen very fragmentary. Spire concealed, aperture narrow above and strongly curved, outer lip thickened and extending above the spire, the margin incurved and dentate, inner lip with strong transverse teeth on the posterior area and perhaps continued to the anterior end.

Length, approximately 30 mm.; width, approximately 20 mm.
Locality: Pahi. Collected by Marshall.
Appears to be distinct from other species recorded from our Tertiaries, but is too fragmentary to determine definitely. The specimen to be lodged in the Wanganui Museum.

Admete maorium n. sp. (Plate XVIII, figs. 7, 8.)

Shell small, shortly fusiform, spire short; whorls five or six, prominently shouldered, apical whorls smooth and rounded; sutures somewhat impressed. Sculptured with stout axial and spiral cords forming small nodules on the crossings, both distinctly narrower than the interspaces, the axials are the more distant and becoming more or less obsolete on the base, there are twelve on the last whorl; of the spiral cords there are two on the spire-whorls and eight on the last, the lower five small, gradually diminishing anteriorly, of the three prominent cords the second and third are the more widely spaced. Aperture ovate, slightly oblique, outer lip imperfect, the margin no doubt crenulated; columella almost straight, slightly twisted at the extremity, narrowly but strongly callused, and with three strong evenly spaced plates on the anterior half.
Length, 8·5 mm.; width, 5 mm.
Locality: Target Gully. Collected by Marshall.
Type to be presented to the Wanganui Museum.
Allied to *A. suteri* Marshall and Murdoch, but differs in the stronger sculpture, less number of axial cords, and the position of the plates on the columella.

Daphnella varicostata n. sp. (Plate XIX, fig. 1.)

Shell small, fusiform; spire lightly turreted, its length nearly equalling the aperture and canal; sutures somewhat impressed, narrowly margined below, usually more distinct on the higher whorls; whorls eight, the third and succeeding whorls convex, rising rather abruptly at the sutures, the last produced and gradually contracted to the beak; protoconch smooth; apex minute, whorls gradually increasing, thence with axial and spiral sculpture, the axials very irregular, close and distinctly raised, or almost obsolete in places, or broad and lightly rounded, usually feeble on the body, and the lines of growth well marked; the spirals small and variable, the grooves narrow, more strongly marked towards the beak; there are eight or nine spirals on the penultimate whorl. Aperture narrow, outer lip with sharp margin, the posterior sinus small, situated immediately below the suture, distinctly marked by the growth-striae; columella lightly curved, the anterior end slightly deflected to the left, thinly callused, and with small oblique threadlets corresponding with the adjacent spirals; canal short and fairly wide.
Length, 15 mm.; width, 6·25 mm.
Locality: Awamoa. Collected by Marshall.
Type and co-types to be presented to the Wanganui Museum.
There are three examples each varying slightly in the axial sculpture. With these is another example having very minute close spiral lines, the axials very feeble, almost suppressed, the sutures apparently not margined, and the protoconch increasing in girth more rapidly. The two latter characters are of some importance, but meantime it appears better to record the form "var. A."

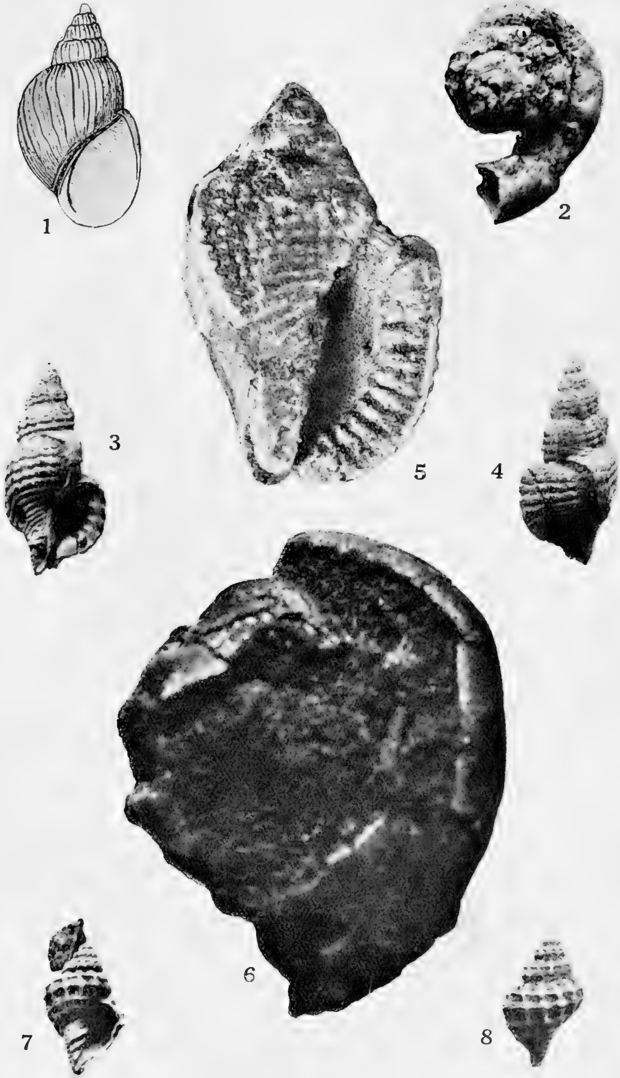

Fig. 1.—*Couthouyia concinna* n. sp.
Fig. 2.—*Vermicularia ophiodes* n. sp.
Figs. 3, 4.—*Cymatium suteri* n. sp.
Fig. 5.—*Cymatium pahiense* n. sp.
Fig. 6.—*Cypraea* sp.
Figs. 7, 8.—*Admete maorium* n. sp.

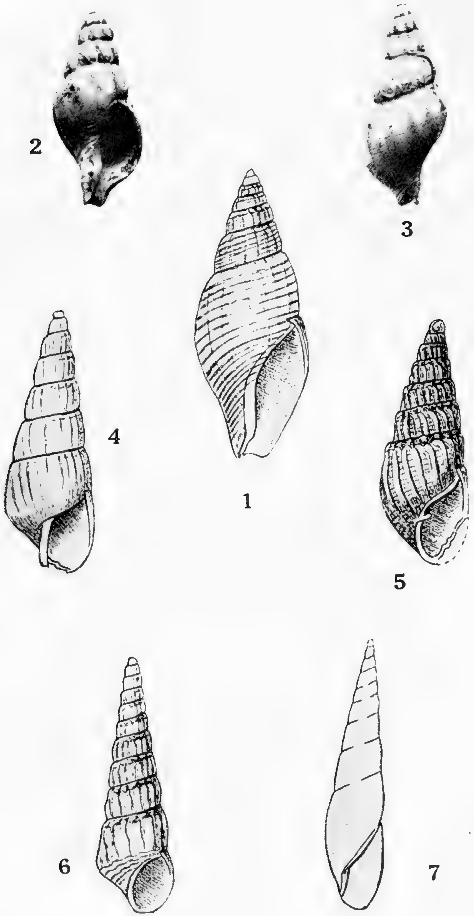

FIG. 1.—*Daphnella varicostata* n. sp.
FIGS. 2, 3.—*Euthria subcallimorpha* n. sp.
FIG. 4.—*Eulimella awamoaensis* n. sp.
FIG. 5.—*Odostomia (Pyrgulina) pseudorugata* n. sp.
FIG. 6.—*Turbonilla awamoaensis* n. sp.
FIG. 7.—*Eulima aoteaensis* n. sp.

Euthria subcallimorpha n. sp. (Plate XIX, figs. 2, 3.)

Shell small, fusiform; spire equal to or slightly longer than the aperture; sutures impressed, fairly deep; whorls five, the apex missing, convex, the last rounded at the periphery, thence gradually contracted to the canal; sculpture—there are eight low rounded axials, more pronounced on the spire-whorls, feeble on the base of the last and vanishing towards the canal, they are rather narrower than the interspaces; the spirals consist of fine close incised lines, forming lightly raised threadlets on the upper spire-whorls, and with five or six on the canal more prominent. Aperture ovate, slightly oblique, narrowed above, below produced into a short open canal; outer lip sharp and with a number of small denticles within the margin, columella almost vertical, slightly callused, smooth, beak slightly twisted to the left.

Length, 12 mm.; width, 5·5 mm.; length of aperture and canal measured on the angle, 6 mm.

Locality: Target Gully. Collected by Marshall.

Type to be presented to the Wanganui Museum.

The only example has the axial ribs somewhat rubbed. It may be distinguished from *callimorpha* by the absence of the keel on the spire-whorls, the shoulder not excavated, the finer spiral sculpture, and somewhat longer canal.

Hemifusus (Mayeria) goniodes Suter.

N.Z. Geol. Surv. Pal. Bull. No. 5, p. 23, pl. 3, figs. 15, 16.

Two examples of this species were obtained at Pahi and agree well with Suter's description. The keel on the spire-whorls is well below the middle, the shoulder sloping and concave, the sutures somewhat impressed, submargined below and with a few small spiral threads, the spiral sculpture is distinctly developed on the anterior end only; growth-lines are somewhat prominent and appear to indicate a broad shallow sinus on the shoulder. It appears doubtful if the genus *Hemifusus* is best suited for the species, but better material is necessary to settle the question.

Length (imperfect specimen), 63 mm.; width, 27 mm.

Locality: Pahi. Collected by Marshall.

Eulimella awamoaensis n. sp. (Plate XIX, fig. 4.)

Shell small, subulate, straight, and polished; aperture about one-third of the total length; sutures distinctly channelled; whorls eight; the apex of the protoconch broken, it is apparently oblique; whorls flattened, narrowly subangled a little below the sutures, most marked on the higher whorls, the last narrowly curved on the periphery and convex below; sculpture consists of a number of irregularly-disposed feeble axial riblets, spiral striae very indistinct; aperture narrow above, outer lip straight, columella rounded, narrow and straight, basal lip imperfect, apparently somewhat produced.

Length, 7 mm.; width, 2·25 mm.; length of aperture, 2 mm.

Locality: Awamoa. Collected by Marshall.

Type to be presented to the Wanganui Museum.

NOTE.—In general form the species is near to *E. limbata* Suter.

Odostomia (Pyrgulina) pseudorugata n. sp. (Plate XIX, fig. 5.)

Shell small, elongated, narrowly turreted; whorls seven, protoconch smooth, heterostrophe, nucleus lateral, succeeding whorls slightly convex, subangled a little below the sutures, the latter deeply impressed. Sculpture consists of about seventeen rounded and slightly inclined-forward axial ribs, extending across the base and rather narrower than the interspaces; these are crossed by fine spiral threads which form minute granules on the crossings, a stronger and more distinctly nodular cord on the subangle and a similar cord margining the sutures; there are about five spirals on the penultimate whorl. Aperture imperfect (outer-lip broken), columella nearly vertical, callused and with a stout plate above the middle.

Length, 3 mm.; width, 1 mm. Aperture slightly more than one-third of the total length.

Locality: Target Gully. Collected by Marshall.

Type to be presented to the Wanganui Museum.

Closely allied to *O. rugata* Hutton, from which it differs in its narrower form, slight but distinct nodular angle below the sutures, and the absence of a pronounced cord on the base; in *O. rugata* the basal cord is apparently always present, although the axials are frequently extended below it.

Turbonilla awamoaensis n. sp. (Plate XIX, fig. 6.)

Shell small, subulate, whorls ten, protoconch missing, flattened or slightly concave below the sutures, thence convex; sutures slightly impressed and, on the lower whorls, with one or two fine spiral threads above; whorls strongly axially ribbed, about fourteen ribs on the penultimate, including an occasional broader varex, the axials narrower than the interspaces, slightly flexuous and with a subnodular appearance immediately below the sutures, absent on the base; the last with a number of small undulating spiral threadlets towards the base, obsolete on approaching the columella; aperture oval, the basal lip slightly effuse, columella slightly curved, narrowly and stoutly callused.

Length, 10 mm.; width, 2·75 mm.

Locality: Awamoa. Collected by Marshall.

Type to be presented to the Wanganui Museum.

The sculpture readily distinguishes it from our other Tertiary forms.

Eulima aoteaensis n. sp. (Plate XIX, fig. 7.)

Shell small, subulate, straight, and highly polished; varices very indistinct, without sculpture excepting the microscopic growth-lines; whorls eight or nine, almost flat, the sutures oblique and very lightly impressed; the aperture about one-third of total length; the apical whorl missing, the next a little more rounded than the succeeding whorls, the last narrowing and slightly produced at the anterior end; aperture slightly oblique, very narrow above, lip almost straight, base rounded and slightly effuse; the columella almost straight, with a well-defined callus slightly spreading on the middle area and narrowing to the anterior end.

Length, 6·5 mm.; width, 1·25 mm.; length of aperture, 2 mm.

Locality: Target Gully. Collected by Marshall.

Type to be presented to the Wanganui Museum.

This species had been submitted to Suter, and is labelled by him "*Eulima* n. sp." The form of the aperture, together with the length of the last whorl, appears to distinguish it from other New Zealand species.

ART. XI.—*Fossils from the Paparoa Rapids, on the Wanganui River.*

By P. MARSHALL, M.A., D.Sc., F.N.Z.Inst., Hector and Hutton Medallist, and R. MURDOCH.

[*Read before the Wanganui Philosophical Society, 25th October, 1920; received by Editor, 31st December, 1920; issued separately, 27th June, 1921.*]

No complete collection of fossils has yet been recorded from the strata that crop out along the course of the Wanganui River. For the most part the strata contain but few fossils, and in those localities where organic remains are abundant the material in which they are embedded is pebbly, or it has a concretionary nature, which makes it difficult to extract the fossils in a condition that allows of exact identification. The most promising locality that is known at present is probably that of the Paparoa Rapids, some twenty miles below Taumarunui. Park* was the first geologist to make any collections here, and he recognized some thirty species, the nature of which seemed to show that the strata were of a distinctly lower horizon than any that he found on the coast between Wanganui and Patea. A visit was paid by one of us to the locality in January, 1920, with the object of making as complete a collection as time and circumstances would allow. Two days were spent there, but the collection that was made did not contain a very large number of species. At the Paparoa Rapids the strata on the right bank of the river are almost horizontal, but on the left bank they have been disturbed by an extensive slip, and have locally a high easterly dip. The fossil-bearing rock is a fine, hard, bluish-grey sandstone, slightly concretionary in its nature, and large fossil shells are very conspicuous in it. The actual material of the sands is such as might well be derived from the rocks of Maitai age, of which the main mountain-ranges of the North Island are composed.

The following is a list of the species which were collected, the Recent species being marked with an asterisk.

Ancilla sp.; apex only
**Calyptraea novae-zelandiae* Less.
Chione acuminata Hutt.
**Chione yatei* (Gray)
Cominella aff. *intermedia* Sut.
Conus sp.; a fragment only
Corbula pumila Hutt.
Crassatellites attenuatus (Hutt.)
Crassatellites traillí (Hutt.)
Crepidula gregaria Sow.
Cucullaea worthingtoni Hutt.
Cytherea ensyi Hutt.
Dentalium solidum Hutt.
**Divaricella cumingi* (Ad. & Ang.)
**Dosinia anus* (Phil.)
**Dosinia subrosea* (Gray)
Epitonium lyratum (Zitt.)
Glycymeris cordata (Hutt.)
Glycymeris subglobosa Sut.
Limopsis zitteli Iher.
Luponia aff. *ovulatella* Tate
**Mactra scalpellum* Reeve
Natica (Polinices) gibbosus Hutt
Panope worthingtoni Hutt.
Paphia curta (Hutt.)
**Pecten convexus* Q. & G.
Pecten huttoni (Park)
Struthiolaria cincta Hutt.
Surcula aff. *fusiformis* (Hutt.)
Turbo aff. *superbus* Zitt.
Turritella semiconcava Sut.
Verconella nodosa var.; not Recent
Verconella aff. *dilatata*; fragment only
Voluta sp.; not Recent

* J. PARK, *Rep. Geol. Explor. during 1886–87*, p. 173, 1887.

There are only thirty-four species in this list, and many of them are represented by fragmentary material only, or they are filled with a hard and tough matrix. The hinge-teeth and apertures of many of the species are obscured, and this makes the identification a little uncertain. Only seven of the species are certainly Recent, and the percentage of Recent species therefore falls as low as 21. The small size of the collection, the fact that large species only were in a condition to be collected, and the uncertainty of identification in some cases make it unsafe to rely too closely on this percentage in correlating the strata with those of other localities in New Zealand.

The nature of the mollusca points rather to the Target Gully horizon, for there are only six species that do not occur there, and these species are found in horizons of much the same position near Oamaru or in the Trelissick Basin. On the other hand, the fauna of this stratum is of a distinctly older type than that of any of the coastal localities of the district in which we have collected fossils up to the present time.

Art. XII.—*Tertiary Rocks near Hawera.*

By P. Marshall, M.A., D.Sc., F.N.Z.Inst., Hector and Hutton Medallist, and R. Murdoch.

[*Read before the Wanganui Philosophical Society, 25th October, 1920; received by Editor, 31st December, 1920; issued separately, 27th June, 1921.*]

In the last volume of the *Transactions of the New Zealand Institute* we published lists of fossils from various localities on the coast-line to the north-west of Wanganui. During the past year we have been able to make collections on the beach at Hawera, some twenty miles farther along the coast in the north-west direction. Throughout this distance the rocks are of the same general nature as they are near Wanganui—in other words, micaceous sands and clays (the papa rock). If anything, the material is rather more sandy on the average than it is farther south. There is perhaps rather less mica, and black grains are rather more numerous among the quartz-grains. The strike of the strata changes a good deal. As stated in our former paper, the strike between Castlecliff and Nukumaru is, on the average, 70°. By the time Patea is reached it is as much as 100°, and still farther north, at the mouth of the Tangahoe Stream, on the coast opposite Mokoia, it is 145°. This shows clearly that there is a gradual swing in the strike as one proceeds to the north-west. The dip is always to the south-west and is always slight, and has an average of about 4°.

The direction of the strike and dip as related to that of the coast is such that older and older beds are exposed as one journeys north until the mouth of the Tangahoe is reached. At this point the trend of the coast is parallel to the strike of the strata, and as one goes still farther north younger and younger strata again begin to make their appearance. About 500 ft. of strata separate the lowest horizon three miles north of Waipipi from the horizon at the mouth of the Tangahoe Stream. The Waihi beach is five miles to the north of the mouth of the Tangahoe, and the horizon exposed on the beach at that point is about 100 ft. higher than the lowest horizon at the Tangahoe mouth, and is therefore 400 ft. lower than the Waipipi horizon, or, in other words, 4,200 ft. below the highest beds at Castlecliff.

The great regularity of the stratification which is so noticeable to the south-east of Waipipi is just as noticeable in the strata exposed along the coast-line to the north-west of that place. There is no unconformity as far as our observations went, and there is no evidence of a stratigraphical disconformity. The similarity, too, of the molluscan faunas in the localities that have been mentioned is also so great as to show clearly that there is a palaeontological continuity.

FOSSILS FROM HAWERA.

Ancilla depressa (Sow.)
Anomia huttoni Sut.
Arca novae-zelandiae E. A. Smith
Atrina zelandica (Gray)
Calliostoma pellucidum (Val.)
Calliostoma selectum (Chemn.)
Calyptraea novae-zelandiae var. *inflata* (Hutt.)
**Cardium spatiosum* Hutt.
**Chione chiloensis* Phil.
**Chione chiloensis* var. *truncata* Sut.
Chione mesodesma (Q. & G.)
Chione yatei (Gray)
**Crassatellites* aff. *trailli* (Hutt.)
**Crepidula gregaria* Sow.
Crepidula monoxyla (Less.)
Cytherea oblonga (Hanley)
**Dentalium pareorense* Pilsbry and Sharp
**Dentalium solidum* Hutt.
Divaricella cumingi (Ad. & Ang.)
Dosinia lambata (Gould)
Dosinia subrosea (Gray)
**Fulgoraria morgani* Marshall and Murdoch
**Fulgoraria* sp.; not Recent
**Fusinus* aff. *spiralis* aff. *dentatus* (Hutt.)
Glycymeris laticostata (Q. & G.)
**Glycymeris subglobosa* Sut.
**Lima waipipiensis* Marshall and Murdoch
**Lucinida levifoliata* Marshall and Murdoch
Macoma edgari Iredale
Macrocallista multistriata (Sow.)
Mactra scalpellum Reeve
**Melina zealandica* Sut.
**Miltha zelandiae* Marshall and Murdoch
**Natica ovata* Hutt.
**Natica sagena* (Sut.)
Nuculana bellula (A. Ad.)
**Olivella neozelanica* (Hutt.)
Ostrea angasi Sow.
Ostrea cucullata Born = *corrugata* Hutt
**Ostrea ingens* Zitt.
Panope zelandica Q. & G.
**Paphia curta* (Hutt.)
**Pecten semiplicatus* Hutt.
**Pecten triphooki* Zitt.
Pecten zelandiae Gray
**Phalium fibratum* Marshall and Murdoch
Protocardia pulchella (Gray)
Psammobia stangeri Gray
**Struthiolaria canaliculata* Zitt.
**Struthiolaria zelandiae* Marshall and Murdoch
Struthiolaria aff. *papulosa* (Mart.)
Thais aff. *lacunosa* (Brug.)
Turritella carlottae Watson
Turritella rosea Q. & G.
Turritella symmetrica Hutt.
Venericardia purpurata (Desh.)
Venericardia unidentata (Basterot)
Verconella dilatata (Q. & G.)
Verconella mandarina (Duclos)
Verconella nodosa (Mart.)
Zenatia acinaces (Q. & G.)

The species marked with an asterisk are extinct. There are sixty-one species in this list, of which twenty-five are extinct: thus the percentage of extinct species is 41.

Our examination of the coast-line between Wanganui and the Waingongoro has now proceeded far enough to allow us to discuss various geological theories in the light of the facts that have so far been disclosed. We have now traversed the coast-line for nearly the whole distance of fifty miles, and the following opinions appear to us to be well established:—

(1.) The series of rocks represents a period of continuous marine deposition.

(2.) The climate during this period of deposition was at no time colder than at the present, but, on the other hand, during the greater part of the time conditions were distinctly more genial.

(3.) There is no evidence of any sudden addition to the marine molluscan fauna whilst the deposition was in progress.

(1.) The first of these opinions has to be supported from the palaeontological, stratigraphical, and lithological facts that have been observed. From the palaeontological standpoint the evidence at first sight seems to be in favour of a decided break between the faunas of the two extremes—Castlecliff and Whakino. So greatly do the faunas in these two localities differ from one another that any geologist who saw the Castlecliff fauna at one time and that of Whakino–Waihi near Hawera at another, without examining any of the intermediate localities, would unhesitatingly come to the opinion that they represented different geological periods. It is, of course, true that several identical species occur in the two localities; but it is also true that the dominant species in the one locality are either absent from the fauna of the other or are there reduced to an insignificant proportion. Collections that have been made at intervening points, from two of which we have already published lists, show, however, a clear connection between the two divergent faunas. We have found no locality where the change in the faunas is so marked as to prove that there is a break in the palaeontological succession. The locality that we have found to be most suggestive of such a break is at a point three-quarters of a mile to the south of the Nukumaru boat-landing. Here we have found the last specimens of *Melina zealandica, Lutraria solida, Cytherea enysi, Lucinida levifoliata, Mesodesma crassa,* and *Struthiolaria frazeri.* These species, however, do not all disappear at the same horizon, but in a thickness of rock that measures about 100 ft. There is also the additional fact that the horizon in which all these species occur contains also as many as 76 per cent. of Recent species, and the fauna is clearly related in the most definite manner to that in the series of rocks that lies above it. For these reasons we do not regard this horizon as indicating in any sense a palaeontological break. On the other hand, there must be a most definite reason for the important faunal change which is so conspicuous at this horizon. It is our belief that this change is due to climatic conditions, or, at any rate, to a most important change in the temperature of the ocean-water which washed these shores at that time. The species that continued to exist after this time were, however, as varied, and indicate a temperature of sea-water at least as high as that of the present Cook Strait. We are inclined to think—though on this point there is room for much divergent opinion—that, on the one hand, the Waipipi series and the Whakino series contain a fauna that is, from the percentage of Recent species, and from the very nature of the fauna, perhaps equivalent to the Upper Miocene of Europe; but since it is probable that in an isolated country like New Zealand faunal change was relatively slow, it is undesirable, at the present time at least, to place much reliance on any such correlation. On the other hand, the Castlecliff series contains a fauna with such a high percentage of Recent species that it is in all probability more or less equivalent to the Upper Pliocene of Europe. While we think that the extreme faunas show as great a difference as is indicated by these periods, we also think that, divergent as they are, a complete transition occurs in the strata between them from the one fauna to the other.

This opinion as to the continuity of the rock-series is also strongly supported by stratigraphical evidence, which may be summarized under three heads :—

(*a*.) We can nowhere find an important stratigraphical break in the line of cliffs, which is almost continuous throughout the distance. There is, of course, a great deal of irregularity in the stratification, due to tidal scour and to current-bedding, but the cause and nature of this is at once apparent. The only place where we have found anything more important is at a locality about two miles and a half to the north of Kai Iwi. In this place, as mentioned in a previous paper, there is clearly an old land-surface, which is indicated by a thin deposit of beach-worn pebbles, a layer of carbonaceous matter, strata penetrated by roots, and borings of littoral mollusca. On the other hand, this structure is not associated with any distinct change in the species of mollusca, and it must, in our opinion, be regarded as due to a merely temporary and local emergence of a coast-line that was otherwise undergoing a submergence about as rapid as the accumulation of sediment for a long period of time.

(*b*.) We have found no sudden change of dip and strike that has extended through a thickness of more than 100 ft. of sediment. Throughout the strata that are exposed on the coast-line the strike and dip are remarkably constant. The strike swings round gradually from 85° at Castlecliff to 125° near Whakino, but, except for a few local variations, there is no sudden change. Perhaps the most marked of these sudden variations is that which occurs at the mouth of the Waipipi Stream, but in a few hundred yards along the beach the normal strike is restored.

(*c*.) Lithologically the sediments are very similar throughout. In those few localities where there are embedded pebbles they are always fragments of submetamorphic rocks of the nature of greywackes. Where the sediments are of a finer nature they are always bluish-grey in colour, and contain a great abundance of quartz and of muscovite mica. The lithological nature of this fine sediment is so similar throughout that there is little doubt that it has all been derived from one and the same source. This conclusion points to the probability that the sediments were all deposited while the areas of land and sea remained approximately the same, and consequently there is a presumption that all the sediments were deposited during the same geological period.

It may therefore be taken as a fact that palaeontological, stratigraphical, and lithological evidence alike support the belief that the series of rocks exposed on the coast-line between Wanganui and Hawera represents a period of continuous sedimentation which in New Zealand geology may be said to belong to the upper part of that great geological system which we, by somewhat extending the classification of Captain Hutton, have called the Oamaru system. We are of opinion that the Wanganui system must now be regarded as having lost its individuality, and that it must in future be looked upon as the upper strata of the great Oamaru system. We consider it possible that the period of deposition of these rocks extended over the period that in Europe elapsed between the Upper Miocene and the Upper Pliocene, though we do not wish to insist upon this correlation. It appears to us that under the peculiar conditions in New Zealand which necessarily resulted from the prolonged isolation of this small land the rate of organic change, so far as it is shown in the marine mollusca, does not give a very satisfactory basis for the correlation of the New Zealand sediments with those of Europe, so far at least as the Tertiary rocks are concerned.

(2.) Climate: If it be accepted that the continuity of the strata in the Wanganui coast is as precise as has been described, it at once becomes evident that climatic conditions in New Zealand have been warm or mild during the whole period of time that was occupied in the deposition of the sediment. It has also been suggested that this lapse of time is more or less equivalent to the interval between the Upper Miocene and the Upper Pliocene in Europe. Whether this is the case or not, it may be taken as certain that the period called by Hutton the "older Pliocene" is comprehended in this interval. All who have studied New Zealand geology are aware that Hutton was of opinion that the great extension of the glaciers of New Zealand occurred during this Upper Pliocene. We hold that the evidence which we have been able to bring together shows conclusively that the climate of New Zealand during this Upper Pliocene period was at the least as genial as it is now, and that there can have been no glacial extension relative to the present sea-level during that period. There is, on the other hand, much evidence that the warm climate of the early Tertiary has become a good deal colder during the late Tertiary in this country. At least three genera which indicate warm conditions—*Melina*, *Olivella*, and *Miltha*—have now disappeared. In many other genera species of large size have been replaced by others of much smaller dimensions. Large species of *Melina* are at present restricted to the warmer tropical waters, and it may well be held that *Olivella* and the large species of *Miltha* indicate the prevalence of warm climatic conditions. This conclusion is enforced by the occurrence of large species of *Cardium*, *Cytherea*, *Pecten*, *Ostrea*, *Paphia*, *Natica*, and *Dentalium*. It becomes evident that climatic conditions in New Zealand between the Upper Pliocene and the Upper Miocene, so far as these periods can be judged by the nature of the marine mollusca now exposed on the cliffs of the north coast of Cook Strait, were never colder than now, and during the greater part of that time they were a great deal more genial. There is also evidence that during at least the earlier portion of this interval the climate was a great deal warmer than it is at the present day.

(3.) Change in fauna: We regard it as a fact that during the long period of time that is represented by these sediments there has been no sudden appearance of a new fauna. Everywhere the fauna contained in each separate stratum may reasonably be regarded as the lineal descendant of that in lower strata, though in each stratum there are perhaps a few species or genera that are found sparingly elsewhere. In no case, however, is there such a change as to justify the opinion that a foreign element has been introduced into the previous fauna. This idea of the continuity of the marine molluscan fauna of the younger Tertiary rocks of New Zealand may be carried a little further, for it is a fact that the fauna of the highest beds that are exposed differs but slightly from the marine molluscan fauna of the present day. It is certainly a fact that no additional foreign element distinguishes the Recent fauna from that which is contained in the Castlecliff beds.

It has frequently been remarked before by one of us when speaking of the molluscan fauna of the earlier portion of the Oamaru system—notably that of Target Gully—that it was distinctly richer than that of the present day. It is hardly correct to make this statement in speaking of any comparison between the fauna of the Waipipi series and that of the Castlecliff series. The fauna that has been collected from the former locality up to the present time is not very extensive, and it is notably wanting in the smaller species. These facts effectively prevent a complete comparison being made. It can, however, be safely said that, while the Castlecliff fauna contains a large number of species that are not found at Waipipi, most of these additional species have been found elsewhere in Tertiary rocks of greater age than those of the Waipipi series.

During the time that elapsed between the Waipipi and the Castlecliff periods of deposition, perhaps Upper Miocene to Upper Pliocene, a period elsewhere estimated as equal to a lapse of 690,000 years, an important change took place in the fauna. This change was not the result of the introduction or addition of new species or of new genera, but was due to the extinction of some genera which had been of importance up to the middle of the period, and of numerous species that had given a definite character to the earlier fauna.

As has already been remarked, the molluscan fauna of the Castlecliff series differs in few respects from the Recent fauna. It is probable that the difference is even less than a comparison of the lists would suggest, for the Castlecliff beds were deposited at a depth that approached 100 fathoms, and we have at present an incomplete knowledge of the fauna of the New Zealand sea-floor at that depth. Dredgings that were made outside the Great Barrier in 1904 brought to light several species that had previously been collected in the Castlecliff series, and had been thought to be extinct. From our work on the mollusca of the beds on the Wanganui coast-line we consider that we have a knowledge of at least the main features of the New Zealand marine mollusca from the Upper Miocene to the present day. Such a knowledge must shed an important light on theories that have been advanced in regard to the relations or land connections between New Zealand and other countries during this lapse of time. A number of eminent authorities have written on this subject, but at the present moment we wish to restrict ourselves to those who have made specific statements in regard to these land connections during the period with which we have dealt—namely, from the Upper Miocene to the present day. Hutton* has definitely stated that during the older Pliocene New Zealand was in direct communication with New Guinea. The statement is based mainly on the occurrence of *Diplodon aucklandicus* in lignite-beds at the Dunstan, in Otago, a species which is said by Hutton to have its nearest ally in New Guinea. We consider it to be impossible that a continental extension of such a magnitude should have occurred without having the greatest effect on the molluscan fauna of New Zealand at that time, and of this we have not been able to find any trace. Marshall† has stated that the great Pleistocene elevation connected New Zealand with some of the northern tropical islands, and provided also a shallow-water connection with Antarctica. This statement was based on older opinions of Hutton. It is sufficient

* F. W. Hutton, *Index Faunae Novae Zealandiae*, p. 18, Dulau and Co., 1904.

† P. Marshall, *New Zealand and Adjacent Islands*, p. 49, Carl Winter, Heidelberg, 1912.

to say that a comparison of the mollusca of the Castlecliff beds with the Recent mollusca shows definitely that New Zealand did not at that time receive additions of any importance whatever to its marine molluscan fauna, and therefore that any extension of the area of New Zealand at that time did not in any way impair its isolation.

Park* has stated that during the Pleistocene the area of New Zealand was many times greater than now, that the whole of the South Island and most of the North Island was glaciated, and in a map he shows the land extending to New Caledonia The general similarity between the fauna of the Castlecliff beds and the Recent fauna goes far to disprove the idea of glaciation of this district, while there is no evidence known to us, so far as the mollusca are concerned, that would show a Pleistocene extension of New Zealand to New Caledonia. Hutton in various other publications urged not only that New Zealand was greatly extended during the early Pliocene, but also that it was heavily glaciated at that time. It is probable that in the rock-series that we have described the Nukumaru series is about the age of the early Pliocene. In these beds we have at once a proof that this part of New Zealand was not elevated at that time, and we also have distinct proof that the climate was no colder, but was probably a good deal warmer than at the present day.

There are, however, clear proofs that New Zealand, or at least this part of the country, was considerably elevated at the close of the time of deposition of the Castlecliff beds. Two of these may be quoted. Artesian wells in the lower valley of the Wanganui River bed have reached a depth of 400 ft. without passing through the alluvial matter that the river has deposited. The valley of the Waingongoro River had a bed that extended to an unknown depth below the present sea-level, and had a width of about half a mile at the present beach-level. In addition to these facts, the strata of the series of rocks that has been described have all been elevated and eroded off to a uniform level before the next series of rocks was deposited. This upper rock-series rests in all cases unconformably on those that we have described, lying directly on the Whakino-Waihi beds in the extreme north of the district at which we have worked. The general occurrence of the sediments suggests that all the overlying beds were removed by erosion before these Pleistocene sediments were deposited. As to the precise age of this upper series of rocks we have at present no exact information. They frequently contain a large number of molluscan fossils at the base, but we have seen no extinct species of mollusca among them, and it is probable that they are approximately equivalent to the Pleistocene of Europe. Thomson has lately proposed to apply the name "Hawera series" to them. There is no particular objection to this, though the term "Pleistocene" has long been used in New Zealand, and it has not yet been shown that they are not a reasonable equivalent of the European Pleistocene.

It is perhaps advisable to recapitulate that after the Castlecliff series had been deposited there was a prolonged period of moderate elevation during which a great deal of erosion took place. Though this elevation was considerable, it was not great enough to bring the New Zealand area sufficiently close to any other country to allow of the introduction of any new features into the marine molluscan fauna of New Zealand.

The work that has been done in recent years on the fossil and Recent mollusca of New Zealand is now of sufficient amount and importance

* J. Park, *Geology of New Zealand,* p. 14, 1910

to justify a consideration of the indications that they offer regarding the relations of New Zealand to other land areas in past time. It is evident that an accurate knowledge of the Recent fauna is of special importance when one is dealing with the main facts of the Tertiary geology of this country. Sir James Hector some forty years ago said, "An accurate knowledge of the affinities and distribution of the Recent shells of New Zealand is a very necessary element in the geological survey of this country."* The application of this principle is as essential now as it was then. Hutton, in the Introduction of his Manual of 1880,† states that the better the fauna of New Zealand becomes known, the more prominently does it stand out as distinct from that of any other country, and this is particularly the case with its shells. Again, in his Introduction to the *Index Faunae Novae Zealandiae*,‡ he summarizes the elements of our fauna, points out the affinities with other faunal regions, and applies the test of geological evidence to indicate the time of their appearance in our area and the probable source from which they were derived. Hutton's review of our fauna, however much we may differ from many of his conclusions, does most distinctly emphasize its ancient character and the long period of isolation that is needed to account for many of its peculiarities.

Palaeontology in New Zealand has within recent years made a very considerable advance, more especially in our knowledge of the earlier Tertiary faunas, though there is still a rich field for further research. Enough, however, is now known to simplify many of the difficult problems that beset Hutton in 1904.

At the first view it may appear that our molluscan fauna contains a very considerable Australian element. According to Suter§ there are about 140 species common to both, a number that is about equal to one-eighth of the total species that he records. Recent investigations show that many of his determinations cannot be upheld, that others are very doubtful, and others again, such as *Tonna*, are really varietal and not strictly identical with the Australian species. But, admitting that there is a considerable number of species common to both, including the Cymatiidae, a group of large shells every New Zealand species of which occurs in Australian waters, it is not necessary to imagine a bridge across the Tasman Sea, or even to demand a close approach of the two land areas. The larvae of the marine mollusca are free-swimming creatures. In some species this stage in their life-history is brief, but in others it is of some length. Myriads of them are, of course, carried out to sea and perish, but when aided by ocean currents and other favourable conditions they are able to travel long distances. The southern portion of Australia, or at least Tasmania, may be said to lie in the region of the "roaring forties," and the southern portion of the Tasman Sea is constantly swept for a portion of the year by hard and prolonged westerly gales, and with this aid from time to time some of the larvae would be certain to reach our shores. We might reasonably expect a larger and more important Australian element in our molluscan fauna than we actually have. It is obvious that very few of the species that survived the journey across the Tasman Sea would succeed in establishing themselves in the face of a new set of natural enemies, as well as changes in climatic and physical conditions. If the accession to our fauna had been

* In Hutton's *Manual of the New Zealand Mollusca*, Preface, p. iii, 1880.
† *Ibid.*, p. ii.
‡ F. W. HUTTON, *Index Faunae Novae Zealandiae*, Introduction, pp. 13–19, 1904.
§ H. SUTER, *Manual of the New Zealand Mollusca*, pp. v, vi, 1913.

the result of a colonization across shallow water, or from a land close at hand, we should have expected to find a compact assembly, and not the more or less scattered fragments that are actually found.

Apart from the Australian element, the marine mollusca possess no characters suggestive of recent accessions from other faunal regions, for the Antarctic element is very largely a relic from older geological times.

The terrestrial and fresh-water mollusca require for their dispersal a close approach of lands, if not an actual land bridge. It is true that occasionally marine currents may bring some species to oceanic islands, but if these were introduced in some far-off period it would be extremely difficult, if not impossible, to be certain as to their origin.

Of the land mollusca which have been grouped under the Flammulinidae, *Endodonta* and *Laoma* comprise by far the greater number of our snails. They are ancient inhabitants and a primitive race. The geographic range of the group is almost world-wide, but palaeontology so far has found very little record of them. Pilsbry* remarks that "the Carboniferous of Nova Scotia has afforded a small helicoid which in form and sculpture can only be compared with such Endodontidae as *Pyramidula* or *Charopa*." In support of our belief in the great antiquity of these helicoids, it may be pointed out that a number of genera appear to have developed in our area and are restricted to it, and that no New Zealand species has been recorded from any other faunal region. Of other groups, the Athoracophoridae may perhaps have been developed in our region. The Rhytidae, which include our large carnivorous snails, are of very ancient lineage. The operculate group is in great measure peculiar to our fauna. Hedley† remarks on this when he discussed the relation of the fauna and flora of Australia to that of New Zealand. Partly to account for the dispersal of *Placostylus* Hedley constructed his Melanesian Plateau.‡ If that land area or archipelago be granted a great antiquity it would appear to provide all the necessary communications even for the most primitive forms.

The groups of fresh-water mollusca are in perfect accord with the land mollusca. *Gundlackia*, *Potamopyrgus*, *Lymnaea*, *Isidora*, and *Melanopsis* are all of ancient lineage, while *Diplodon* is recorded from our Cretaceous beds at the Malvern Hills. Hedley,§ writing on the surviving refugees of ancient Antarctic life, discusses many interesting problems of distribution. He regards their advent as taking place by circuitous routes at wide intervals of time, and thinks that they are of great antiquity.

In our younger rocks the percentage of Recent species is very high, and in making comparisons between these we prefer to use the names of definite horizons where the species have actually been collected, rather than period-names, which may often involve incorrect correlation.

For the first of these we select the blue clays and sands of the coastal cliffs near Castlecliff. The fauna of these beds differs from the Recent fauna only in the presence of *Ataxocerithium*, and in the absence of a few obscure genera and a few groups whose habitat is between tide-level or in very shallow water. The total of extinct species is here not more than 7 per cent.

In the Kai Iwi beds, three-quarters of a mile south of the stream, the fauna presents no distinctive features from that at Castlecliff, except

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* *Manual of Conchology*, vol. 9, p. xxxix, 1894.
† *Natural Science*, vol. 3, p. 189, 1893.
‡ *Proc. Linn. Soc. N.S.W.*, vol. 7, ser. 2, pp. 337–39, 1893.
§ *Proc. Roy. Soc. N.S.W.*, vol. 29, pp. 278–86, 1895.

perhaps a slightly higher percentage of extinct forms. Nukumaru beach, from the boat-landing to a point one mile to the south of it, has a fauna that shows a somewhat marked difference, not only in the greater percentage of extinct forms and in the occurrence of the genera *Melina* and *Lutraria*, but the assembly of species has changed notably. Some of the Recent species are in great abundance, others have distinctly decreased, and others are uniformly distributed; and in addition to this several are characterized by their unusually large size.

The Waipipi beds, from a quarter of a mile south of the stream to three miles to the north of it, show a still more marked change of fauna. In addition to the genera *Melina* and *Lutraria*, there are *Crassatellites*, *Miltha*, *Cardium* and *Olivella*, a difference in the assembly of Volutes, *Dentalium*, *Pecten*, and *Struthiolaria*. The abundance of the individuals of extinct species is somewhat pronounced as compared with the Recent, and the large species are in particular abundance.

The Whakino-Waihi beds, on the coast near Hawera, have a fauna closely similar to that of the Waipipi beds. The percentage of extinct species is only slightly greater, but there is a difference in the prominent species. *Lutraria* has not been found; *Melina*, *Cardium*, and *Crassatellites* are scarce, while *Pecten*, *Natica* and *Dentalium* are in great abundance; *Chione chiloensis* is not uncommon. Of the Recent species, *Atrina zelandica* and *Ostrea angasi* are in great abundance.

It has already been pointed out that from Castlecliff to Waipipi there is an unbroken stratified series. We now extend that series to Waihi, and note that within its limits we see a most marked faunal change within a continuous series of deposits. Had it so happened that the beds that lie between the different horizons that are mentioned above had not been preserved, and that the several fragments had been so disturbed that stratigraphical evidence was practically valueless, palaeontology would then have been the only guide to their respective ages. It would have been evident that Castlecliff and Kai Iwi were essentially of the same age. The Nukumaru beds, on the other hand, might well have been regarded as a formation of a different period, and in the Waipipi strata the faunal change is so great that they would probably have been assigned a greater antiquity than they actually possess. On the other hand, the Whakino-Waihi beds are so similar in fauna to those at Waipipi that they would probably have been placed in the same horizon, whereas they are actually separated by several hundred feet of strata. The change in the fauna was slow between the Waihi-Whakino and Waipipi stages, and between the Kai Iwi and Castlecliff stages, but it was relatively rapid between the Waipipi and Nukumaru stages. This rapidity, we think, marks a great change in the physical or climatic conditions of the time.

It may fairly be claimed that there were no important accessions to the fauna during the Castlecliff to Whakino-Waihi period of deposition, for, as stated previously, the majority of the Recent genera are represented, and usually by Recent species, and the extinct species that occur in any abundance have already been recognized in earlier formations in New Zealand. Even genera such as *Couthouyia*, *Ataxocerithium*, and *Melina* occur at Target Gully, and a fragment of *Miltha*, perhaps similar to the Waipipi species, has been collected at Mount Donald.

While the Waihi beds are the lowest of the unbroken series of deposits on this coast, and while the palaeontology of the Tawhiti beds as recorded by Marshall, and the Ormond beds as recorded by Henderson and Ongley, indicate a fairly close relationship, we cannot claim that the one would directly succeed the other. It is, however, perfectly clear that there is a far closer relationship between the Waihi and Tawhiti beds than between the Waihi and Castlecliff beds. The change from the Tawhiti to the Waihi beds does not in any way suggest that elements of a new fauna were introduced between these periods. On the other hand, the Tawhiti fauna is as closely related to the fauna of Target Gully as it is to the Waihi fauna. And, again, there is no indication of the introduction of new elements to the marine molluscan fauna during that interval of time.

The various lists that have now been published of the mollusca of many Tertiary horizons near Oamaru enable us to carry this review a little further. These lists appear to indicate a gradually changing fauna; nowhere does there seem to be an inrush of additional types. The genera that we have in our marine mollusca now were practically all present at the time that the Target Gully beds were deposited. The fauna of that time was certainly richer than the present one. The change that has taken place since then has been of the nature of reduction rather than of addition. We have, then, been forced to the conclusion that from the time the Wangaloa and Hampden beds were deposited until the present day the marine mollusca of New Zealand has shown a gradual development without any important additions at any time from other fauna regions. This, of course, implies that New Zealand has been completely isolated throughout this long interval of time.

The genera *Murex* and *Trophon*, that Hutton* refers to as having reached New Zealand from the Australian region in Pliocene time, have now been collected from Target Gully. The statement of Hutton that *Typhis* is of Eocene occurrence in Australia and Miocene in New Zealand needs revision, for the Australian Eocene is now generally classed as Miocene, while *Typhis* occurs as low as the Wharekuri beds in New Zealand. Further and more careful comparison of Australian and New Zealand specimens of *Pectunculus laticostatus* is necessary before any conclusions can be drawn from the time of appearance of the species in the Tertiary rocks of these countries. *Dosinia greyi* has been recorded from Wangaloa by Marshall. It is thus clear that the palaeontological proofs brought forward by Hutton in 1904 of a Tertiary land connection with Australia fall to the ground in the light of the fuller information that has since been acquired.

It has been frequently suggested that the resemblance between the Miocene fossils of South America and those of New Zealand is so great that it proves that those lands were either actually connected in the middle Tertiary or were separated by a narrow stretch of water only.† Accurate comparisons have shown that many of these identifications were inaccurate, and the number of species common to the two lands has now been reduced by Suter to six only. It is probable, however, that still further comparisons are required. It is, at any rate, noticeable that the six species referred to do not occur in the same Tertiary horizon in New Zealand, and that half of them occur in our lowest Tertiaries (Wangaloa and Hampden), which are probably equivalent to the Eocene of Europe. Recent work has shown that it is very noticeable that the Cretaceous fossils of Seymour Island are far more similar to the Cretaceous of New Zealand than the Tertiary fossils of the same locality are to those of this country. The Navidad and South Patagonian Tertiary fossils also are distinctly different from those of New Zealand.

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* F. W. Hutton, *Index Faunae Novae Zealandiae*, Introduction, p. 18, 1904.

† C. Chilton, *Subantarctic Islands of New Zealand*, vol. 2, p. 805, Government Printer, Wellington, 1909.

ART. XIII.—*Geology of the Waikato Heads District and the Kawa Unconformity.*

By M. J. GILBERT, M.Sc. (Rev. Brother FERGUS), Sacred Heart College, Auckland.

Communicated by J. A. Bartrum.

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Plates XX, XXI.

CONTENTS.

INTRODUCTION.

THE entrance to the Manukau Harbour and the lower part of the Waikato River separate three notably distinct topographic and structural regions. That to the north of the Manukau is characterized by a broad range of hills of resistant rock, deeply dissected by streams. The middle area is constituted by a line of ancient sand-dunes facing the ocean, and is considerably worn by streams, moderately low country rising behind it to the east. The third area, that south of the Waikato River, is a broad minutely-dissected upland of more varied structure than the others, and it, with the second or middle area, forms the subject of this paper.

PREVIOUS WORK IN THE DISTRICT.

Hochstetter (1867) in 1859 collected fossils from the Waikato South Head, as well as from the plant-beds near Oruarangi Point, some four

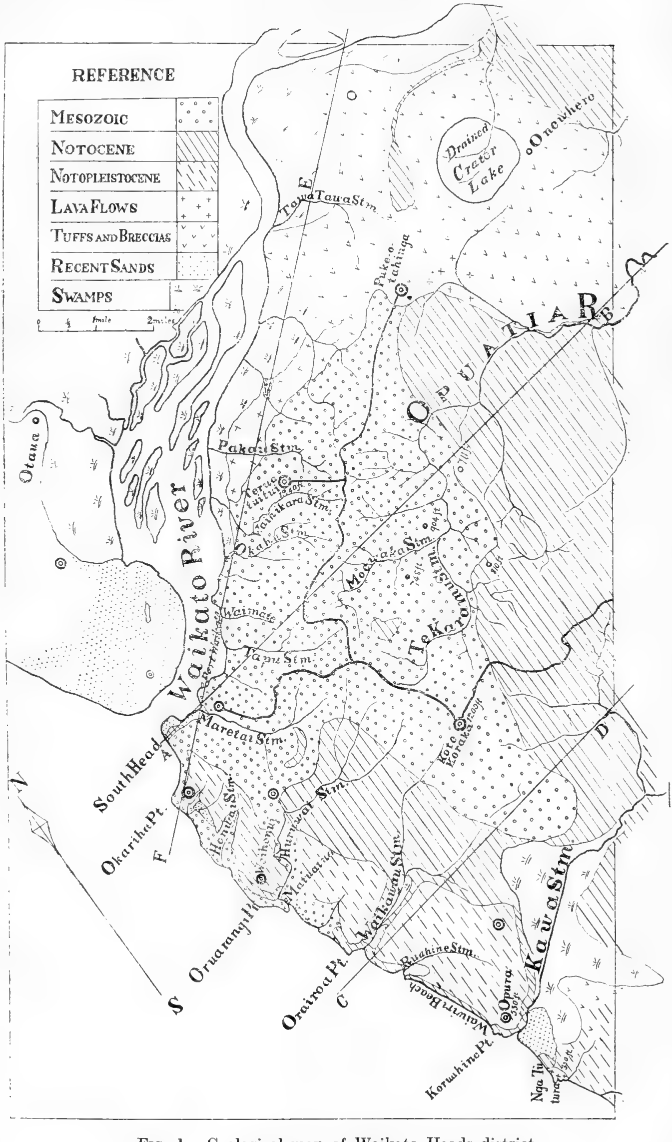

Fig. 1.—Geological map of Waikato Heads district.

miles farther south, and classed the beds containing them as Neocomian. The sand-dune area was briefly described by him, and the structure illustrated by a section across the sand-dunes near the northern end.

Park (1910) alludes to the dune formation of the sandhills, and further calls attention to the oxidation of the ironsand into hard bands of limonite.

Cox in 1876 journeyed south along the coast from the mouth of the Waikato River, but so hurriedly that he appears to have failed to observe a conspicuous unconformity in the Tertiary strata at the Kawa Stream (fig. 11) and a less noticeable one at the Waikawau Stream (fig. 9), though in his report he expressed the conviction that an unconformity existed at the base of the beds he called the "*Cardita* beds," and classed as lowest Eocene in age.

Hutton (1867) had reported on the same district, and would seem to be misunderstood by Cox (1877, p. 16) when the latter quotes him as classing the *Cardita* beds with the Waitematas, in which he distinctly says he could find no fossils (1867, p. 16). Cox's report is somewhat confusing.

One of the most valuable contributions to the knowledge of the geology of Port Waikato district is that by the late E. A. Newell Arber (1917), who allocated the plant-beds of the Mesozoic sequence to the Neocomian. A feature of particular interest is his discovery of leaves of the angiosperms *Artocarpidium Arberi* Laur. and *Phyllites* sp., thought by him to be amongst the earliest dicotyledons yet discovered, and, as Dr. L. Laurent says, "it is hardly possible to attach too much importance to the discoveries."

Bartrum (1919B) described a fossiliferous bed at the Kawa Creek, some fourteen miles south of Waikato Heads. He published a list of fossils collected from the bed, and described six new species discovered there by him (Bartrum, 1919A).

Almost the only other reference of any importance to the geology of the area studied is one by Bartrum (1917) to the discovery of several types of volcanic rocks in pebbles of conglomerates in the Mesozoic strata.*

THE COASTAL AREA BETWEEN MANUKAU ENTRANCE AND WAIKATO RIVER.

From the Manukau Harbour to the Waikato River, in a belt averaging five to six miles in width, stretch now deforested hills, which for twenty miles form a straight coast-line of almost continuous cliffs averaging 500 ft. to 600 ft. in height, broken only by the narrow valleys of a few streams draining to the west. Immediately behind these hills is a belt of low country bordering the Waiuku Creek, and forming the Akaaka Swamp in the south. East from this belt the land rises gently, forming undulating country of subdued topography, the highest point being the volcanic cone of Pukekohe Hill, some 710 ft. high.

The characteristic cross-bedding of wind-deposited sands is conspicuous from top to bottom along the line of cliffs facing the sea (Plate XX, fig. 1). The beds vary in texture from a fine to a fairly coarse sand, and many consist of a large proportion of magnetite with grains of feldspar and some quartz. Certain very fine beds appear to be pumiceous. The contained magnetite has been oxidized to the brownish hydrated oxide of iron

* Whilst this was in press reference to the geology of the district appeared in a report by Dr. J. Henderson on the Huntly Subdivision, which was published in *14th Ann. Rep. N.Z. Geol. Surv.*, 1920, and distributed early in 1921.

(limonite), forming tough, resistant, anastomosing bands, or more frequently lens-like or irregular beds of considerable thickness, which constitute the most resistant parts of the nearly vertical cliffs, and in a few cases, as at the Fishing Rock, opposite Waipipi, form reefs running a short distance out to sea.

From the general proximity of the watershed to the line of cliffs, and the longer and more gentle easterly slope towards the Waiuku Creek, and from the loftiness of the cliffs, which have been cut back by the waves almost to the watershed, and the character of some of the lower beds, it is evident that these hills at one time extended much farther seaward—probably several miles at least. Except in the extreme south of this area the sand of these hills is much limonitized and consolidated, while the surface on the easterly (or landward) slope is decomposed to a yellowish-red clay to a depth often of 6 ft., and is covered with a fairly good soil.

Near the Waikato River and the "gaps" or stream-valleys opening west the surface is composed of loose sand travelling inland. This is particularly well shown at Lake Pokorua. Only in a few places, such as the Waiuku and Pokorua gaps, is there convenient access to the beach.

A mile south of Pokorua Stream outlet a bed of lignite outcrops for a distance of 100 ft. at the foot of the cliffs. It is about 5 ft. above high water, but rises gently to the south. The only other bed of lignite outcropping on the coast is a small one in a short stream-valley two miles south of Manukau Heads. The only other lithologic feature deserving of mention is a bed of sand from 3 ft. to 6 ft. thick, near the foot of the cliffs close to the outcrop of lignite, which is a fine, light, white sand, evidently pumiceous.

The Area East of the Sand-dunes.

To the east of the sand-dune range, bands of lignite 18 in. thick can be seen on both sides of Waiuku Creek, just above or at high-water mark Beds which are either pumiceous or of very fine light sandstone occur above the lignite. On the east bank a coarse conglomerate sometimes occurs. A short distance to the north of Awhitu Wharf a bed of lignite occurs intercalated in sand. Stream-bedding is noticeable in most of these deposits of sand along the Waiuku Creek.

Hochstetter (1867, p. 272) furnishes a section which seems too generalized in respect of the lignite formation. The occurrence of but two small bands, the larger not more than 100 ft. long, in a length of sea-cliff extending twenty miles hardly warrants the use of the name "lignite formation" to include the western lower beds on the coast range in which these two bands occur. Their very frequent occurrence in the sand and silt-beds along the Waiuku Creek, however, amply justifies the name so far as it is applied to the low-lying area east of the coast range. The undulating country east of Waiuku Creek and of the Akaaka Swamp consists of an extensive deposit of basaltic breccia—the "basaltic boulder formation" of Hochstetter (1867, p. 268), Hutton (1867, p. 7), and Cox (1877, p. 17)—mixed with much red loam resulting from decomposition of the breccias and tuffs.

The most extensive lava-flow is that at Waitangi Stream, two miles from Waiuku; whilst the volcanic tuffs become very prominent in the Koraka district, near Drury. On the south side of the Waikato River, at Pakau Stream, and at Tauranganui, three miles to the north-east, lava-flows occur associated with volcanic breccia similar to that forming several small isolated hills in the Akaaka Swamp. Evidence of stream-bedding has been observed in the tuffs and breccia at Tauranganui.

A Suggestion of Origin of the Sand-dunes and of the Lignite-beds.

North of Manukau Harbour is a strongly resistant coast-line which has retrogressed considerably owing to wave-attack. Similarly, south of the Waikato River all evidence points to considerable sea-cliff recession. The writer's belief touches entirely new ground, and it is this : that regularity of coastal outline was reached between Waikato Head and Manukau North Head by spit or perhaps barrier-beach formation in the not distant past, when the relative level of sea and land approximated the present, and that a great estuary of the Waikato River was formed behind this barrier, in which pumice-silts were deposited and bands of lignite formed. This beach supplied the material raised by wind into lofty sandhills, which have been cut into by the waves as the shore-line advanced towards maturity.

Mr. J. A. Bartrum, in mentioning to me that this accorded with his own view, called my attention to a fact which I have since been able to confirm—namely, that there are similar sand-ranges west of Helensville, going north along the western margin of the Kaipara Harbour. He further pointed out that in that district there is every evidence of former uplift in elevated erosion-plains.

This theory of the origin of the sand-ranges with an extensive estuary of the Waikato River behind them readily accounts for the origin of the pumiceous silts and the lignite bands west of the ranges, for it is believed that the silts were formed in the estuary by the deposition of fine material, largely pumiceous, brought down by the Waikato River from the great pumice lands of the middle of the Island. There are pumice-silts at Mangere, opposite Onehunga, at Otahuhu, and near Drury and Papakura. They are thus very widespread round the shores of Manukau Harbour, the waters of which cannot have supplied the material. The Waikato River, then, appears to be the only source of origin that can satisfactorily account for these silts. Well-borings in various places around Waiuku and the Aka-aka Swamp support the view that an extensive estuary existed. The lignites at and above high-water mark along the Waiuku Creek, and exposed in railway-cuttings between Otahuhu and Papakura, would be formed in this estuary by the accumulation of vegetable material in the swamps.

The two lignite bands at the foot of the sand-dunes on the coast contain fragments of wood, undecomposed or slightly carbonized, and, amongst other vegetable remains, the abundant long leaves of the raupo (*Typha angustifolia*). They were probably formed in shallow lakes or lagoons occurring in the hollows of the sandhills in their early stages, just as the remains of similar vegetation are accumulating at the present time around the swampy raupo-covered margins of Lake Pokorua, north-west from Waipipi, and other lakes even in the shifting sand-dunes near the Waikato River. It is possible, however, that they had an origin similar to that of the Waiuku bands—that is, in the swamps marginal to the early Waikato estuary, which have since been covered up by the inland advance of the dune-belt, and then re-exposed by sea-cliff recession in conformity with the general retrogression of the coast both north and south of this area.

Sub-recent Oscillations of Level: Origin of Manukau Harbour.

The bands of lignite exposed at frequent intervals along the banks of Waiuku Creek are either at or slightly above high-water mark, and are covered to a depth of from 5 ft. to 20 ft. by silts. They thus furnish evidence of sub-recent minor oscillations of the district. In the arm of

Manukau Harbour that penetrates to Otahuhu—indeed, in most of the harbour's ramifications—similar evidence is available. These silts are now being cut back rapidly by wave-action at high-water,* and present low cliffs that rise to no great height above high-water level.

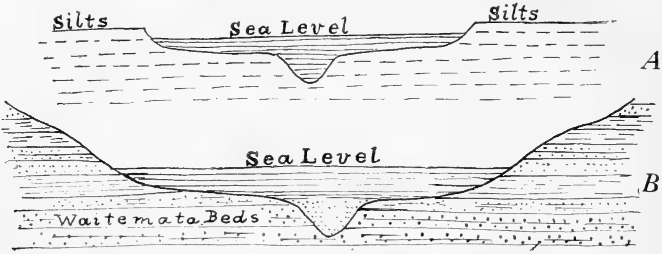

Fig. 2.—A. Manukau Harbour. B. Waitemata Harbour (Grafton Gully continuation).

The story they unfold is briefly as follows: After their deposition, uplift over the whole Auckland area occurred, of which local evidence is found also in the Waitemata Harbour.† Following the uplift the silts were dissected by the various streams emptying into the Manukau Harbour, such as the Waiuku, and the present channels thus formed. Depression soon followed, admitting the tidal waters into the stream-courses. (See fig. 2, A.)

Mutual Relations of the Areas North and South of the Waikato River: an Hypothesis of Major Faulting.

It is believed that the northern shore of the Manukau is roughly coincident with a fault-line running east and west, and that the Waikato River in the last few miles of its course traverses another fault-line parallel with the first, cutting the Mesozoic rocks at right angles to their strike. This latter has been called the Waikato fault. The country between is deemed faulted down at least 2,000 ft., leaving the eroded Mesozoic rocks on the south standing 12,000 ft. above sea-level.

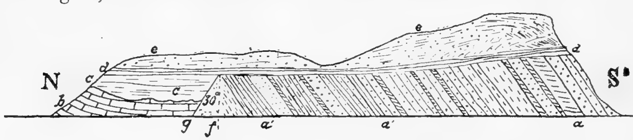

Fig. 3.—Coast section, Waikato South Head. *a′*, belemnite marly shales; *a*, sands and shales; *b*, sandy limestone; *c*, brown sands and silts; *d*, gray clays and silts; *e*, red clays and sands; *f*, zone of comminuted shale; *g*, fault.

Though no conclusive evidence of the faulting could be obtained, the south bank of the Waikato River presents the appearance of a deeply dissected fault-scarp; and, further, at the South Head there is a nearly vertical fault,

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* Tidal interval at spring tides, 14 ft.

† I am indebted to Mr. J. A. Bartrum for pointing this out to me, and for a sketch of the continuation of Grafton Gully into the harbour, which he drew from data supplied by the Harbour Board, and which is reproduced in fig. 2, B.

heading 30° to the north and striking 30° north of east, roughly along the line of the river, and traceable for some 50 yards. The limestones on the north must be downthrown 200 ft. to 300 ft. at least. This fault may very well be one of the step-faults of the zone of faulting referred to above. Brown sands and sandy limestone are here brought in contact with Mesozoic shales (belemnite-beds) dipping 45° south west and striking 30° west of north, forming the southern (or upthrow) side of the fault. The shales are finely comminuted in a band some 20 ft. wide along the line of the fault.

The most important reason for suggesting faulting is the abrupt termination of the older rocks along a fairly definite line, and their replacement by an area of much later sedimentation. Along the maturely dissected scarp of the Waikato fault between Maretai Stream and the South Head, wave-attack has in places produced typical sea-cliffs, above which are hanging valleys.

It is possible, though unlikely from their position, that river-planation, and not wave-attack, was responsible for the wearing-back of these cliffs.

THE AREA SOUTH OF THE WAIKATO.

General Description.

The country to the south of the Waikato River dealt with herein is an upland, 600 ft. to 1,200 ft. above the level of the sea, consisting of uniformly resistant rocks, except along the sea-coast, where the upper portions are much less resistant than the lower. This upland is deeply dissected by stream-valleys running north-west and east from the main watershed, which sends out numerous sharp spurs, so that the surface is very uneven and rugged,

FIG. 4.—Section along line AB of map.

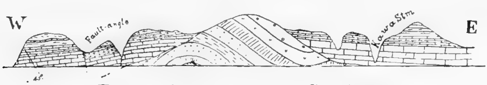

FIG. 5.—Section along line CD of map.

FIG. 6.—Section along line EF of map.

presenting few level tracts. The rocks consist of a basement (herein called the "older-mass") of symmetrically folded sediments, on the eroded and weathered surface of which in many places the younger-mass beds* rest horizontally, and therefore unconformably; these latter consist of moderately resistant marine sediment. They again are covered unconformably along the coast by less resistant Pleistocene and Recent† clays and sands.

* Part of the Notocene of Thomson (1917, p. 408).
† The Notopleistocene of Thomson (1917, p. 411).

Drainage of the Southern Area.

The Opuatia River, with its upper east-flowing tributaries, cuts across the strike of the rocks of the Mesozoic older-mass where these are exposed in its upper course. This indifference to the strike of the folded rocks can be explained by supposing these streams to be superposed consequents. On account of having had their courses shortened by coast-recession, the streams flowing west from the watershed are shorter than those to the east. Those flowing north-west, having maturely dissected the fault-scarp facing the Waikato River, are obviously streams consequent on the deformation. Their courses are short and their drainage areas small.

From Port Waikato the main watershed runs in a south-easterly direction for forty miles or more.

The Maretai Stream, flowing north into the Waikato River, has cut its way down to grade along what is believed to be a fault-line, on the west side of which the beds of the older-mass are strongly downfaulted, the scarp on the upthrow (or eastern) side being immaturely dissected. This fault probably extends a long distance south-west. A sunken outlier of the younger-mass at Newdick's, on the western side of the stream-valley, appears to owe its position to the effect of the faulting along this line.

Most of the streams flowing east or west are graded, and the Okahu and Maretai Streams, flowing north-west, are similarly graded in their lower courses. The Waikawau Stream, seven miles south from the Waikato River, is graded for some two miles of its lower course. Its middle course is between the high vertical walls of its limestone gorge, which soon widens out to a broad valley, the floor of which is covered by flood-plain and delta deposits.

The Kawa Stream, still farther south, has a comparatively bottle-necked outlet to the sea. In its middle course it flows across extensive flood-plain swamps, which cover a broad depression, believed to have originated in the foldings and dislocations of the beds of the older-mass and younger-mass alike, which are made evident in the coast sections from the Waikawau Stream along the Waiwiri Beach to the Kawa Stream. Solution may have played its part, as in the Waikawau and upper Huruwai valleys. The writer's first impression was that it represented a gigantic sinkhole.

The Older-mass of the Southern Area.

It has been pointed out above that the southern area consists stratigraphically of a younger-mass unconformably overlying an older-mass. The writer considers that the sediments of the older-mass are folded in fairly symmetrical waves measuring four miles from crest to crest, the strike of the axes of the folds being about 30° west of north. The limbs of the folds have an average dip of about 30° and a maximum of 45°. The average is that of thirty-two determinations in different localities. These sediments are therefore not less than 7,000 ft. thick in those portions above sea-level. The conclusion as to the symmetry of the waves is deduced from the evidence of strike and dip of the beds along the Waikato River, as well as from those along the Opuatia and Huruwai Streams and the coast sections.

In the deepest part of the anticline, which is exposed in a good section at the South Waikato Head, the lowest beds visible are the belemnite shales—a fine, slightly calcareous mudstone containing some thin, light-coloured, highly calcareous bands. In these, but more conspicuously in all the higher beds in this formation, plant-remains are abundant, though rarely in other than fragmentary form. Tree and fern trunks and large roots are abundant, more particularly two miles south of the Heads in a very thick bed of concretionary sandstone.

The following is roughly the sequence, in ascending order, of the beds as shown in the coast sections from south of the Huruwai Stream to the Waikato Heads. (See Plate XXI, fig. 2.)

(1.) 700 ft. of dark marly shales containing marine fossils (Cox, p. 20), and herein spoken of as the "belemnite-beds."*

(2.) Hard grey sandstone with shaly beds.

(3.) Thick beds of concretionary sandstone, containing tree-trunks in abundance, amongst which could be recognized some resembling tree-ferns. These beds thin out laterally, rapidly giving place to thin bands of shale and sandstone.

(4.) Shales with bands of a hard, shiny, black, impure coal 1 ft. and 1½ ft. thick, dipping seaward at an angle of 35° to west. These outcrop on the strike coast near Hanwai Stream.

(5.) Alternating beds of hard shale and sandstone, the shale bands outcropping at Oruarangi Point, about five miles south of Waikato River, being rich in well-preserved plant-impressions.

(6.) Bands of shale interbedded with sandstone and containing thin coaly bands.

(7.) Fine conglomerate.

(8.) Coarse sandstone, stream-bedded, with large fragments of wood, outcropping on the beach south of Huruwai Creek.

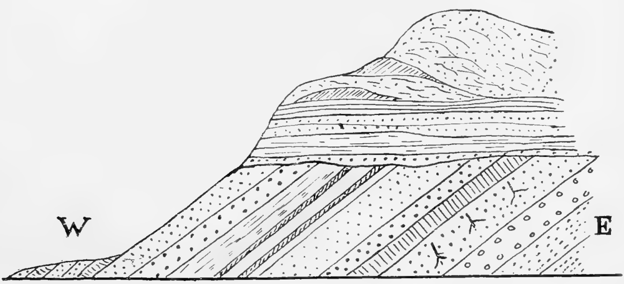

FIG. 7.—Observed section north of Hanwai Creek. Height of section, 200 ft.; length, 100 yards. Mesozoics (strike 25° west of north, dip 35° to west) overlain by horizontal Notopleistocene beds.

Though the strike of the main axes of the folds is 30° west of north, it occasionally changes locally to north-and-south and east-and-west, for there is much local distortion, notably in the axis of the syncline where the Waimate Stream enters the Waikato River, about two miles above its mouth.

* A similar series of shale-beds, though unfossiliferous, appears at the top of the watershed between the Okahu and the Moewaka Streams, where deep weathering has increased their friability.

A little north of Orairoa Point, six miles south of Waikato River, the basal sedimentaries disappear under the seaward-dipping beds of the younger-mass, and are not found again north of the Kawa Stream, though they are said to outcrop farther south.

From the South Head to the Waikawau Stream the Mesozoic beds form locally a prominent strike coast—*i.e.*, the coast follows the strike of the seaward-dipping beds, leaving here and there a promontory of very resistant sandstone beds presenting precipitous bluffs to the fierce attacks of the violent Tasman Sea.

The Marine Fossiliferous Shales or Belemnite-beds.

As stated above, the shale-beds at the Waikato South Head contain marine fossils. Cox (1877, p. 19) reported having obtained the following: "*Aucella plicata, Inoceramus haasti, Inoceramus* (sp. ind.), *Belemnites aucklandicus, Halobia* sp., *Placunopsis striatula,* and other species not determined."

As the result of many hours of patient search, the writer recently gathered from these shales numbers of belemnites, which are abundant, and eight or ten other fossil species not yet determined, but the majority apparently not previously reported from this locality. All that can be said is that amongst the species found at Waikato Heads shales are brachiopods, pelecypods, and gasteropods.* (See Plate XXI, fig. 1.)

The Fossil-plant Beds.

From 2,000 ft. to 3,000 ft. higher up in the conformable sequence occur the beds near Oruarangi Point first collected from by Hochstetter (1867, p. 278). These are alternating sandstones and shales, and contain abundant well-preserved plant-fossils.

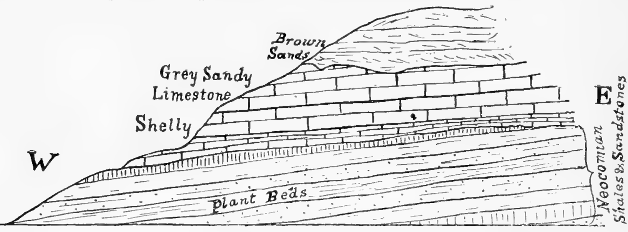

Fig. 8.—Probable section at Oruarangi Point (near plant-beds).

Newell Arber (1917, pp. 18, 20) in a recent palaeontological bulletin describes and figures a number of fossil plants from these beds.

After a careful comparison of the plant-fossils gathered on two visits to these plant-beds, and of others gathered by Mr. J. A. Bartrum from

* Mr. J. A. Bartrum has informed me since the above was written that he forwarded a selection of the fossils from these beds to Dr. C. T. Trechmann, of Durham, and amongst them the following forms were determined by him (accompanying remarks are those made by Dr. Trechmann): *Arca* (*Parallelodon*) *egertonianus* Stoliczka (found in Spiti shales, India, and in Somaliland); *Arca blandfordiana* Stoliczka; *Aucella* cf. *spitiensis extensa* Holdhaus; *Limea* sp. (two); *Pyrgopolon* (?) (? a serpulid); *Serpula* sp. (the *Serpula* is rather like *Serpula convoluta* Goldf. from the Dogger: see Zittel-Eastman, p. 138); *Trigonia* sp. Several other forms, notably lamellibranchs and a serpulid, though generically unidentifiable, furnish additions to the above list.

the same place, with those figured by Arber, a selection was made of types that appeared to be new, and forwarded by Mr. Bartrum to Arber for determination, but his death occurred before he was able to examine them.

On the banks of the Waikato River near Waimate Creek, at about high-water mark, well-preserved plant-impressions can be obtained from various beds, especially from one of fine white sandstone about 1 ft. in thickness. Some 6 ft. above this bed occurs a bed of coal 12 in. to 18 in. thick associated with a similar fine sandstone. These beds, occurring in the axis of a syncline, are not less than 2,000 ft. above the belemnite-beds, from which they are distant two miles across the general strike of the sequence, the effect of downthrow along the Maretai fault-plane being taken into account.

Age of the Older-mass.

Arber (1917) classes the upper plant-beds at Oruarangi Point in the Neocomian, as did Hochstetter (1867) originally. The fossil plants in the beds mentioned above at Waimate, about two miles up the Waikato River from its mouth, are apparently the same as those at Oruarangi; the beds containing them are therefore Neocomian, and hence the lower belemnite-beds are most probably of Jurassic age.

General History of the Coastal Area South of the Waikato River.

Mid-Cretaceous uplift and folding of the Jurassic and early Cretaceous sediments (here spoken of as the "older-mass") was followed by dissection and by planation to a greater or less degree; depression then ensued, and was succeeded by a long period of sedimentation, during which most of the beds of the younger-mass were laid down. Subsequent deformation of the older-mass, involving warping and dislocation of the beds of the younger-mass, and general though unequal uplift, initiated a long period of erosion, during which movements of elevation continued, and the younger-mass was stripped from much of the higher portions of the uplifted area, whilst the older-mass was deeply cut into by superposed consequent streams. At the same time, too, the fault-scarp along the line of the Waikato River, a product of the deformation which followed the conclusion of deposition of the younger-mass, was maturely dissected.

During the period when the beds of the younger-mass were being laid down slight uplift took place, at least in some localities, as at the Kawa, where the movement was sufficient to bring about sea-planation of certain impure limestones after they had been slightly warped. With slow depression, again, other beds were laid down unconformably above the warped and planed limestones; local volcanic activity occurred, depositing beds of ash and lava. These were again covered by swamp-silts, and, upon uplift, by wind-blown sands.

Relation between the Mesozoic Older-mass and the Younger-mass (or Notocene) Beds.

The Notocene beds, using the name suggested by Thomson (1917, p. 408) for the "covering strata" or "younger rock-series" of New Zealand, were deposited on the eroded surface of the folded older-mass. (See figs. 3, 4, 5, 6, 7, and 8.)

An outlier of Notocene beds at Pa Brown, high up near the source of the Moewaka Stream, a tributary of the Opuatia, is of great importance as indicating the former greater extent of these beds. This small outlier, covering about a quarter of a square mile, consists of 40 ft. to 50 ft. of platy bands of an extremely hard limestone, containing abundant large oyster-shells, sharks' teeth, and small indeterminate shell-fragments, underlain by a thick layer of calcareous sandstone, very similar lithologically to that in the bed of the Opuatia Stream four to five miles farther east. A short distance to the west the Mesozoic rocks of the watershed rise 100 ft. to 200 ft. higher.

An examination of the upper parts of the valleys of the Maretai, the Huruwai, and the Waikawau Streams reveals the same phenomenon as the Opuatia Valley—namely, that the Notocene suddenly appears deep down in troughs in the Mesozoic older-mass. The lowest beds there observable are calcareous sandstone, passing upwards into a hard, scantily fossiliferous, platy limestone, which changes in facies with great rapidity. Again at the Waikato South Head there is a downfaulted block of the Notocene beds which owes its preservation to its resistant character. (See fig. 3.)

No shore-line deposits have been found in these valleys or depressions to support the view that the Notocene beds were laid down in deeply eroded valleys into which the sea penetrated when the land was depressed, although fragments of Mesozoic rocks were found in a basal bed of the younger-mass near Orairoa Point, half a mile south of the Huruwai Stream. The upper Notocene beds are often of hard, pure limestone, and must have been deposited in deep, clear water at a distance from land. Having in view the fact that the Notocene beds have suffered very considerable erosion, the final conclusion is that they covered the whole area—even the more elevated tracts occupied by the Mesozoic rocks, where now no trace of them is left. They covered a broadly truncated surface of the Mesozoic rocks, and when later uplift set in would be removed most readily from the uplifted areas. As pointed out, the Notocene beds in several places occupy valley-like depressions in the Mesozoic strata, either as the result of faulting or owing to involvement in the folding of the Mesozoic older-mass that occurred subsequent to the deposition of these younger-mass beds. The latter supposition appears the more probable explanation, although a more careful examination of the district is needed to settle the point.

The Younger-mass (or Notocene) Beds.

The beds of the younger-mass dip slightly to the south along the coast, and their sequence from their lowest upwards is not easy to determine. The following is the probable upward sequence :—

(1.) At the base algal tabular limestone. It contains angular fragments of the underlying Mesozoic rocks where it rests on the latter at Orairoa Point, north of Huruwai Stream. This limestone seems to rest on still lower blue sea-muds, and to lose both its tabular and brecciaceous character.

(2.) Grey calcareous sandstone, 300 ft. thick in places such as the Opuatia Stream valley and the upper Waikawau, changing to a blue sea-mud at the base of the outcrops on the coast between the Waikawau and Kawa Streams.

(3.) Tabular limestones. At the Waikawau and the Ruahine Streams, and along the northern half of Waiwiri Beach, the upward succession is of alternating calcareous sandy beds, and thin, hard, marly limestone, all becoming tabular, sandy, or even shelly limestones farther back from the coast and south from the Ruahine Stream. They appear as a pure, hard, coarsely crystalline limestone in a large cave two miles from the coast on the north bank of the Waikawau Stream. Half-way up this series of thin beds a discontinuity occurs in the Waikawau section.

Minor faulting and some planation, probably by wave-action, occurred, and was followed by the deposition of a dark-greenish sandy bed containing many easily gathered marine fossils. Other similar but less fossiliferous beds follow, being interbedded with thin, hard, closely-jointed, more calcareous layers, the whole attaining a thickness of 130 ft. to 150 ft.* They are called the "blue marls" or "*Cardita* beds" by Cox (1877), from the presence in them of "a large *Cardita* that cannot be distinguished from '*Cardita planicostata*' of Europe [see Hector, 1877, p. viii], and are probably of Lower Eocene age." They are correlated with what has been spoken of earlier in this paper as the tabular limestones of Pa Brown and other localities.

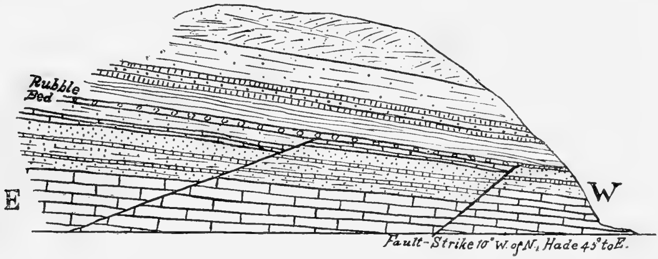

FIG. 9.—Observed section at South Head, Waikawau.

The exposures of the Notocene beds along Waiwiri Beach show some warping and frequent faulting on a small scale, with possibly a much more powerful fault at a point where the sea-cliffs are temporarily interrupted. (See fig. 10.)

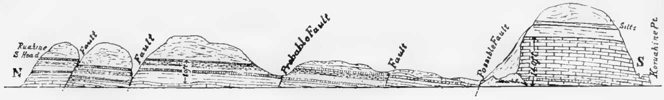

FIG. 10.—Coast section along Waiwiri Beach (two miles).

The beds of Koruahine Bluff, at the south end of Waiwiri Beach, which could not be definitely correlated with others either north or south in this section owing to the rapid changes in the facies of the limestones, furnished numerous fossils, among which were abundant echinoids, a few brachiopods, several species of *Pecten*, and abundant Foraminifera, with occasional sharks' teeth. They are not like the fossils of the "*Cardita* beds," which are prominent along Waiwiri Beach, but rather resemble those of the shelly bed at the Huruwai Stream and of the tabular limestone at Waikato South Head. These beds probably correlate with the warped and sea-planed beds of the syncline at the base of the Kawa section, for their fossil content is somewhat similar. Thomson has expressed the opinion after examining them that the brachiopods are typically Oamaruian.

* On revisiting the Waikawau in February of 1920 the writer found an immense slip had recently occurred, obscuring the features of the section here referred to, but facilitating the collection of fossils from a very fossiliferous band higher up the cliff than the rubble-bed.

The glauconitic greensands of the south Kawa section (see fig. 11) were not traced north of the Kawa Stream.

(4.) Above the tabular limestones appear fine light-coloured silts and clays. These close the Notocene sequence.

(5.) Brown sands. As pointed out already, the Notocene beds show folding, and on their eroded surface rest the younger beds.* In most of the sections the brown sands follow the tabular limestones unconformably. However, near the Hanwai Creek and the Waikato South Head they rest on beds of fine light-coloured silts and clays, called by Hochstetter (1867) "Pleistocene silts," which contain no fossils. (See figs. 3 and 7.) The brown sands show the characteristic irregular bedding of wind-blown sands, except where bands of silt are interbedded with them in their lower parts.

(6.) Shifting sands of recent date close the sequence.

The Kawa Section.

The most important section shown along this coast is that to the south of Kawa Stream, and referred to herein as the "Kawa section." The well-marked unconformity in the sequence of its strata, the evidence of volcanic activity, and the pumice-bed, 170 ft. to 180 ft. above sea-level, possibly

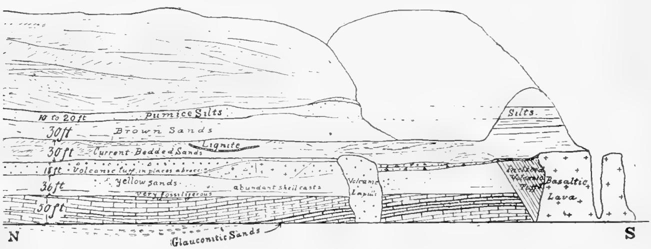

Fig. 11.—Coast section south of Kawa Stream.

connecting these beds with the history of the Waikato River, are the features which give it this importance. It was described in detail by Bartrum (1919b). The following brief description contains a few facts not recorded by him.

Order of Ascending Sequence. (See fig. 11.)

1. Blue calcareous sea-muds.
2. Glauconitic greensands (15 ft. to 20 ft.).
3. Above the glauconitic greeesands come 50 ft. to 60 ft. of thin calcareous sea-muds. These thin beds, after deposition, were affected by movements of compression, resulting in faulting and gentle folding, and accompanying uplift. Then followed a period of planation by the sea which cut their upper surface into a plane of marine denudation.
4. Fossiliferous yellow sands to a depth of 36 ft. were now deposited by the sea on the marine-planed surface of the slowly sinking land. Mr. J. A. Bartrum has published a list of fossils from this bed and has described some new species (Bartrum, 1919a and 1919b).

* The Notopleistocene beds of Thomson (1917).

5. Volcanic ash, breccia, and basaltic lava. The marginal portions of the plug contain included fragments of the calcareous beds through which it was extruded. The volcanic-ash bed contains large fragments of the underlying calcareous beds, and varies from a coarse ash in the north to a breccia or agglomerate as it approaches the neck of the volcano. These beds are distinctly unconformable to the underlying fossiliferous sands.
6. Stream-bedded sands, 30 ft. thick, follow; they include a band of lignite 8 in. thick. In proximity to agglomerate which is above the volcanic lava-plug they appear locally to overlie beds of included tuff of which the upper limit is a sharply marked erosion-plane coincident approximately with the upper level of the yellow fossiliferous sands.
7. Brown sands (30 ft.) follow, whose lower layers are horizontally bedded, whilst higher up they are composed of peculiar lenses encrusted by limonitized ironsand. The thin encrusting layers show an interlacing tendency typical of wind-blown sands where the winds change direction frequently, and so form confused series of ripple-marks. It is not easy to explain why the encrusting layers alone should become limonitized, leaving the sand between loose and unaltered.
8. Pumice-bed (10 ft. to 20 ft.). This is a white, light, slightly plastic clay band, its very thinly bedded nature indicating deposition in the fairly still water of a swamp or lake. It is undoubtedly a fine pumice, enclosing large fragments of the same material. Non-pumiceous silts of irregular thickness replace the pumice to the south, above the volcanic conglomerate which covers the remnant of the lava-plug.
9. 200 ft. of brown, oxidized, wind-blown sands rich in limonite concretions.

The Kawa Pumice-bed in Relation to the Waikato River.

The occurrence of this bed of pumice-sand, containing coarser fragments of pumice, 180 ft. above high water, so far south of the mouth of the Waikato River makes one hesitate to ascribe its origin to transport by that river of material from the pumice plateau through which it flows for so much of its upper and middle course. No other origin, however, readily suggests itself, whilst this theory has several facts to support it:—

(1.) There is no other visible source whence the material may be derived.

(2.) The characteristic deposits made by the Waikato in the Bay of Plenty district and in the Hauraki Plains are largely rhyolitic pumice-silt which resembles the Kawa deposit.

(3.) Not only has the coastal area risen, but the whole country to the east and south-east as far as the middle Waikato basin, including the southern portion of the Hauraki Plains, across which the river flows in a north-westerly direction, has also been elevated with reference to sea-level since the course of the Waikato River was diverted from its old channel leading through the Hinuwera Valley to the Hauraki Gulf. There has thus been regional uplift. At the point below Maungatautari Gorge where the river enters the middle Waikato basin the surface of the plain is 300 ft. above sea-level. According to Henderson (1918, p. 60) this plain was formed by loose pumice of fluviatile origin whilst the land was depressed. About this time also the river changed its course from the Hinuwera Valley to the north-west across its own alluvial plain. (See Henderson 1918, pp. 112–15; and Cussen, 1889, p. 409, and 1894, pp. 401–10). The pumice of the Kawa beds must have been brought down at that time and deposited in a depression forming a swamp on the borders of a large estuary or low-lying coastal land such as then existed. When elevation ensued the tendency would be for the river to deepen its bed, and this has been done across the middle Waikato basin, the deepening here corresponding approximately to the uplift of the

Kawa pumice-bed, above which all the beds are subaerial deposits. (See Cussen, 1889, p. 413.)

4. It might be suggested that wave transport may have brought the pumice from far-distant localities; but the nature of the material and its bedding negative such a suggestion.

It may be mentioned that Mr. Bartrum (1919A, p. 104) similarly is inclined to ascribe the origin of this pumice-bed to the Waikato River.

Structural Plateau near the Coast.

The Notopleistocene formations along the coast form a structural plateau governed by the bedding of the horizontal sheet of limonitized sands forming the uppermost beds and now acutely dissected by the westerly streams. The residual ridges between these streams are all about the same height, and, seen from the northerly geodetic station, Waihonui, they are remarkably uniform. These divides are sometimes, as at Waihouni and Opura, small tablelands, remnants of the old platform.

Slipped Country above Waiwiri Beach.

For a quarter of a mile back from the Waiwiri beach the country has slipped along parallel lines, presenting seaward-facing scarps 10 ft. to 30 ft. or 40 ft. high. The whole area between these scarps and the sea-cliffs is tossed into hummocky mounds. Only the upper or sandy beds appear to be affected, and these are being slowly pushed over the cliffs on to the beach. The scarps form a rude semicircle facing the sea for a distance of over a mile. They are said to be as fresh-looking to-day as they were forty-five years ago. The scarps reveal cross-bedding everywhere.

The composition of these beds is a light, dull, black sand, the blackness not being due to grains of magnetite, which is not abundant, but to dull, light grains of material probably owing its origin to the erosion of shale-beds of the Mesozoics. They are unlike any of the other beds north or south that occupy a higher horizon than the *Cardita* beds or tabular limestone. The *Cardita* beds appear to have formed the base of a plain of marine denudation in this locality, possibly contemporaneous with that at the Kawa, or perhaps more recent, when the yellow and brown sands, &c., were removed by wave-action.

Sinkholes.

Close to the ridge above the great area of slipped country are several sinkholes, or swallow-holes, vertical cavities formed by the internal running of the sands beneath the surface, which then subsided. Similar sinkholes can be observed in the pumice lands near Hamilton. One at Pa Brown, due to solution of the limestone beneath the surface, is of much larger dimensions than those between the Ruahine and Kawa Streams.

Microscopic Characters of some of the Rocks.

The Kawa Basalt.—In a holocrystalline pilotaxitic groundmass consisting of long microlites of feldspar, showing good flow-structure, with less prominent prisms and grains of augite and olivine and very numerous fine specks of magnetite, occur separate phenocrysts of augite and olivine, and some glomero-porphyritic phenocrysts of olivine and augite with associated chlorite. The augite is usually colourless, but sometimes has a pink border. The olivine phenocrysts show the mesh-structure characteristic of alteration to serpentine along lines of fracture and around the edges. A secondary fibrous mineral, chlorite, is formed in numerous cavities. Large olivine nodules, up to 2 in. in diameter, are numerous in this basalt.

FIG. 1.—Showing the characteristic dune-bedding in the consolidated sands close to the bed of lignite near the Fishing Rock, on the coast north-west of Waiuku.

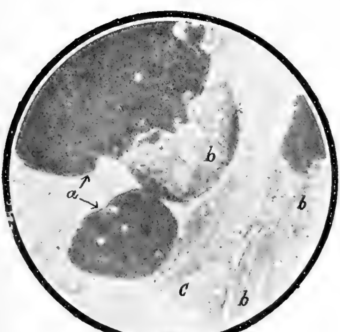

FIG. 2.

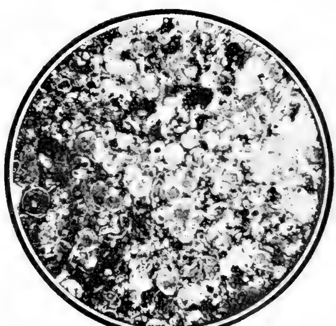

FIG. 3.

FIG. 2.—Photomicrograph of algal limestone north of Te Orairoa Point. The section shows the structure of the algae very clearly, but on so fine a scale that the photograph reproduces it poorly. *a*, an alga (? *Lithothamnion*); *b*, Polyzoa; *c*, a foraminifer, probably *Amphistegina*. × 24.

FIG. 3.—Photomicrograph of fine *Globigerina* limestone, Koruahine Point. × 24.
(Photomicrographs by J. A. Bartrum.)

Fig. 1.—Mesozoic shales and sandstones of the "strike coast," a little south of Okariha Point.

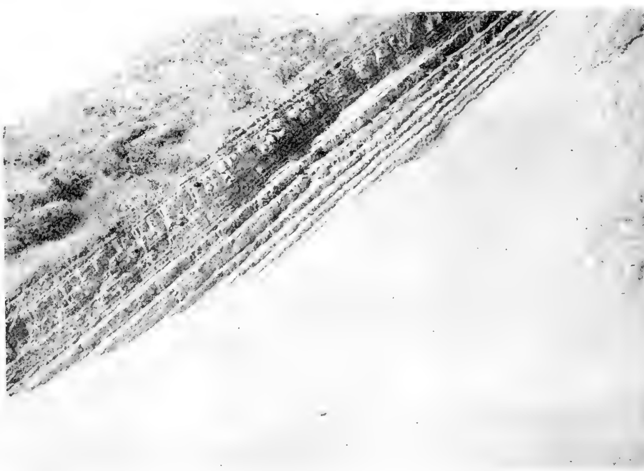

Fig. 2.—The belemnite shales (Mesozoic) at the South Head, Waikato River.

Waitangi Bay Basalt.—A couple of miles to the north of Waiuku there occurs a basaltic lava-flow which can be traced along the bed of the Waitangi Stream. Elsewhere it is covered deeply in a ferruginous clay resulting from the decomposition of basalt, so that its extent could not be ascertained. At one time the rock was quarried for road-metal at Waitangi Bay, where the stream enters Waiuku Creek. Here it is coarsely columnar. Examined under the microscope this rock is seen to be quite similar to the basalts common round Auckland City. It consists of a holocrystalline, pilotaxitic groundmass of long feldspar laths and small granular interstitial augite and olivine, enclosing numerous large phenocrysts of olivine and pale to colourless augite. The feldspar is mainly a basic labradorite, some of the twinned crystals being fairly large laths. Subsidiary iron-ore (magnetite) is scattered about in short streaks.

The Pakau Basalt.—About seven miles up the south bank of the Waikato River is a lava-flow across which several streams, including the Pakau, flow in relatively shallow valleys after leaving the deep, gorge-like valleys their headwaters have cut in the Mesozoic rocks of the Waikato fault-scarp.

At a point about a mile to the east of the Pakau Stream, where another stream forms a waterfall over the edge of the basaltic lava-flow, the Mesozoic sandstones and shales are seen in direct contact unconformably underlying the lava-sheet. This lava-sheet and the associated basaltic breccia to the east are believed to be of the same age as the basaltic flows and breccias spread over a wide area to the north of the Waikato River and eastward of Waiuku, and to be more recent than the Kawa flow.

At the Opuatia Bridge and in the environs of Puke-o-tahinga the lava rests directly on the Notocene calcareous sea-muds. Behind the Onewhero store and Post-office is a circular basin one mile in diameter, originally a crater and subsequently a lake, which has been insilted to the level of its present floor and now forms good farm land. It was drained by a stream through a breach in the north-eastern margin of the crater. This stream exposes the original lava-flow beneath the tuffs of the lip and for a mile farther on, till finally, where its waters tumble into a deep gully, the lava can be seen to occupy a trough representing an old stream-valley in the Notocene calcareous sea-muds.

The Pakau basalt, microscopically, consists of numerous large phenocrysts of olivine with less important colourless augite, in a pilotaxitic groundmass. The groundmass is made up of twinned feldspar microlites of basic labradorite with abundant augite and olivine granules and subsidiary iron-ore scattered about in large and small grains.

Algal Limestone.—South end of Matuatua Beach. This limestone occurs at the base of the cliffs less than a mile south of the Huruwai Stream, and near Te Orairoa Point. Examined in microscopic section it is seen to consist mainly of algal concretions, fragments of echinoid shells and shell-plates and spines, corals, Foraminifera, and a good many polyzoans. (See Plate XX, fig. 2.)

Glauconitic Limestone.—From same locality. Associated with the coarse-looking algal limestone, and probably above it, is a glauconitic type, composed of numerous grains of glauconite with tests of Foraminifera and a few angular grains of quartz. Recrystallized calcite forms a finely granular mosaic filling some of the interstices between the organic fragments.

Marly Limestone.—North Kawa Head. This limestone consists chiefly of the tests of *Globigerina*, of which the chambers are frequently detached, and other Foraminifera. Small granular calcite often fills the foraminiferal chambers.

Globigerina *Limestone.*—Koruahine Point, south end of Waiwiri Beach. *Globigerina* shells almost entirely constitute this rock, which may therefore be considered a *Globigerina* ooze. In the section examined there were, in addition, other foraminiferal remains, and an echinoid spine, together with some grains of iron-pyrites. (Plate XX, fig. 3.)

Summary and Conclusions.

South of the Waikato River occurs a folded older-mass of Mesozoic age, on the broadly truncated erosion-surface of which was laid down a younger-mass of Tertiary strata showing unconformity, or at least discontinuity of deposition between some series, as at the Kawa.

North of the Waikato River is an area of younger (Quaternary) sedimentary strata with a line of elevated sand-dunes fronting the coast.

Along lines of major dislocation coincident with the northern limit of the Manukau Harbour in one case, and, in the other, with the line of the lower Waikato River, considerable differential movements resulted in uplift of the areas to the north and south relatively to the middle (or Manukau) area. The latest considerable movement of the southern area appears to have been uplift to the approximate height of 180 ft., and to have occurred since the Waikato River began to discharge itself by its present outlet.* Minor oscillations have occurred in sub-recent times, especially in the middle area.

The Manukau sand-dune range originated in a spit or barrier beach which created a broad estuary of the Waikato River.

The Manukau Harbour owes its origin to streams, during minor uplift, cutting into the silts deposited in the former Waikato estuary, whilst subsequently the area subsided slightly, allowing the sea to penetrate into these stream-courses and rapidly push back the low sea-cliffs cut in the unconsolidated silts

The ages of the Tertiary strata and the importance of the physical unconformity and stratigraphical discontinuity in the Kawa beds cannot be decided definitely without further palaeontological evidence, which it is hoped will be available in the near future.

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* This estimate is based upon the data furnished by the pumice-bed in the section exposed south of Kawa Stream.

ART. XIV.—*Notes on the Geology of Great Barrier Island, New Zealand.*

By J. A. BARTRUM, Auckland University College.

[*Read before the Auckland Institute, 15th December, 1920; received by Editor, 31st December, 1920; issued separately, 27th June, 1921.*]

Plates XXII–XXVII.

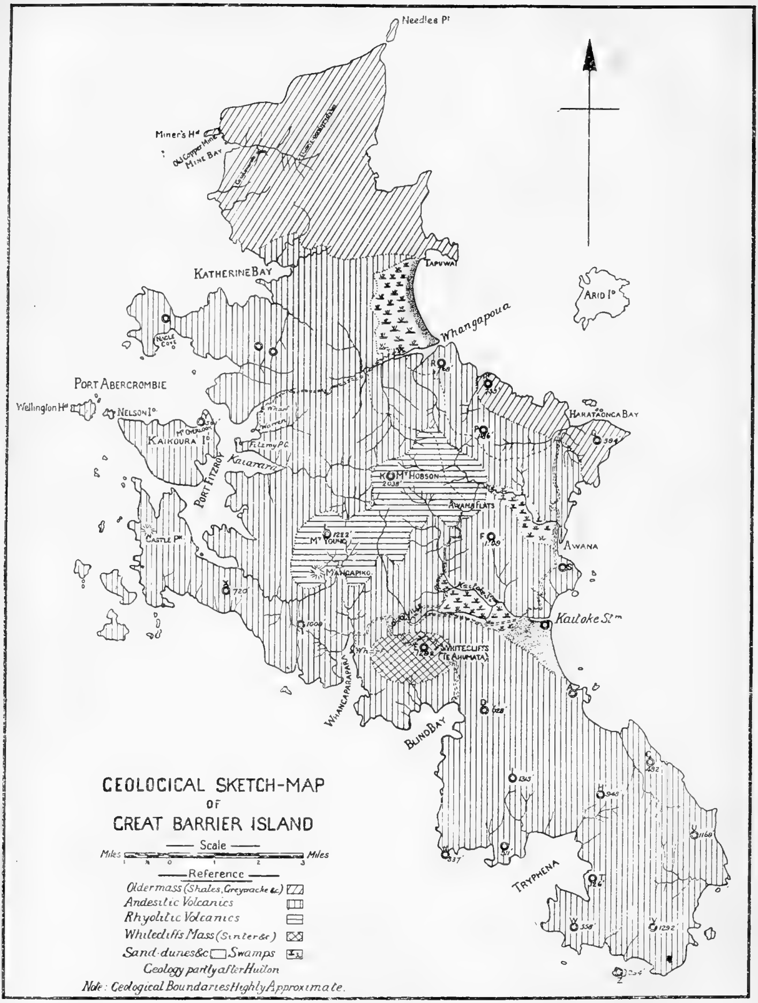
IN 1919 the writer spent a short holiday at the northern end of Great Barrier Island, and found that the geology of that part of the island is rather indifferently represented by Hutton's paper of 1869,* which still remains the only important account of that area. In many respects Hutton's work is admirable, for considerable difficulties attach even now to a close study of some parts of the island, and years ago these must have been even greater. Hutton's chief error is that he failed to recognize a large area of rhyolitic rocks as such, and mapped them as "pinkish slates." This is, however, entirely excusable, for these rocks are very finely banded, and in section resemble very finely granular sediments, though upon examination with a first-class instrument they can be seen to be in reality minutely microspherulitic rhyolites.

Park (1897), who deals with the geology of the central portion of the island in his paper on the geology and veins of the Hauraki goldfields, makes a similar error in classing them as banded sinters similar to those he asserts form the higher portions of a mountain-mass near Whangaparapara, with a remarkable series of breakaway cliffs which give it its local name, Whitecliffs Range. (Plate XXIII, fig. 2.) The Maori name for it is Te Ahumata.

The writer's visit served to yield him little more than an approximate idea of the geology: one or two large areas to the north are *terra incognita* to him, and the appended map shows very crudely sketched boundaries between the various rock formations. He managed, however, to spend a day or so at Mine Bay, on the north-west coast, where Hutton maps so many interesting dykes intrusive into the shales and greywackes which form the basement of the island, and to make a moderately careful study of many of these dykes. The number of them is so great at Mine Bay itself, along the coast both north and south from there, and in the valley of Mine Bay Creek, that a full collection was out of the question, and no map could exhibit their location unless published on a very large scale.

The writer made his headquarters at the house of Mr. Warren, of Port Fitzroy, and cannot sufficiently thank Mr. Warren and all members of his household for the assistance they gave him in numerous ways. From there he made a number of excursions on foot and by boat, and finally took a walk along the recognized foot route from near Cooper's to the top of Mount Hobson, thence by a devious traverse to Awana Flat,

* Full reference is appended in a list of literature cited to be found at the end of this paper.


Needles Pt
Miner's Hd
Old Copper Mine
Mine Bay
Katherine Bay
Tapuwai
Arid Io
Whangapoua
Nagle Cove
Port Abercrombie
Wellington Hd
Nelson Io
Haratäonga Bay
Kaikoura Io
Mt Overlook
Fitzroy P.O.
Katarara
Port Fitzroy
K Mt Hobson
2038'
Awana Flats
Awana
Castle Pk
Mt Young
1222'
Mangapiko
Kaitoke Stm
Whitecliffs
(Te Ahumata)
Whangaparapara
Blind Bay
Tryphena
GEOLOGICAL SKETCH-MAP
OF
GREAT BARRIER ISLAND
Scale
Miles
Miles
Reference
Older mass (Shales, Greywacke &c.)
Andesitic Volcanics
Rhyolitic Volcanics
Whitecliffs Mass (Sinter &c.)
Sand-dunes &c.
Swamps
Geology partly after Hutton
Note: Geological Boundaries Highly Approximate.

from which place he visited Oroville, in the Kaitoke Valley, and then returned by the road and tracks along the east coast from Kaitoke Creek to Harataonga Bay, whence he took the bush track, crossing the higher country some distance from the coast, to Whangapoua.

In spite of the cursory nature of the writer's examination of a large portion of the area mapped, it appeared to him desirable to make such provisional alterations and additions to Hutton's account of its geology as are now possible, instead of waiting perhaps a long time until an opportunity presented itself for making a more thorough geological survey.

Scheme of Paper.

The aim of this paper on the geology of Great Barrier Island may be summarized as follows:—

(1.) To present a statement of the physiography and stratigraphy of the island, and more particularly of its northern half:

(2.) To record the discovery in the basement (? Mesozoic) rocks of some interesting conglomerate bands containing granite, pegmatite, granulite, and other boulders:

(3.) To describe a little more fully than Hutton (1869) the rocks intrusive into the basement:

(4.) To discuss briefly the origin of the copper lode at Miner's Head.

Physiography of Great Barrier Island.

Great Barrier Island is a rugged, elevated, much-dissected, probably one-cycle mountain-mass, about twenty-four miles in length, and varying up to thirteen miles in width. It is built largely of moderately resistant rocks, amongst which well-compacted andesitic conglomerates and breccias and rhyolite lavas figure most prominently. Each of these two rock-types builds its own characteristic terrain, recognizable with ease even at considerable distance. The andesitic fragmentals often build the hill landscape best described as turreted, with successions of frowning bluffs breaking the monotony of gentler slopes. The rhyolites lend themselves to the evolution of the weirdest pinnacled crags and sheer precipices, which, with alluring whiteness, give a fascinating picturesqueness to the landscape carved from them. (See Plate XXIV.)

The area of shales and greywackes at the north of the island lacks much of the ruggedness of the more southerly portion, but is none the less steep and topographically fine-textured. On the north-west it descends abruptly to the sea in stupendous lofty precipices. (See Plate XXIII, fig. 1.)

Like its prototype the Cape Colville (or Coromandel, or Hauraki) Peninsula, of which it is undoubtedly the former continuation, Great Barrier Island represents the remnant of a maturely dissected, mountainous, heterogeneous land-mass with insequent drainage, which was depressed with reference to sea-level in the not-far-distant geologic past, so that the sea entered far into the deep, comparatively narrow trenches carved in the earlier mass.

More particularly on the western coast, islets and reefs thickly fringe the shore-line, representing extensions of this earlier land-mass which have not yet been cut down by wave-attack. (See Plate XXII, fig. 1.) Youthful, precipitous, lofty cliffs form this highly irregular immature coast, except locally where bays such as Katherine, Blind, and Tryphena Bays exhibit unimportant shore progradation, or where at Port Fitzroy the cliffs are interrupted temporarily by deep, narrow entrances to the wonderful and beautiful harbour.

Delta-building is active in bay-heads entered by streams of any importance, but there is a noteworthy absence, even in the landlocked Fitzroy Harbour, of the mangrove-dotted mud-flats so common in most of the North Auckland harbours. This is to be accounted for in part because of the insignificant size of the inflowing streams, in part because of the great depth of the sea-occupied trenches.

The eastern coast of the island differs very greatly from the western. It is exposed to more vigorous wave-attack from the ocean, with the result that it has been cut back until the coast-line is much more regular than the western. Several large harbours similar to Port Fitzroy existed at one time, but all have been shut off from the open sea by spits or barrier beaches, and the resulting lagoons have in large part been obliterated by blown sand and swamp or other filling. One of the best examples is furnished by the lower Kaitoke area, in the central portion of the island The earlier inlet has apparently been enclosed by a barrier beach. Landwards from this is a zone of low sand-dunes, and then comes a remarkable area of swamps. (See Plate XXII, fig. 2.) At the Awana Stream, similarly, swamps occupy an extensive tract within a flaring portion of the lower valley, just above a bottle-necked outlet to the ocean which is due to the close approach of two opposed spurs cut in resistant andesitic fragmentals.

Barrier Beaches or Spits.

In considering whether the former harbours of the eastern coast of Great Barrier Island have been blocked off by barrier beaches or spits one has many opposing considerations to weigh. The problem is best considered by reference to the analogous physiographic conditions of the Cape Colville Peninsula, where, in similar manner, the western harbours remain open, whilst the eastern are largely shut off by wave-built sand-accumulations.

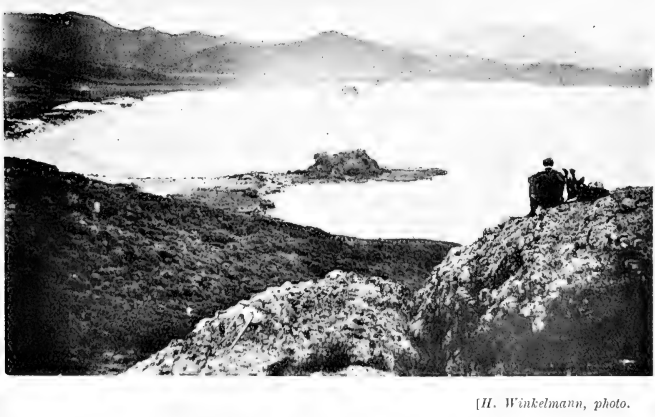
There is undoubtedly a strong northward drift of the sea-waters, which brings pumice, for example, from the Bay of Plenty around Cape Colville and deposits it in such places as Whangateau (near Cape Rodney) on the shores of the mainland; but this cannot have had any effect in creating the present conditions at Great Barrier Island, for both coasts should show similar features if this were so.

The fundamental reason undoubtedly is that which has allowed the building of such typical barrier beaches as the somewhat complex one that encloses the Katikati–Tauranga harbour, on the southward continuation of the east coast of Coromandel Peninsula. There is abundant evidence that the waves of the open ocean have in that district removed a very considerable strip of land in cutting back the present sea-cliffs.

It is also to be observed that the depth of water off shore at the conclusion of the major movement of subsidence noted was shallow wherever barrier beaches have been built, for in such localities the earlier land-surface was invariably of low relief, often consisting of the flood-plains of the now greatly diminished rivers, or of the flattish floors of their wide, late-mature valleys. The initiation of the building of the beaches is almost certainly to be correlated with sub-recent uplift of a few feet, which is demonstrated by uplifted shore-terraces, wave-cut platforms, sea-caves,

[H. Winkelmann, photo.

Fig. 1.—The rugged, youthful, western coast of Great Barrier Island. View looking north-north-west towards the entrance to Port Abercrombie. The sea-cliffs are cut in andesitic fragmentals.



[H. Winkelmann, photo.

Fig. 2.—Kaitoke Beach from the south, mid-east coast, Great Barrier Island. Mount Hobson is visible in the centre-right distance.

[H. Winkelmann, photo.

Fig. 1.—The Needles, north-east coast of Great Barrier Island. Lofty sea-cliffs are typical of the northern coast of the island.

[H. Winkelmann, photo.

Fig. 2.—Breakaway cliffs of Whitecliffs Range, near Whangaparapara, viewed from the north. Mine-workings in altered andesitic rocks can be seen below the cliffs.

and other similar criteria observable at different portions of the coast-lines in the mid-Auckland area; for, as D. W. Johnson shows in *Shore Processes and Shore-line Development*, the disturbance of the equilibrium of the graded off-shore profile by uplift is the most general cause of the building of these off-shore bars.

In corresponding manner, at the Great Barrier Island, a graded profile must have been established fairly early by vigorous wave-attack upon the easily removed areas of low relief on the eastern coast, and barrier beaches would soon come into existence upon any subsequent uplift taking place.

SUMMARY OF STRATIGRAPHY.

Great Barrier Island is constituted by a basement mass of folded sediments, largely shales and greywackes, and herein called the "oldermass,"* which extend over the northern part of the island as far south approximately as a line drawn from the head of Katherine Bay on the west coast to Tupawai on the east, and which are again exposed in a small area near Harataonga Bay, farther south. These rocks have been extensively eroded and then covered in the Tertiary by a sheet of andesitic volcanics which is probably well over 1,000 ft. in depth. These are in turn overlain by later acid volcanic rocks, with accompanying sinters, in a central area around and south of Mount Hobson.

The andesitic rocks are largely coarse fragmentals, with subsidiary lavas; they form the mass of the island south of the northern sedimentary area, and are covered at higher levels by acidic rocks in the area mentioned.

THE BASEMENT SEDIMENTS, OR OLDERMASS.

The writer closely examined the outcrops of the older sediments for fossils, but was unable to find any, in spite of the fact that (*fide* Sollas and McKay, 1905, vol. 1, p. 146) Hutton discovered a coral. There is little doubt that the oldermass of the island is comprised of rocks substantially the same as those of Coromandel Peninsula which yielded a few Mesozoic fossils south of Coromandel (Fraser and Adams, 1907, pp. 49–50). In facies they are mainly shales, but with moderately frequent greywackes which are sometimes—as, for example, at Harataonga Bay—finely inter-banded with the shales. In the same locality, further, a small amount of fine conglomerate is displayed, which recalls somewhat the conglomerate of the comparable Manaia series of Coromandel Peninsula (Fraser and Adams, 1907, pp. 48–62). In the headwaters of Mine Bay Creek there is a coarse conglomerate with greywacke boulders.

One of the most striking features of the oldermass is the way in which its rocks have been seamed by the numerous dykes mentioned in the introduction above. A detailed account of their petrography will be given in a later section

A most interesting and important discovery was made of bands of coarse conglomerate with abundant granitic, pegmatitic, and granulitic pebbles and boulders. Undoubtedly these yield very definite information as to the character of the earlier (pre-Mesozoic) land-mass affording the clastic material.

* A usage introduced to New Zealand geology by Cotton (1916).

Structure.

The structure of the oldermass in the northern portion of New Zealand is still imperfectly known, so that a few definite observations of strike and dip may prove of value. In the vicinity of the intrusive dykes intense shattering has disguised the structure of the sediments. Plate XXV, fig. 3, illustrates folding in these beds at Harataoaga Bay.

Observations.—(1.) Immediately south of Miner's Head a conglomerate band strikes N. 35° W., with a dip of 70° to the north-east. (2.) In the valley of Mine Bay Creek two conglomerate bands gave respectively (*a*) strike north-west and south-east, dip 60° to the south-west; (*b*) strike N. 60° W., dip 70° to the south-south-west. (3.) Towards the head of Mine Bay Creek: strike N. 5° W., dip 30° to the east.

Conglomerate Bands in Basement Sediments.

Three outcrops of conglomerates were found—the first at the foreshore near the adit crosscut of the old copper-mine at Miner's Head, on the north-west coast of the island; the other two not far distant in branches of a small tributary to Mine Bay Creek, which enters from the south about half a mile up-stream from the foreshore. The first varies in width from about 8 in. to a little over 1 ft., and contains large well-rounded beach-boulders ranging in size up to 10 in. in diameter. The material of the boulders is typical coarse granite with conspicuous white mica, a biotite granite with equally conspicuous biotite, and plentiful hard shales and other sedimentary types.

The outcrops in Mine Bay Creek basin show a much more substantial depth than the first mentioned; both probably belong to the same band, which has a width of about 7 ft. The majority of the boulders are much smaller and less assorted than in the other band, and there is an abundance of arkositic matrix. A bi-mica granite, in boulders as large as 18 in. in diameter, forms the bulk of the constituent boulders, but shales too are plentiful, whilst granulites (some with garnet, some without), pegmatites, and occasional andesite are also represented.

Sections were cut from a number of the boulders, but microscopic examination did not add greatly to the knowledge gained by macroscopical examination. One fact worth mention is that the biotite of some of the boulders from the band near the copper-mine adit contains small zircon crystals around which are intense pleochroic haloes.

The pegmatites are fine-grained, composed almost wholly of graphically intergrown orthoclase and quartz, with frequent small flakes of biotite. The photomicrographs, figs. 1, 2, and 3 of Plate XXVII, adequately exemplify a pegmatite and two types of granulite, one with garnet and the other lacking it.

Significance of the Material of the Conglomerates.

The presence of rocks such as granulites in the basement shales and greywackes of Great Barrier Island indicates the existence near that area of a land-mass which had been subjected to intense pressure before the deposition of those sediments, a question already considered in some detail by the writer in a recent paper (Bartrum, 1920). The coarse, well-rounded nature of the boulders of the conglomerates, and their freshness, particularly in the band near Miner's Head, indicate that they were deposited near the shore-line of a land-mass. They suggest a temporary movement of elevation of the area of deposition, followed by a continuance of depression. There is, however, no evidence to show the exact location of the land-mass, but we are undoubtedly beginning to know a little more of it than previously. It certainly lies buried beneath the unmetamorphosed sediments of the Whangarei district, for andesitic rocks intrusive into these sediments at Parua Bay contain very abundant xenolites of hornblende-schists and hornblende-epidote-schists.

The period of pressure causing this acute metamorphism of the rocks of this pre-Mesozoic land probably was coeval with that causing the granulation of granites in the central portion of the North Island (Park, 1893), and of dioritic rocks at Albany, near Auckland (Bartrum, 1920), now found in Tertiary conglomerates in those districts. It is a fair inference that this land was extensive both north and south of the city of Auckland.

The Andesitic Volcanic Rocks.

The andesitic mass resting upon the basement of eroded sediments, and occupying the main portion of the island south of the northern area of sediments, consists to a great extent of coarse fragmentals, breccias in the main, though conglomerates are also abundant. Many of the rocks here loosely called breccias are perhaps more strictly agglomerates, but the writer had not an opportunity in the field of making the distinction. Lavas of limited extent are frequently intercalated in the mass, but tuffs are scarce. Hutton (1869) records the presence of seams of black laminated shale in a coarse soft tufaceous sandstone forming the base of the series at Onewhero, in Maori (Katherine) Bay, a locality not visited by the writer.

Sollas and McKay (1905, vol. 1, p. 146) describe a hyalopilitic pyroxene-andesite belonging to this series of rocks, and Park (1897), though he does not definitely state that the propylites, or altered andesites, of the central portion of the island, which carry gold-silver veins, belong to the series, leads one to infer that he believes such to be the case, and records types that " are augitic and generally contain hypersthene, which often occurs in excess of the augite."

A number of sections were cut from flows in many diverse localities, and of some of the fragmental material. All indicate a remarkable uniformity of facies. Hypersthene-andesites are very common, augite in these being greatly subordinate to the hypersthene, or even absent. In one slide the hypersthene has deep resorption borders of iron-ore, which is not at all a common phenomenon ; this is well illustrated by the photomicrograph, fig. 4 of Plate XXVI. The other varieties of andesite can be classed as pyroxene types, with both augite and hypersthene prominent.

In the majority of the sections there is surprising uniformity in general appearance. The clear-cut phenocrysts, embracing always plentiful feldspar in addition to pyroxene, are spread in a very constant minutely crystalline groundmass consisting mainly of tiny feldspar laths with a little pyroxene and iron-ore. Sometimes it is so fine as to be practically irresolvable, and in such cases it is perhaps to be considered hyalopilitic.

A boulder from a conglomerate at Port Fitzroy furnishes a good example of intersertal structure : numerous small crystals of plagioclase, with other coarser crystals of the same mineral and pyroxene, are interspersed closely in a glass crowded with minute prisms of pyroxene and a few small crystals of magnetite. Fig. 5 of Plate XXVI illustrates a typical portion of a section of pyroxene-andesite.

Comparison with similar Fragmental Series.

There is little doubt that the andesitic mass of Great Barrier Island is coeval with that so well exhibited in rocks possessing similar mode of occurrence at Coromandel and elsewhere throughout the Coromandel Peninsula. These are the "Beeson's Island" or "second period" rocks of earlier writers (*cf.* Fraser and Adams, 1907; Fraser, 1910), which are considered Miocene in age.

Acidic Volcanic Rocks of the "Third Period."

In conformity with conditions on the Coromandel Peninsula, where the latest volcanics are practically without exception rhyolitic lavas, breccias, and tuffs, and cap an erosion-surface of the "second period" andesites, there are on Great Barrier Island truly comparable acidic "third period" rocks. The writer did not make as extensive an examination of them as he desired, but visited them on the lower north-west slopes of Mount Young, the western slopes of Mount Hobson, and examined them fairly thoroughly along the ridges south-east and east of Mount Hobson which form the long pinnacled divide between the headwaters of Kaitoke Stream and of Awana Stream. The writer's route from the top of Mount Hobson was an irregular zigzag along this ridge, and across the upper basin of the Awana Stream to Awana Flat. Along his route, and particularly west of it in the circle of precipitous crags surrounding a basin-like hollow in the headwaters of the Kaitoke Stream, these "third period" rocks are by far the most conspicuous feature of the landscape, and the bizarre pinnacles and sheer-walled bluffs are scarcely to be matched even in rugged regions such as that of exactly similar rocks on the main divide between the Kauaeranga and Tairua Rivers, south-east of Thames. (See Plate XXIV.)

The main portion of the mass of acidic volcanic rocks at Great Barrier Island appears to consist of pinkish-grey rhyolitic lava with very fine wavy fluxion-banding. There is breccia in several places, but it is apparently not extensive. No important tufaceous beds were seen, but the topography in the vicinity of Mount Young indicates their possible occurrence there in quantity.

Hutton (1869) and Park (1897) deal with the rocks of this series, the former excusably considering them "pink slates," the latter bedded sinter. Undoubtedly Park was influenced by the occurrence of siliceous sinter in large quantity on the Whitecliffs Range; McKay's able description leaves no room for doubt that there is here a considerable mass of sinter (McKay, 1897). Park (1897) refers to the same mass, and adds an interesting detail, which the writer can verify from examination of specimens given him, to the effect that some of this sinter is oolitic. The oolites are about $\frac{1}{8}$ in. in diameter, and consist of concentric shells of very fine white mud; they imperfectly resemble the celebrated oolites of the Carlsbad springs. A few sections were cut from rocks forming the fringe of the Whitecliffs (or Te Ahumata) mass, and tend to show that all of it is not sinter, but more or less silicified rhyolite and rhyolitic tufaceous breccia. The silicification is perhaps a result of the hydrothermal activity manifested by sinter in other parts of the mass; but this suggestion is at best a surmise.

Park (1897, p. 105) refers in some detail to "a remarkable breccia, which has been carved by subaerial denudation into the most fantastic and grotesque features," which, he says, is "immediately east of the great siliceous deposit" (? rhyolite), and forms the watershed between the Kaitoke and Awana Streams. At every point where the writer examined the rocks at this ridge they were of the usual rhyolite, but he admits that certain portions of the ridge were not visited. Park continues, however, "This breccia is flanked or overlain by the siliceous deposit on all sides of the Awana Flat. It is composed of a bluish-grey, shining, siliceous rock embedded in a matrix resembling a fine ash or tuff. . . . On the low spurs and ridges near the fantastically carved rocks overlooking the great Kaitoke basin this breccia material is seen to decompose in a deep, yellow-coloured, mealy, sandy clay. The origin of this breccia is evidently connected with some of the volcanic outbursts of andesitic matter which preceded the deposition of the great sinter deposit around this region."

Whilst admitting that his visit afforded him but a cursory glance at the geology of this district, and that he had not read Park's statement in advance of it, the writer is at a loss to understand the location of this breccia. He would certainly doubt that it forms the "fantastic and grotesque" features of the ridges west of Awana Flat, and there is some uncertainty as to whether or not Park actually means that it does so in this locality, since he says that "This breccia is flanked or overlain by the siliceous deposit on all sides of the Awana Flat." To the east and south-east of Awana Flat the topography indicates that the rhyolitic rocks give place to the andesitic, which are known to outcrop a very few feet below the level of the flat on the south-western slope to the Kaitoke Stream from the flat, and which form a wide strip along the east coast north from the mouth of that stream.

The writer did, however, observe a most curious obsidian "breccia"—possibly a true breccia, more probably only such in appearance, and in reality a weathered coarsely perlitic obsidianitic flow. This is exposed, lying hard upon the andesitic rocks (mentioned above) outcropping a very few feet below it, in a cutting of the track from Awana Flat towards Oroville, the site of the now disused mines in the Kaitoke Valley. The depth of the breccia actually exposed is insignificant, but it is possible that its thickness is locally considerable, and that it represents some phase of the breccia described by Park.

The obsidian discovered here explains the otherwise inexplicable occurrence of obsidian noted by McKay (1897) on Te Ahumata, which is, indeed, a further argument in favour of the view that the upper portion of that elevation—the sinter of McKay and Park—is largely rhyolitic. This mass rests on andesitic material which is exposed on the lower slopes of the White-cliffs Range, and which, in altered form—propylite—is the country of the gold-silver veins (*fide* Park, 1897).

Petrography of the Rhyolites.

Petrographically the rhyolites examined from the acidic area north of Te Ahumata show little variety. In hand-specimen none showed any noticeable phenocrysts, and the majority, as already stated, have a very fine, regular, but somewhat sinuous fluxion-banding. The colours vary from greyish-white to pinkish. In thinnest section, using a microscope with good resolving-power, the banded varieties show up as very minutely micro-spherulitic. Phenocrysts are practically absent. Small druses of opal may show up in section, and in the field a few larger opal- or chalcedony-filled cavities were observed.

One section of a banded type shows dense somewhat axiolitic narrow dark bands, between which are clearer bands largely of very finely crystalline quartz. A few very small crystals of feldspar represent the only phenocrysts.

An Acid Dyke in the Andesitic Fragmentals.

Before leaving the subject of the rhyolitic rocks, mention must be made of a very striking dyke, apparently of rhyolite, forming a conspicuous feature of the landscape on the northern wall of the Awana Valley. It can be seen readily from the open country near the top of the ridge crossed by the inland or "bush" track from Harataonga Bay to Whangapoua. Seen from there at a distance of a little less than three-quarters of a mile it appears a great vertical wall, probably at least 100 ft. high, built of horizontal columns apparently of rhyolite, which outcrops near it to the south, and piercing andesitic conglomerates clearly visible in the adjacent bluffs. (See Plate XXV, fig. 1.)

Petrography of the Dyke Complex in the Basement Sediments.

Having read Hutton's (1869) description of the Mine Bay area, the writer had anticipated that his own visit would yield him petrographic material of very great interest. He was not altogether disappointed, but found that practically all the dykes he examined were greatly affected by decomposition or alteration of some kind or another. This fact militates against the exact deciphering of some of the varieties.

The list of rock-types examined includes (1) pegmatite or granite-granophyre, (2) quartz-porphyry, (3) quartz-porphyrite and quartz-andesite, (4) porphyrites and andesites. Hutton's original list includes diorite, quartz-porphyry, and felstone. In a later paper (1889) he describes an elvanite, or dyke-rock showing quartz phenocrysts in a felsitic ground-mass. Apparently he did not examine the rocks microscopically, and his identifications are therefore by no means sound.

Very few indeed of the rocks have escaped the prevailing alteration. This is exhibited in the conversion of feldspars to kaolin, often with calcite and quartz as additional products, and the hydration of biotite and ferro-magnesian minerals generally to chlorite, sometimes with the addition of calcite. The production, and often introduction, of calcite is most general, and strings of it seam the dykes and adjacent sediments. Pyrite is a further secondary mineral which is occasionally abundant. In several instances metallization has proceeded along the walls of dykes, producing small lodes in which the commonest minerals are chalcopyrite, sphalerite, galena, and pyrite. It is possible that the general alteration of the dyke-rocks is a result of the same processes as gave rise to the introduction of ore-minerals, but it must be admitted that the wall-rock of the dykes appears to give no evidence of any of the changes expectable on that hypothesis.

1. *Pegmatite or Granite-granophyre.*

This is a curious rock forming an intrusion on the south-east wall of the copper lode at Miner's Head, and surprisingly free from signs of having been affected by the near passage of the solutions giving rise to the lode. The minerals are equidimensional, and form a mosaic reminiscent of that displayed by granulites Much of the rock shows graphic structure.

[H. Winkelmann, photo.

Typical rhyolitic bluffs, summit of Mount Young, looking north-west.

FIG. 1.

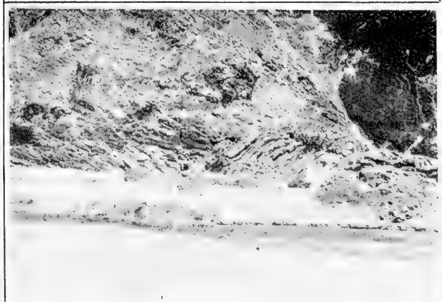


FIG. 2.

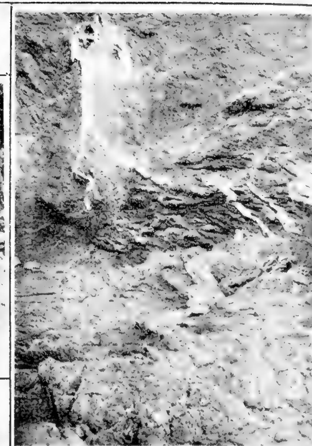


FIG. 3.

FIG. 1.—A conspicuous acid dyke intruding andesitic conglomerates on northern wall of valley of Awana Stream. (Photographed with short-focus lens from a point distant about three-quarters of a mile.)

FIG. 2.—Ramifying narrow dykes intruding shattered shale of oldermass, south shore of Mine Bay, Great Barrier Island.

FIG. 3.—Closely folded fine-bedded sediments of oldermass, north end of Harataonga Bay, east coast of Great Barrier Island.

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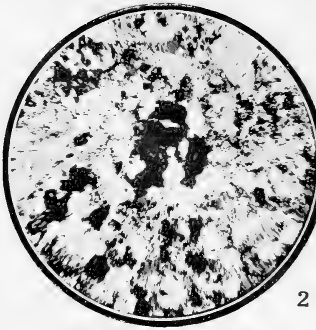

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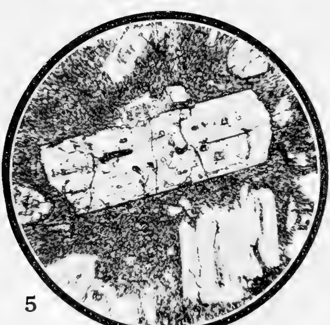

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Fig. 1.—Graphic intergrowth of quartz and orthoclase in pegmatite. Boulder from conglomerate in oldermass, Mine Bay Creek. Crossed nicols. × 26.

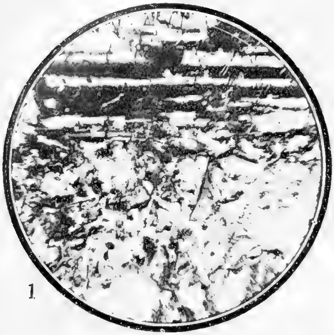
Fig. 2.—Granulite with garnet (black, in centre) from conglomerate in oldermass, Mine Bay Creek. Crossed nicols. × 26.

Fig. 3.—Granulite from conglomerate in oldermass, Mine Bay Creek. Crossed nicols. × 26.

Fig. 4.—Hypersthene with resorbed borders in "second period" andeside, Kaitoke Valley. × 26.

Fig. 5.—Section of a typical "second period" andesite, showing a phenocryst of hypersthene and the characteristic fine groundmass. × 26.

Fig. 6.—Phenocrysts of zoned plagioclase and of quartz in quartz-porphyry from headwaters of Mine Bay Creek. Crossed nicols. × 26.



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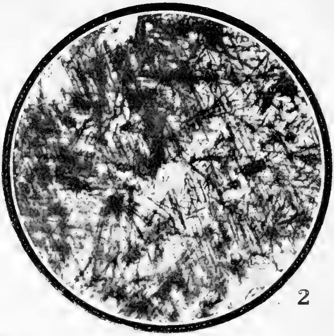

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FIG. 1.—A porphyrite from the dyke complex of Mine Bay. Part of a large plagioclase crystal is recognizable, and the irregular nature of the coarse groundmass can just be discerned. Crossed nicols. × 26.

FIG. 2.—Sagenitic pseudomorph after biotite in porphyrite from Mine Bay area. × 150.

FIG. 3.—Quartz-mica-porphyrite from intrusion near old copper-mine. Phenocrysts of biotite and plagioclase can be seen. Crossed nicols. × 26.

FIG. 4.—A quartz phenocryst from a hornblende-biotite-quartz-porphyrite forming intrusion a little south of Miner's Head. The crystal shows a distinct corrosion border. Crossed nicols. × 26.

FIG. 5.—Pilotaxitic andesite from dyke in oldermass of Mine Bay Creek. Crossed nicols. × 26.

Quartz forms about half the bulk of the minerals, though cryptoperthite is fairly plentiful along with orthoclase. The only other minerals are a little plagioclase and some flakes of biotite. It is possible that this rock is the "true dyke of granite" mentioned casually by Hector (1870) in his paper on mining in New Zealand.

There is some uncertainty in the writer's mind as to the exact classification of this rock; the structure is typical neither of pegmatites nor granophyres.

2. *Quartz-porphyry.*

Several dykes of this type are recorded by Hutton (1869), as well as a number of an allied rock called by him "felstone," and defined by Hector (1870) as a rock lacking phenocrysts, but otherwise similar to quartz-porphyry. Many of Hutton's quartz-porphyry dykes seem to be in reality porphyrites with quartz.

The quartz-porphyries so called by the present writer have rather finely granular groundmass and large phenocrysts of quartz and weathered orthoclase and plagioclase, with a few flakes of altered biotite. The groundmass seems largely feldspar, so that the classification is perhaps uncertain in the absence of chemical analysis. Dykes of this rock are rare; only three were found, all of them close together in the headwaters of Mine Bay Creek.

Many of Hutton's "felstone" dykes are very doubtfully acidic. The groundmass approaches the felsitic, but the phenocrysts, if present, are rare ones of feldspar. The alteration is so intense that exact identification is almost impossible. In the field these dykes may ramify in intricate fashion, as can be seen from Plate XXV, fig. 2.

The photomicrograph, fig. 6 of Plate XXVI, exhibits a typical quartz phenocryst, along with zoned plagioclase, in a quartz-porphyry forming a narrow finely banded dyke in the headwaters of Mine Bay Creek.

3. *Quartz-porphyrites and Quartz-andesite.*

The distinction between the terms "porphyrite" and "andesite" when applied to dyke-rocks is at best an artificial one. Those here classed as porphyrites show rather coarse feldspar phenocrysts in hand-specimen, along with prominent biotite or else hornblende, or chlorite pseudomorphs after those minerals; they have a coarse groundmass lacking the usual structures found in andesites. In the Great Barrier dykes these latter rocks are very typical representatives of their class; feldspar is their only common prominent phenocryst. Fig. 1 of Plate XXVII illustrates the coarse irregular structure of the groundmass of a type best classed as a porphyrite.

Porphyrites and andesites are by far the commonest of the intrusives; some contain quartz and some are without it. All show the prevailing alteration, though in a few instances this is not intense. Two good examples of comparative freshness are furnished by a quartz-biotite-porphyrite forming a massive intrusion near the adit of the old copper-mine, and by a wide intrusion in a small bay just south of Miner's Head, which is mapped by Hutton as a diorite, but is in fact a quartz-porphyrite, rich in both biotite and hornblende.

The majority of the quartz-porphyrites are types with altered biotite, usually with chloritic, sometimes with sagenitic, pseudomorphs after that mineral. An excellent example of such a sagenite pseudomorph is afforded by fig. 2 of Plate XXVII.

In a section cut from a greatly altered porphyrite-like rock there are nests of chalcedony and some phenocrysts still recognizable as microperthite in spite of their being largely replaced by calcite and quartz. In the rather fine-grained groundmass there are laths of plagioclase, whilst a little of the quartz appears to be primary.

In the quartz-porphyrite from near the copper-mine the phenocrysts are mainly basic andesine, with a moderate number of flakes of biotite. The groundmass is fairly coarse, and consists mainly of plagioclase with abundant small shreds of biotite and a certain amount of quartz; it contains occasional radial structures. Occasional pseudomorphs after hornblende are recognizable. Fig. 3 of Plate XXVII illustrates a typical portion of this porphyrite, whilst fig. 4 portrays a quartz phenocryst in the hornblende-biotite type which has already been mentioned. In this latter rock the biotite is very fresh, and is perhaps in excess of the greenish-brown somewhat chloritized hornblende; a few large phenocrysts of quartz are visible, typically corroded, but andesine is again the most abundant phenocryst. There is quartz in the groundmass. Zircon, apatite, and iron-ore are present in small amount.

The only andesitic dyke-rock containing phenocrysts of free quartz outcrops in the bed of Mine Bay Creek about a mile above its mouth. It contains ilmenite with associated sphene.

4. *Porphyrites and Andesites.*

Porphyrites and andesites are amongts the commonest of the intrusive rocks represented. A mica type, always greatly altered, is the most prevalent of the porphyrites. The only other variety noted is a coarse highly feldspathic one, almost lacking in ferro-magnesian minerals.

The andesites are varied. Even when appearing fairly fresh macroscopically, all are found in section to be altered to a greater or less extent. Some are highly feldspathic, some noticeably pilotaxitic (see photomicrograph, fig. 5, Plate XXVII). Many are altered beyond recognition of variety. It is possible, however, positively to identify the following varieties: Mica-andesite from a small tributary to Mine Bay Creek about half a mile above its mouth, augite-andesite from a prominent dyke at the north end of Harataonga Bay, and an andesite with brown hornblende from a dyke near the north head of Mine Bay. In the augite-andesite the structure of the groundmass is unusual, for the plagioclase laths are enwrapped pseudo-poecilitically by a clear mineral resembling quartz.

Comparison with Intrusives of Coromandel Peninsula.

The presence of abundant porphyrites and andesites in the basement rocks of Great Barrier Island is another evidence of the close similarity of that area to the Coromandel Peninsula, where even greater variety is shown in dykes of the same petrographic character, which are intrusive especially into the Moehau series of pre-Jurassic age (Fraser and Adams, 1907, p. 22). Particularly on the western flank of the Moehau Range intrusions are both numerous and varied, but all are basic intermediate in character (Fraser and Adams, 1907, pp. 87–93).

It is impossible in Great Barrier Island to form any estimate of the age of the intrusions, or indeed to correlate the basement rocks themselves with the divisions accepted by Fraser and Adams for those beds in the Coromandel Peninsula, but these authors adduce several arguments in favour of the view that many of the similar intrusions in the district referred to must have been pre-Tertiary (1907, pp. 88–89). There can be little doubt that those of Great Barrier Island are substantially contemporaneous with these latter.

Origin of Copper Lodes.

Unfortunately the writer has not had the opportunity for a very close study of the copper deposits; the main lode has been worked out, and only a few remnants of the lode-material are visible here and there in the workings. Such information as is available makes Hutton's view of the origin of the deposit untenable, in spite of the fact that he had the advantage of examining the lode whilst mining operations were in progress. Hutton (1869) considered that it originated superficially as a breccia filling a surface fissure.

The present writer's view is that the lode is due to the metallization of an irregular shatter-zone trending approximately north and south. The solutions depositing the cupriferous material were almost certainly genetically related to the numerous porphyrite intrusions near by. This view has very weighty support from the presence of small veins of mixed sulphides —largely chalcopyrite with galena, blende, and pyrite—which are exposed actually on the walls of porphyrite dykes in old prospecting-drives on the north shore of Mine Bay, and up a rill entering Mine Bay Creek from the north about 15 chains up-stream from its mouth (the "New Lode" of Hutton's map).

In the deposit at Miner's Head the ore-minerals are mainly chalcopyrite with its oxidation products; these have been deposited in the crevices of the shattered vein-filling, which is predominantly a somewhat altered argillaceous rock. Hutton considered that the presence of fragments of "diorite" in the vein-filling showed that the intrusions were earlier than the lode, and therefore had no genetic relations to this latter. He apparently failed to appreciate the possibility that the intrusions are not all absolutely contemporaneous.

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Art. XV.—*A Conglomerate at Onerahi, near Whangarei, Auckland, New Zealand.*

By J. A. Bartrum, Auckland University College.

[*Read before the New Zealand Science Congress, Palmerston North, 27th January, 1921: received by Editor, 21st February, 1921; issued separately, 27th June, 1921.*]

Plate XXVIII.

Introduction.

There are certain conglomerates intercalated in Tertiary and earlier strata in various parts of the North Island of New Zealand, amongst the constituent pebbles and boulders of many of which there is material showing evidence of having been subjected to far more intense pressures than have any of the rocks constituting the basement of that Island, with the exception of some at Whangaroa (Bell and Clarke, 1909, p. 44). At this place schistosity is locally developed upon rocks described by Bell and Clarke as altered igneous types, but the cause is ascribed by them to shearing-stresses along a fault-zone.

In a recent paper the writer summarized the recorded occurrences in the North Island of conglomerates containing granitic or dioritic material showing acute pressure-effects, and described a variety of rocks from an occurrence near Albany, in the vicinity of Auckland (Bartrum, 1920). In a second paper he described granitic and granulitic boulders from a conglomerate in the basement rocks of Great Barrier Island.*

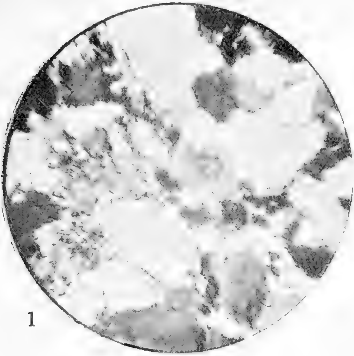
The present note, published here by permission of the Director of the New Zealand Geological Survey, describes interesting pressure-affected and other rock-types from a conglomerate at Onerahi, near Whangarei, which furnish additional evidence of the widespread nature of this pre-Mesozoic land. It is believed that it was not wholly destroyed until after mid-Tertiary times, for the boulders of the Tertiary conglomerates seem too free from decomposition to be merely a rewash of Mesozoic conglomerates. These latter, in any case, are scarce in relation to the wide extent of basement rocks now uncovered for examination.

In a paper read before the Melbourne meeting of the Australasian Association for the Advancement of Science in January, 1921, the present writer adduced arguments in favour of the correlation of the rocks of the pre-Mesozoic land-mass of the North Island with those of the Aorere system, so well developed in the South Island.

General and Petrographic Description of Onerahi Conglomerate.

In December, 1919, in company with Mr. H. T. Ferrar, of the New Zealand Geological Survey, the writer discovered a conglomerate intercalated in greensands exposed between tide-marks a short distance east of the wharf at Onerahi, near Whangarei. The series of beds of which it is part is probably Tertiary in age, and is considerably disturbed by folding. The beds below the conglomerate are not visible, but above it come about 20 ft. of greensands, and then a gradual passage to an argillaceous limestone

* See this volume, pp. 119–20.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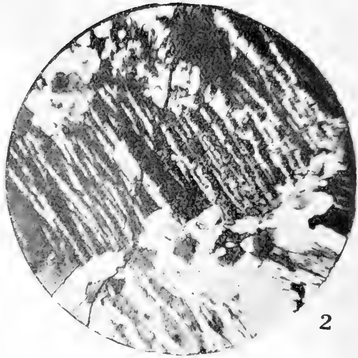
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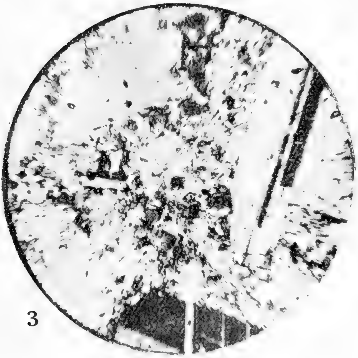
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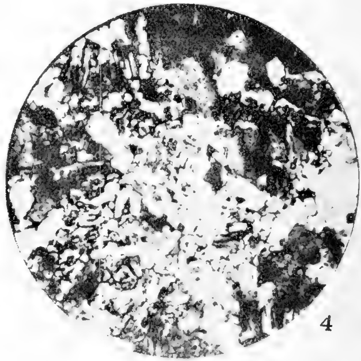
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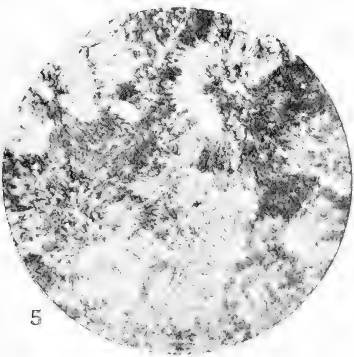
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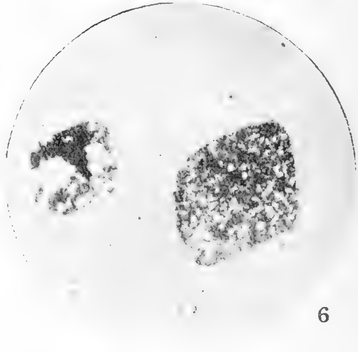
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Fig. 1.—Granulated (?) quartzite from conglomerate at Onerahi. Crossed nicols. × 25.
Fig. 2.—Perthitic feldspar from gneissic granite from conglomerate at Onerahi. Crossed nicols. × 25.
Fig. 3.—Plagioclase phenocrysts in granophyre from conglomerate at Onerahi. Crossed nicols. × 25.
Fig. 4.—Granophyric matrix of rock illustrated by fig. 3 above. Crossed nicols. × 133.
Fig. 5.—Spherulitic structures in matrix of acidic (?) tuff from Onerahi conglomerate. Crossed nicols. × 133.
Fig. 6.—Quartz phenocryst from acidic (?) tuff from conglomerate at Onerahi. It contains rounded fragments of finely granophyric hornblende-feldspar rock. Crossed nicols. × 133.

Face p. 128.]

similar to the very extensive limestone of the North Auckland area usually spoken of as the "hydraulic limestone." The question of its age is still unsettled.

The band of conglomerate is lensoid, ranging up to about 5 ft. in depth, and is exposed standing steeply on edge for about 15 yards. Its pebbles and boulders are well rounded, and, though mainly small, vary upwards in size to 3 in. or more in diameter. The material is chiefly greywacke and shale, with other types of sedimentary rocks, but interesting igneous rocks are also frequent. One other type was also found : it is a quartz-rich granulite, which probably represents a granulated and partially recrystallized quartzite. The rocks of igneous origin include :—

1. Gneissic granite.
2. Acid intrusives—
    (*a*.) Quartz porphyries ;
    (*b*.) Granophyre.
3. (?) Tufaceous acidic rock.
4. Andesitic tuff.

Detailed Petrography.

Granulated (?) Quartzite. (Plate XXVIII, fig. 1.)

Macroscopically this rock resembles hornfels. In section it is seen to be almost wholly quartz showing highly prominent shadow-extinction, with a little untwinned feldspar and perthite. Granulation has been intense, and the minerals form a mass of somewhat interlocking, coarse, partially recrystallized grains with granulated borders.

There are occasional grains of epidote, whilst minute shreds of muscovite are present, mainly in the granulation-products.

Gneissic Granite. (Plate XXVIII, fig. 2.)

This is a very curious granitic rock showing gneissic structure distinctly in hand-specimen. Quartz makes up about half the bulk of the rock, the rest consisting of a very little acid plagioclase and of the coarse perthite so prominently displayed by the photomicrograph.

The only other minerals are rare sphene, a few tiny flakes of muscovite, and some irregular patches representing alteration-products, probably of biotite.

The perthite is on a very coarse scale, and at first glance resembles graphically intergrown quartz and orthoclase ; occasionally the crystals may actually be such intergrowths, but in the majority of cases there is very minute albite-lamination crossing the coarse perthitic striping of the mineral.

The gneissic structure visible macroscopically appears in section as zones of shearing.

Quartz Porphyries.

These are conspicuously porphyritic rocks, somewhat dark in colour, showing feldspar and occasionally quartz phenocrysts in hand-specimen.

Nearly all the sections show a fairly finely holocrystalline granular groundmass, in which are abundant large acid plagioclase phenocrysts. Occasionally there are plentiful orthoclase and quartz crystals. Biotite is present in greatly inferior amount ; it may be fresh or represented by alteration pseudomorphs. The groundmass typically consists of quartz and orthoclase in subequal amounts, but where quartz occurs as a phenocryst the groundmass shows correspondingly less of that mineral. It is sometimes so coarse that the rocks then deserve to be classed as granite-porphyry.

In one section there are a few spongy crystals of brown hornblende, which enclose several quartz-grains ; in the same section there is a xenolite which is apparently a fine weathered granodiorite.

Granophyre. (Plate XXVIII, fig. 3.)

This rock has occasional fairly coarse idiomorphic phenocrysts of plagioclase in a groundmass which contains a moderate amount of plagioclase in laths enwrapped pseudo-poecilitically by quartz crystals which sometimes are large. A very great portion of the matrix, however, consists of micropegmatite, as is well exemplified by fig. 4, Plate XXVIII. There are a few minute flakes of greenish-brown biotite.

The occurrence of granophyres in New Zealand is rather limited. Sollas and McKay (1906, vol. 2, p. 182) describe them from a conglomerate outcropping on the east shore of Palliser Bay, near Wellington. A rock collected by Smith (1908) from river-gravels in Westland, and described by him as granite-porphyry, seems equally to merit the name "spherulitic granophyre."

(?) Tufaceous Acidic Rock.

A difficult rock to classify. It is decidedly fragmental in general character, but appears to have the fragments enclosed in a matrix which is unlike that of a tuff. It is a finely granular mixture of feldspar, green hornblende, and probably quartz, with frequent spherulitic and micropegmatitic intergrowths (see photomicrograph, Plate XXVIII, fig. 5). In it there are large broken crystals of plagioclase, a few of orthoclase, many coarse ones of quartz, and some biotites which are generally chloritized. There are also very small fragments of finely micropegmatitic material, of very fine-grained andesites (some with a little green hornblende), and of an exceedingly fine-grained rock made up of green hornblende and feldspar along with a little micropegmatite and probably quartz.

An interesting phenomenon is the enclosure of micropegmatite and of some of this last-mentioned rock by quartz crystals. In some instances (see Plate XXVIII, fig. 6) there is a very definite band-like margin to the inclusions.

These inclusions, and the nature of the matrix, furnish grounds for suspecting that the rock is not a tuff, but an intrusive in which fragments of intruded rocks have been entangled. Marginal resorption could readily explain the rounded forms of the rock-fragments.

Andesitic Tuff.

This is a compact fine-grained rock having an andesitic matrix in which are enclosed small particles of very fine-grained trachytic rock, either trachyte or trachyandesite.

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ART. XVI.—*The Warped Land-surface on the South-eastern Side of the Port Nicholson Depression, Wellington, N.Z.*

By C. A. COTTON, D.Sc., F.N.Z.Inst., Victoria University College, Wellington.

[*Read before the New Zealand Science Congress, Palmerston North, 28th January, 1921; received by Editor, 1st February, 1921; issued separately, 4th July, 1921.*]

Plates XXIX–XXXIV.

CONTENTS.

THE PROBLEM.

IN 1912 the writer described Port Nicholson, the harbour of Wellington, as occupying an area of subsidence with somewhat indefinite boundaries, and later, in 1918, in a brief account of the coastal features of New Zealand, termed it "a locally downwarped and embayed area." It had previously been described by Bell (1910) as a complex graben. The present article is concerned with evidence of warping on the south-eastern side of this area, which is here termed the "Port Nicholson depression"—warping that is of interest not only from a geological point of view, because of its sharpness, but also from the viewpoint of geography, since it forms a boundary of one of the finest natural harbours in the world (fig. 1).

The South-eastern Boundary of the Depression.

Bell appears to have regarded the eastern boundary of the Port Nicholson depression as a fault-scarp, and eastward of the harbour—between it and the Rimutaka Range—his map and profile indicate the presence of a narrow fault-bounded block standing lower than the block forming that range (1910, pp. 537, 539). No mention of tilting of this step-like intermediate block was, however, made by him.

The writer, in 1912, inclined to the belief that either the original boundaries of the subsided block were flexures rather than faults, or, on the other hand, the original subsidence had taken place so long ago that topographic evidence of faulting had been destroyed. The distinct and prominent scarp of the Wellington fault along the north-west side of the harbour was regarded as of much more recent origin than the depression as a whole, which, though it must have been deepened, was not initiated by the late insinking along this fault. Field-work having been mainly confined to the area on the western side of Port Nicholson, the question of the eastern, or south-eastern, boundary of the whole depression was then left open (p. 262), but reasons were given for rejecting the fault-scarp theory in explanation of it (pp. 261–62). It was pointed out that the slope descending to Port Nicholson is maturely dissected, and that the only facet-like forms and blunt-ended spurs more or less in line occur where cliffing by marine erosion has been recently in progress, and this slope as a whole was ascribed without hesitation to the work of normal erosion guided by structure, it being an erosion-scarp along the outcrop of a resistant highly-inclined stratum.

It may be added that the eastern side of the harbour is now distinctly a shore-line of submergence (Plate XXIX, fig. 1) modified by marine erosion, especially at the southern end, where waves driven into the harbour-entrance by southerly winds still retain considerable energy and have cut a continuous line of cliffs with a height in places of 300 ft. The embayments produced by the submergence are small, but this is because of the steep declivities of the drowned ravines which dissect the erosion-scarp. Similar embayments, filled with alluvium, are present farther north-east along the edge of the Hutt River delta, which partly fills the Port Nicholson depression (Plate XXXIII, fig. 1), and also still farther north-east, where the depression widens again after a constriction is passed, and is occupied by a basin-plain in which lie Trentham and Upper Hutt (Plate XXXIII, fig. 2).

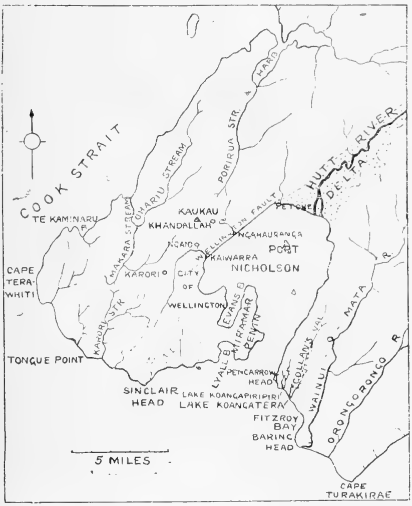

FIG. 1.—Locality map of the Port Nicholson area, New Zealand.

The coincidence of the trend of the erosion-scarp forming this eastern shore-line, and also of nearly all the major drainage-lines in the district, with the strike of the folded rocks, suggests not only that the features are subsequent, but also that they are guided by an alternation of weak and resistant beds in the highly-inclined series of greywackes and argillites forming the bed-rock of the district. The contrast between the weak and resistant zones appears to be due in reality to the relative freedom from joints and planes of shearing in the rocks of the latter, and to the jointed, sheared, and sometimes completely crushed condition of the former, which are perhaps best termed "shatter-belts." These belts, however, with one notable exception—the line of the Wellington fault (Cotton, 1914)—are parallel with the strike, and appear to be the result of thrust-faulting which occurred as an accompaniment of the folding of the strata (post-Hokonui orogeny). (The positions of several fault-zones, or shatter-belts, in the Wellington Peninsula, west of the depression, were indicated by Broadgate, 1916.) Thus the ridge which bounds Port Nicholson and the Hutt Valley on the south-east, along with the straight and parallel valleys of the Mangaroa Stream (a tributary of the Hutt River) and the Wainui-o-mata and Orongorongo Rivers, and the ridges of the Rimutaka Range, to the east, whether or not each is confined to the outcrop of a single formation, may be described with perfect propriety as subsequent in origin. Prior to the formation of the Port Nicholson depression it appears that the whole district was maturely dissected by the subparallel streams of the system just described, and by their numerous small insequent tributaries, with a relief of about 1,500 ft.

The erosion-scarp descending to the shore of Port Nicholson and to the Hutt Valley, as will be shown below, is not the boundary of the whole depression, this being found to be a relatively broad strip of strongly-warped land-surface.

The other boundaries of the depression call for passing reference only. On the north-western side the immaturely dissected scarp of the Wellington fault, mentioned above, meets the warped eastern slope obliquely in the Hutt Valley, which is thus a fault-angle depression. South-westward this fault-scarp extends inland about a mile and there dies out, and thence southward to the sea-coast the western side of the depression is apparently a warped surface, though evidence of the exact nature and extent of the warping has not yet come to light. Seaward, to the south, the depression is open to the Pacific Ocean.

General Tectonic Features of the Depression.

The foregoing features of the Port Nicholson depression, taken in conjunction with the observation that the Wellington fault-scarp follows a pre-existing line of weakness—a very prominent shatter-belt extending north-east and south-west, somewhat oblique to the system of subsequent features previously referred to, and marked by prominent subsequent fault-line valleys (Cotton, 1914)—would seem to indicate that faulting must be regarded as merely an incident in the formation of the depression. The principal event appears to have been the sharp downwarping of a belt of land about thirty miles long elongated in a north-north-east and south-south-west direction (and extending an unknown distance farther to the south-south-west beneath the sea). The depth of downwarping that must be assumed is variable, the maximum being perhaps in the neighbourhood of 1,500 ft., or perhaps rather more, where the broadest part of Port Nicholson now is. The width of the strip affected also varies in different parts, but is at least ten miles where Port Nicholson is widest. Both depth and width diminish, though irregularly, to the north-east up the Hutt Valley.* It is as though the sagging-down in synclinal fashion of an ill-supported superficial flake of the lithosphere crossed fortuitously by the shatter-belt marking a pre-existing fault had resulted incidentally in the formation of the more modern Wellington fault, the scarp of which replaced part of the warped border of the depression.† When the evidence of the features of the neighbouring coasts are taken into account, however, it appears unlikely that the harbour-depression can be accounted for so simply as by mere downward sagging owing to lack of support. The deformation of the ancient strand-lines may be ascribed to compressive folding, or the warping of the land to the east and south-east may be described as tilting of an earth-block, for, as shown below, the warping or tilting has

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* If, as Adkin (1919) has suggested, the drowning of Porirua Harbour and the formation of Port Nicholson are due to the same movement, the downwarped strip must become wider northward, or must send out a branch towards Porirua Harbour.

† Similar synclinal warping with one side partly replaced by a fault occurs in the Aorere district, in northern Nelson (Cotton, 1916B).

taken place about a hinge-line, depression being confined to the western side of this, while to the east there is evidence of uplift only. The tilted block affected by this movement is elongated in a north-north-east and south-south-west direction, and is bounded on the east by a well-marked fault-scarp which forms the eastern front of the Rimutaka Range (Cotton, 1916, p. 318) and the fault-coast of Palliser Bay.

As will be shown below, this movement took place very recently. Such strongly differential movement of a small earth-block in very recent times is unusual even in New Zealand, though it was common enough in somewhat earlier times when the mountain masses were blocked out and the river-courses determined by the movements to which the name "Kaikoura" has been applied (Cotton, 1916). Since the Kaikoura orogenic movements took place throughout New Zealand a very great deal of erosion has occurred, but in the Port Nicholson area, on the other hand, the later stages at least of the tilting, warping, and faulting deformed and dislocated a land-surface the relief of which had already become very nearly that of the present day.

The features here described may perhaps be correctly ascribed to a modern local recrudescence of the Kaikoura movements. It is interesting to note in this connection that the latest movement which affected this area—that which accompanied the earthquake of 1855—tilted a block of considerably greater width, though bounded on the eastern side by the same fault, and that the whole district here described was uplifted, including the previously depressed harbour area (Lyell, 1868). It is as though the events which led to the formation of the harbour-depression were a belated reversion to the Kaikoura type of movement, resulting in strong local deformation of the surface, interrupting the more stately movements of larger blocks now in progress throughout the New Zealand region. The fact that the 1855 movement was of the latter type has led the writer to suspect that even in the Port Nicholson district such movements are now normal, and to formulate a working hypothesis that a succession of nearly uniform uplifts preceded the warping and tilting that formed the Port Nicholson depression. The real succession of movements has not yet been worked out with certainty, however, and some puzzling features still remain unexplained.

It is highly probable that the warping or tilting responsible for the features here described did not go on continuously and rapidly as a single event, but was broken by pauses of considerable length. Little more than the general evidence can be considered at present, however, as it has not yet proved possible to separate satisfactorily the evidence of successive movements.

The Evidence.

Summary.

The evidence of tilting and warping on the eastern side of the Port Nicholson depression is of three kinds: (1) Tilted uplifted coastal platforms, (2) progressively more extensive drowning of valleys from the hinge-line of tilting to the axis of maximum depression (which is accompanied by rejuvenation of the valleys on the other side of the hinge-line), and (3) evidence of regrading in warped valleys, particularly aggradation in such as are tilted backward.

The evidence under the first two heads is found in one line of section only, that formed by the sea-coast, while that under the third head can be seen at a number of places along the eastern boundary of the depressed area.

Tilted Coastal Platforms.

The Platforms farther West.—As previously noted by the writer (1912; 1916A), the coast both east and west of the entrance to Port Nicholson is bordered by remnants of platforms cut by marine abrasion when the land stood considerably lower than it does now. Around the shores of Port Nicholson itself, and on the partially drowned ridges immediately to the west of the entrance, which form part of the deeply depressed area, no traces of uplifted benches clearly referable to marine erosion are to be found above the rock platform that was raised a few feet above sea-level in 1855. Since parts of this shore-line have not suffered severe retrogradation by marine erosion, some remnants of uplifted platforms should survive if such had existed; and it may therefore be assumed from their absence that this part of the coast has always escaped uplift, or that any strands that have been uplifted have been lowered again below sea-level. The profile of the sea-bottom off shore, as revealed by soundings, does not show terraces such as would be produced by submergence of cliff-bordered remnants of cut platforms; but this negative evidence has little significance, for the initially sharp, well-defined subaqueous features that would be thus produced would soon be obliterated by deposition of the large amount of waste supplied from the neighbouring mountainous area of rather easily eroded rocks, which are subject to strong marine as well as subaerial erosion.

To the west of the depressed area the high-standing marine platforms indicate uplift and a limited amount of deformation. Two such platforms are distinctly recognizable (Cotton, 1912, fig. 7; 1916A, fig. 8), but only the lower of these can be traced for any considerable distance along the coast. At Tongue Point it is continuous as a broad shelf (except where intersected by a large ravine) for two miles, and at the ravine, where a section of the ancient beach at the rear of the platform may be seen, its height is 230 ft. In this portion no variation in the height of the rear of the platform has been observed, though its variable width, and especially its variable seaward slope, give a false appearance of irregular variation in height when it is viewed from the offing. For three miles farther westward, as far as Cape Terawhiti, the platform is traceable continuously, though it is thickly covered with talus and only at a few places is wide enough to form a distinct bench. When the cliffs are viewed from the sea, however, the top of the talus-covered wave-cut platform can be distinctly traced all the way, and where the bench is narrow this cannot be far below the ancient strand-line, which is thus seen to descend gradually to a height of about 100 ft. at Cape Terawhiti.

It appears, therefore, either that this portion of the coast was uplifted with a gentle westward tilt, or that it was uplifted more evenly and afterwards tilted gently westward; and, though the evidence cited indicates greater deformation of the ancient strand-line than the writer formerly supposed had occurred (Cotton, 1912), this deformation is slight as compared with that in the Port Nicholson area.

It may be inferred, first, that the land west of the Port Nicholson depression was uplifted with only slight deformation while Port Nicholson was sinking, the two areas being connected by a warped strip; or, secondly, that the two areas represent blocks moving quite independently (though at the coast-line there is no recognizable fault-scarp separating them); or, thirdly, that the uplift which raised the platforms on the west affected the whole district nearly evenly, and that in the Port Nicholson area the uplifted platforms have been resubmerged by more recent warping

—perhaps contemporaneously with the gentle tilting of the western coastal platforms. In the last case, as in the first, there must be a transitional area between the permanently uplifted and the resubmerged areas. The uplifted platforms give no information as to the nature of the warping in the transitional strip, for three-quarters of a mile eastward of Tongue Point they end, their former continuation having been cut away by modern cliff-retreat.

Platforms of the Eastern Side tilted towards the Depression.—To the eastward, though not actually bordering Port Nicholson itself, coastal platforms make their appearance not far from it, and these are strongly tilted.

As on the western side, there is only one bench that can be traced for a considerable distance with certainty; and there is a temptation to correlate it with the 230 ft. platform at Tongue Point, but such correlation is by no means certain. The ancient shore-line at the rear of this bench, which may be termed the "Baring Head platform," as it is developed around Baring Head (Plate XXIX, fig. 2), rises from 100 ft. in Fitzroy Bay (fig. 2) to 450 ft. at the mouth of the Orongorongo River (Plate XXX, fig. 1). Its continuation in both directions beyond these points has been

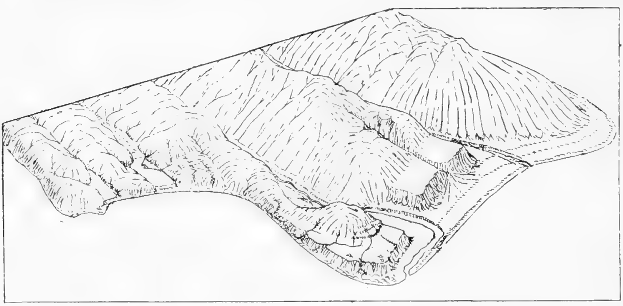


FIG. 2.—Diagram-sketch of the southern end of the tilted area east of Port Nicholson. From left (north-west) to right (south-east) the coastal features shown are: Pencarrow Head, Lake Koangapiripiri, Lake Koangatera, Fitzroy Bay, Baring Head, Wainui-o-mata River, Orongorongo River, Cape Turakirae.

destroyed by cliff-recession, but between them it is quite continuous except for the narrow, steep-sided valley through which the Wainui-o-mata River flows out. The distance in a direct line between the two ends of this platform remnant is two miles, and along this line a tilt of 175 ft. per mile is therefore indicated. This is, of course, very distinctly visible to the eye (fig. 2, and Plate XXX, figs. 1 and 2; see also Cotton, 1916A, fig. 19), though, as the bench follows the trend of the coast around Baring Head, the whole of it cannot be seen at once except from some distance out at sea.

The Baring Head platform is very slightly dissected. It retains its discontinuous covering (in places 30 ft. deep at the present cliff-edge) of gravel and coarse sand, both derived from the local greywacke, the sand being now almost completely weathered into sandy clay. Through this veneer the solid rock projects in places, some of the projections rising 20 ft. above the ground-level as stacks, which are now crumbling to

FIG. 1.—The eastern shore of Port Nicholson, an erosion-scarp with steep-grade ravines, embayed by partial submergence, cliffed by marine erosion, and later in part prograded.

FIG. 2.—The Baring Head platform as seen from Cape Turakirae, 450 ft. high at the eastern (right) end, and 270 ft. high at Baring Head (on the left), broken by a single gap at the mouth of the Wainui-o-mata River.

FIG. 1.—The Baring Head platform between the mouths of the Wainui-o-mata and Orongorongo Rivers, with Cape Turakirae in the distance.

FIG. 2.—The Baring Head platform, Orongorongo platform, and higher benches, as seen from the extremity of Baring Head, showing the accordance of the Baring Head platform across the gap formed by the mouth of the Wainui-o-mata River.

decay. These stacks are exceptional features of the high-standing coastal platforms, the smoothness of which seems at first sight remarkable when they are compared with the rugged rock platforms of the modern shoreline; but the explanation seems to be that the rocky prominences soon succumb to subaerial weathering. At the extremity of Baring Head a rocky table which evidently was cut very nearly at sea-level, being perhaps bare at low water, now forms the outer part of the platform remnant (Plate XXXI, fig. 1), and is separated from the ancient cliff behind it by the bed of a channel 6 ft. or 8 ft. lower, floored with coarse sand containing gravel lenses. This outlying reef was evidently the outcrop of a belt of resistant rock. It and the ancient channel behind it are distinctly traceable along the platform for half a mile northward.

The small streams which drain the surface of the platform appear to be all consequent. On the eastern side of Baring Head they flow directly towards the sea, but on the north-western side the little streams from the cliff above join one which flows for a few hundred yards lengthwise (northward) along the platform before turning seaward. This is quite clearly guided by the channel between the land and the ancient outlying reef described above. The northward direction agrees with the direction of tilting of the platform. No abandoned courses or gaps in the outer reef were observed which would indicate that streams had been diverted either by capture or by tilting from former more direct courses to the sea. On the surface of the platform the streams flow in widely-opened shallow valleys in the soft veneer of gravel and sand, and they have cut notches in the bed-rock only at the cliffed edge of the platform. The above description does not apply to larger, extended streams, such as the Wainui-o-mata, which crosses the platform at grade in a deep valley, or a smaller extended stream between the latter and the Orongorongo, which has deeply notched the platform.

At Baring Head there are also two very distinct remnants of benches at heights of 80 ft. and 160 ft. respectively above the Baring Head platform (fig. 2). At the back and front of each there is a distinct cliff, and the covering of gravel on the highest is still quite fresh. Where observed in a prominent outcrop the gravel consists of a mixture of large and small pebbles without any finer material, and is loosely cemented with iron oxide. These benches are drained by channels which cross them at right angles. As in the case of all uplifted platforms backed by cliffs, it is difficult to determine the exact levels of the ancient shore-lines because of the amount of talus material overlying them. For this reason, together with the fact that the remnants do not extend for more than a few hundred yards along the western side of Baring Head, it was not found practicable to decide whether they are tilted to exactly the same extent as the Baring Head platform or not, though when they are viewed from a distance the impression received is that the benches are approximately parallel.

Eastward of Baring Head, between the Wainui-o-mata and Orongorongo Rivers, the two benches last mentioned do not survive, but above the eastward continuation of the Baring Head platform (which rises here to 450 ft.) there are other well-preserved remnants at a much greater height (Plate XXX, fig. 2). The most prominent of these is the next above the Baring Head platform. It is of considerable width, is submaturely dissected, and rises to a height of 900 ft. at the eastern end. This may be termed the "Orongorongo platform." It and the two higher remnants, which are several hundred feet higher and are nearly as well preserved (Plate XXX, fig. 2), are seen from seaward to be distinctly tilted westward, and their inclination in that direction appears to be parallel to that of the Baring Head platform below them.

None of these platforms can be traced with certainty beyond the Orongorongo River and around Cape Turakirae, which forms the end of a narrow mountain-ridge, but the profile of the ridge is smooth towards the end, and there is a faint suggestion of a bench rounded and lowered at the margin by erosion, the rear of which is at a height of about 1,200 ft. This may perhaps be the continuation of the Orongorongo platform (Plate XXX, fig. 1).

Westward also the continuation of these higher platforms is doubtful, but the Orongorongo bench may perhaps be correctly correlated with a platform of considerable extent forming the crests of the ridge and spurs between the Wainui-o-mata valley and the lake (Koangatera) at the mouth of the Gollan's Valley stream. This platform, which may be named the "Wainui platform," is submaturely dissected. and is 500 ft. high at its rear on the ridge west of the Wainui-o-mata valley. It slopes southward (towards the sea) fairly steeply, but not so steeply that its slope in that direction cannot be explained as probably original.

The points at which the observations of the height of the rear of the Orongorongo platform as 900 ft. and of the Wainui platform as 500 ft. were made are two and a half miles apart, in a north-westerly direction, and thus, on the assumption that these two may be correlated, the tilt indicated is the same as that of the Baring Head platform.

Farther to the west the Wainui platform, still descending, is cut through by Gollan's Valley, on the eastern side of which the height of the rear of the platform is 340 ft. and on the western side only 180 ft. Here (between the lakes Koangatera and Koangapiripiri) the platform is half a mile wide and very distinct, though submaturely dissected. It is not shown on the published contoured map of the district, which at this point is not quite accurate. There is no trace of this platform, or of any others, farther on around or beyond Pencarrow Head.

Besides these remnants of uplifted and tilted coastal plains there is eastward of Baring Head a less strongly uplifted strip of recently emerged sea-bottom, which extends round Cape Turakirae (fig. 2, and Plate XXX, fig. 1) and along the western shore of Palliser Bay (Aston, 1912). It will be referred to as the "Turakirae coastal plain." The greater part of this coastal plain, though its seaward slope is very steep (about 1 in 10), is not yet cliffed at the margin. Strangely enough, it was not found to be tilted to the westward, as the higher benches are. The absence of evidence of tilting, and the difficulty which this raises as to the non-continuation of a feature indicating such recent uplift along the coast westward of Baring Head, necessitate the introduction of a brief description of the Turakirae coastal plain; but, since this would make too long a digression at the present stage of the presentation of the evidence of tilting, it is placed in an appendix.

Evidence from Drowned Valleys.

The tilting of the block east of Port Nicholson on a hinge-line, which may be assumed in explanation of the tilted uplifted platforms described above, involves partial or complete submergence of its north-western edge, and this is found not only in the drowning of the central part of the Port Nicholson depression to form Port Nicholson itself, but also, nearer at hand, in the drowned mouths of two small valleys opening between Pencarrow Head and Baring Head. As the shore-line is followed westward from Baring Head towards Port Nicholson for some distance the mouths of small ravines only are passed, and these hang above the shore-line as a result of cliff-recession that has recently been in progress. Slight submergence produces no noticeable effect on the mouths of hanging valleys such as these, and so the exact position of the hinge-line of tilting cannot be ascertained from them. Farther on, however, Gollan's Valley and the valley of a small stream debouching close to Pencarrow Head are drowned to such an extent as to indicate very considerable submergence (fig. 2, and Plate XXXI, fig. 2).

Gollan's Valley is fairly large, heading eight miles inland, but the other is only two miles long. The streams in both are of such size, however, that it may be supposed that they reached the sea at grade prior to submergence. It is clear that both, when first drowned, were occupied by winding lanes of sea-water, the one three miles and the other rather more than a mile in length. These bays are now cut off from the sea and converted into fresh-water lakes by gravel bars 20 ft. in height above sea-level and accordant with the pre-1855 storm-beach ridge, which is well developed along the neighbouring shore-line in Fitzroy Bay. At the western end of each bar the outflowing water has opened a channel through the gravel.

The enclosed bays are much reduced in size by the growth of swampy deltas at their heads, and the length of the two lakes which now occupy their lower parts (Koangatera in Gollan's Valley and Koangapiripiri in the other) is thus reduced to about half a mile in each case. The upper part of Gollan's Valley is also thickly aggraded with alluvium. Near the mouths the sides of both valleys are cliffed, and out-jutting points are strongly truncated (Plate XXXI, fig. 2). The cliffs reach a height of 100 ft. on the shores of Koangatera and 50 ft. around Koangapiripiri, and they are evidently the work of waves at a time when the bays were still deep and open to the ocean. For a mile up the somewhat winding Gollan's Valley the swampy delta is bordered, however, by low wave-cut cliffs. These must be the work of waves raised on the narrow landlocked waters, and their presence indicates a long period of still-stand prior to 1855, for the relative levels of sea and land were constant long enough not only for the development of distinct cliffs (though on mature hill-slopes of weathered rocks, it is true) by waves with a fetch of no more than a few hundred yards, but also for the delta-front to advance for quite a mile past the farthest inland point where cliffs are traceable. This indicates that the uplift of 1855 was either the precursor of a new series of earth-movements or was an isolated phenomenon; and the shore-line features at the western side of the entrance to Port Nicholson lend support to this view.

As the writer has shown elsewhere (Cotton, 1921), this is a matter of great practical importance. If movements like that of 1855 had been common in the immediate past the outlook for the future safety of the city of Wellington and the continued usefulness of its harbour would be rather poor; for it must be remembered that the cause of the disastrous earthquake of 1855 was directly connected with the uplift which then occurred, and also that the harbour was made fully 5 ft. shallower by the same movement. As it is clear from what has been stated above that the 1855 movement was the first of its kind in this district for thousands of years, the outlook for Wellington is distinctly hopeful.

A rough indication of the measure of the submergence shown by the drowning of the valleys to form the bays now occupied by the lakes Koangatera and Koangapiripiri can be obtained by comparing the widths of the mouths of the embayments with the widths of similar but unsubmerged valleys in the district at various heights above the floor, and also by comparison of the lengths of the drowned portions with the average gradients of similar valleys. For this purpose the contoured map of the district has been used. The result shows that the depth of submergence at Gollan's Valley may be as much as 200 ft., but cannot be more. The Koangapiripiri valley is so small that the result obtained by comparison with the small-scale map available is not very reliable, but the submergence indicated does not seem to be greater than in Gollan's Valley, though indications of greater submergence might be expected, seeing that it is half-way between the latter and the deeply-drowned entrance to Port Nicholson.

The evidence of the drowned valleys supports the hypothesis of fairly even tilting towards the Port Nicholson depression. The position of the hinge-line is not definitely indicated. It is possible that the mouth of the Wainui-o-mata valley has been very slightly drowned and quickly filled again with alluvium by the river, but this is doubtful. Farther east, however, at the mouth of the Orongorongo, there has been no submergence, for this river is cutting on bed-rock at the mouth.

Some of the rejuvenation of which there is evidence in the Orongorongo valley is in all probability a result of the uplift of the eastern side of the tilted area which caused the emergence of the Turakirae coastal plain. Hence the rejuvenation of the eastern valleys is not such good proof of tilting as the drowning of the western valleys.

Evidence from Regraded River-valleys.

Near the coast the larger streams flow without exception in courses parallel with the hinge-line of tilting inferred from the evidence already described. They are close together, and have only very small, steep-graded tributaries. In this part of the district there are, therefore, no streams that would be particularly sensitive to tilting in a west-north-westerly direction towards the Port Nicholson depression. Degradation in the Orongorongo and Wainui-o-mata valleys, of which there is evidence in the presence of low terraces, might be the result of purely regional movement, and distinct terraces can be correlated with uplifted strand-lines on the Turakirae coastal plain, which lies across their mouths. The aggradation in Gollan's Valley, which has previously been described, can be accounted for by the drowning of the valley-mouth. Nevertheless the western branch of Gollan's Valley is aggraded quite to the head, as though as a result of headward tilting, which would be the result of the general downwarping of the surface towards Port Nicholson.

There is a suggestion of aggradation also in some parts of the valley of the Wainui-o-mata, which is somewhat winding. It is a mature valley, with a flood-plain, and this widens out considerably in places, where the valley bends to the west. Though such expansions are due in part to the development of large curves by lateral planation and their later abandonment when the stream returned by a cut-off to a straighter course, they appear to be partly the result also of aggradation in response to backward tilting in certain reaches, either because these are below westward bends in the sinuous valley, or else on account of transverse warping, such as certainly occurs farther north, corrugating the general slope of the country towards the Port Nicholson depression.

These aggradational effects are, however, much less definite proof of tilting than some which are found farther north, opposite the Hutt delta and the upper Hutt Valley. Here, though the principal valleys still trend north-north-east or south-south-west (Cotton, 1914), a number of tributaries of moderate size enter them from the west. The western branch of the

FIG. 1.—The Baring Head platform on Baring Head, showing a flat-topped ancient outlying reef surmounted by stacks.

FIG. 2.—Lake Koangatera, at the drowned mouth of Gollan's Valley, showing strongly-cut sea-cliffs along the sides and bordering the bay-head delta in the foreground.

FIG. 1.—The aggraded, headward-tilted valley of the western branch of the Wainui-o-mata, as seen from a point on the divide at its head.

FIG. 2.—View looking seaward across the widest part of the rocky coastal plain of Cape Turakirae, showing successive beach-ridges built during pauses in the uplift.

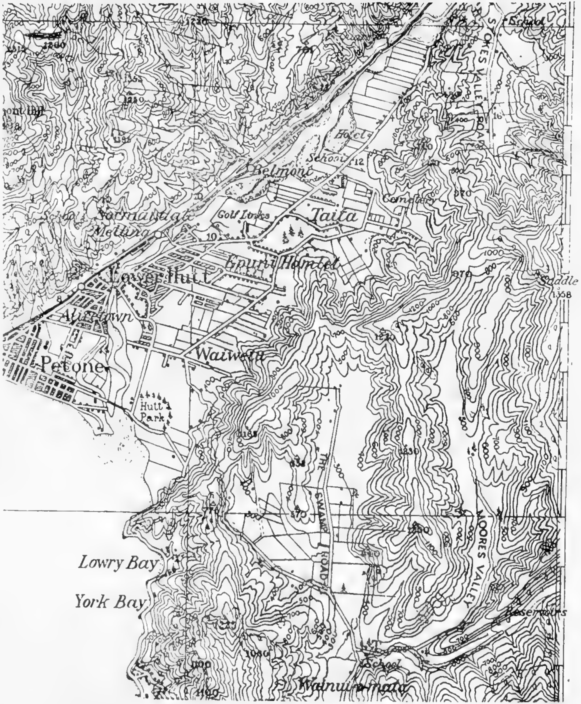
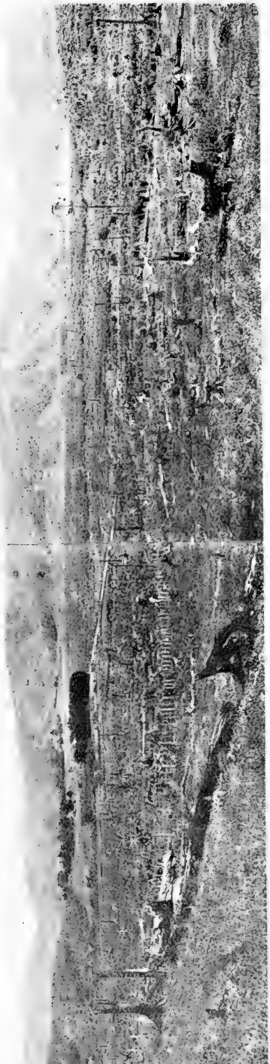


Fig. 1.

Fig. 2.

Fig. 1.—Map of the Hutt River delta, which partly fills the Port Nicholson depression, and the aggraded valley of the western branch of the Wainui-o-mata. Approximate scale: $\frac{1}{2}$ in. + = 1 mile. (From the $\frac{1}{2}$ in. topographic map.)

Fig. 2.—Map showing the Upper Hutt basin-plain (an expansion of the north-eastern continuation of the Port Nicholson depression) and the aggraded tributaries of the Mangaroa. Approximate scale: $\frac{3}{4}$ in. = 1 mile +. (From the map of the Trentham Manœuvre Area.)



An aggraded plain in small headward-tilted tributaries of the Mangaroa River. In the centre the fans are confluent across the neck of a spur, the continuation of which emerges from the alluvium in the left middle distance. Angle of view, south to west.

Wainui-o-mata (Plate XXXII, fig. 1) is a good example of a backward-tilted valley. It is occupied by an aggraded plain almost to the divide at its head, as shown by the contoured map (Plate XXXIII, fig. 1), but the aggradation does not extend far down the main valley beyond the junction, where there is merely a flood-plain in the valley-bottom. Another branch of the Wainui-o-mata, Moore's Valley, is aggraded also, but not to its head, for this does not turn so far westward.

Very striking topographic features resulting from aggradation which must be the result of headward tilting occur in a tributary entering from the west the Mangaroa River, itself a tributary of the Hutt (Plate XXXIII, fig. 2). The Mangaroa is one of the apparently subsequent, north-north-eastward-flowing streams, and so is approximately parallel to the hinge-line of the most prominent tilting. The tributary referred to, or, more correctly, the several small streams which join to form it, flow at right angles to this direction—*i.e.*, east-south-east, or directly against the slope of the land-surface which a little farther on descends below the alluvium in the Hutt Valley (a north-easterly extension of the Port Nicholson depression). It is clear that, before they were tilted headward by an earth-movement, these small streams flowed in courses approximately the same as those they now follow across a maturely dissected surface not very different from that now existing, and the present topographic features indicate that the tilting was so sharp that these steep headwater streams, with declivities as steep as several hundred feet per mile, were caused to aggrade vigorously, so as to spread an extensive sheet of alluvium. (At some stage they may have been ponded, though any evidence of such ponding is now buried beneath alluvium.) The valley-floors are now broad fan-like slopes of alluvium, the greater part of which lies just below the 800 ft. contour (Plate XXXIII, fig. 2). The fans are steep at the valley-heads, where they extend almost to the divide, and lower down are swampy except where they have been drained artificially. They spread out widely in the middle parts of the tilted valleys and taper away towards the junction with the Mangaroa Stream. To such an extent are the valleys filled about the middle of their slope that the fans in two of them have become confluent across the neck of a spur, the end of which now stands as an island surrounded by alluvium (Plate XXXIII, fig. 2, and Plate XXXII, fig. 2).

A few miles north-eastward, at Wallaceville, the Mangaroa Valley is itself aggraded. Some aggradation is to be expected as the axis of the Hutt Valley is approached, for the latter, as mentioned above, is in some places deeply filled with alluvium, and from it aggraded plains extend some little way up tributary valleys, converting them into embayments. Such aggradation does not, however, extend far up small valleys that are strongly tilted down-stream. Above the partial filling due to alluviation outside their debouchures streams entering the depression from the slope of the tilted surface ought, in general, to be rejuvenated. In spite of its belonging to this class of streams the valley of the Mangaroa is aggraded for several miles; for the lower part of the valley, which crosses the tilted block-surface very obliquely, appears to have suffered headward tilting owing to its crossing the transverse corrugation which causes the Hutt Valley to expand so as to become a basin-plain at Trentham and Upper Hutt (Cotton, 1914). This introduces into the tilting for some distance a south-westward component, which appears to be the cause of the aggradation in the Mangaroa, and more especially in Black Creek, a small tributary coming in from the south-west. The valley of the latter is filled in to form a swampy plain a mile wide and three miles in length, which shows up very conspicuously on the contoured map (Plate XXXIII, fig. 2). This plain (the Mangaroa Swamp) is so level that it is highly probable it is in part a filled-in lake due to warping, rather than a plain wholly formed by aggradation.

The Mangaroa River near its junction with the Hutt is now degrading again, and this rejuvenation is shared by the upper part of the Hutt River and its other tributaries. It is due apparently to steepening of the upper course of the Hutt by the latest warping movements.

Appendix.

The Problem of the Turakirae Coastal Plain.

As mentioned previously, there is, to the east of the Port Nicholson depression, besides the uplifted and tilted platforms that have been described a less-strongly uplifted coastal plain, which fringes the coast eastward of Baring Head, around Cape Turakirae, and along the western shore of Palliser Bay. This feature has been described by Aston (1912) as "the raised beaches of Cape Turakirae." Though, on account of its roughness, "plain" may not seem an appropriate term to apply to it, the fact that it is a recently-emerged strip of sea-bottom brings it into the class of coastal plains as defined in systematic geomorphology. As the deposit of gravel and boulders on it is merely a thin and discontinuous veneer, and the obvious stacks and many of what are apparently boulders remain attached to bed-rock, it might also be described as a plain of marine erosion. Aston referred to part of it as a "boulder plain."

Though the seaward slope of the coastal plain is very steep (about 1 in 10), the greater part of it is not yet cliffed at the margin. Unlike the higher benches, the Turakirae coastal plain is not tilted to the westward—or, at any rate, is not tilted to an appreciable extent. Aston found the height of the highest strand-line, at the rear of the plain, to be 95 ft., while the width varies from 250 to 400 yards.

The great size of the boulders and the general ruggedness of the former sea-bottom correspond with the exceptional steepness of its profile, which allowed the sea to abrade the cut platform and attack the cliffs behind the former shore-line with the energy of the ocean-waves practically undiminished by the friction of the bottom.

The plain is widest at Cape Turakirae, and it tapers off and ends about five miles north-eastward.

In addition to that developed prominently in places at the rear of the plain (No. 5 beach of Aston), Aston has recorded the presence of four other storm-beaches at lower levels, built during pauses in uplift. Those which he terms Nos. 4, 3, and 2 are at heights of 80 ft., 60 ft., and 40 ft. above sea-level. The latter two are very prominent and continuous around Cape Turakirae (Plate XXXII, fig. 2). The beach termed No. 1 by Aston he regarded as formed prior to 1855 and uplifted by the movement accompanying the earthquake of that year. Recent observations by the writer show, however, that parts of this beach have now been reworked and incorporated into the modern beach, as has occurred also on some other parts of the coast near Wellington. In some places, no doubt, there was no storm-beach ridge prior to 1855, while in other places the pre-1855 ridge has since been destroyed by marine erosion.

The continuous raised beach-ridges ought to record any tilting along-shore that has occurred since their formation. Down-tilting following even uplift would cause the raised beaches, when traced laterally, to disappear successively beneath the present sea-margin, while progressive tilting during uplift would be indicated by convergence of the beach-ridges. While aneroid observations do not indicate tilting (Aston, 1912), spirit-levelling of the 40 ft. and 60 ft. beaches might show a small amount of the latter kind. The higher beaches are largely smothered by fans, and correlation of isolated parts is somewhat uncertain. So these would be less suitable for testing by precise levelling.

The writer's observations, though his investigation of the Turakirae coastal plain has been very incomplete, have convinced him that the tapering-away of the plain at each end is due not to tilting, but to the rocky platform being cut away by marine erosion as the land rose. At the north-eastern end the beaches are smothered by fans, which must conceal also the cliffed margin of the higher part of the plain. The lower part of the plain continues some distance farther as a narrow bench 20 ft. above the sea, with a cliffed margin.

Towards the western end of the plain the higher beaches are smothered in a similar way by fans, but beyond these there is at the western side of the mouth of the Wainui-o-mata a small cliffed remnant of a beach-covered bench which appears to be at exactly the height of the rear of the plain at Cape Turakirae. The platform which bears the 60 ft. beach-ridge is also distinct on both sides of the mouth of the Wainui-o-mata; but farther west there is no further trace of the coastal plain, though in Fitzroy Bay there is a modern storm-beach ridge 10 ft. to 12 ft. above mean sea-level, and also a raised beach-ridge, presumably the pre-1855 beach, 10 ft. higher.

The discontinuity of the Turakirae coastal plain remains an unsolved problem. There is no trace of it around the comparatively sheltered inner shores of Port Nicholson, or, indeed, anywhere west of Baring Head. If it has been exposed by differential uplift, or its continuation resubmerged by differential subsidence, no fault-scarp boundary between the differently-moving blocks has been traced, and if this boundary is a warped surface the warped part of the Turakirae coastal plain must have been cut away by marine erosion. It is clear, however, that the even uplift of the Turakirae coastal plain took place later than the warping described in the body of this paper.

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Art. XVII.—*Porirua Harbour: a Study of its Shore-line and other Physiographic Features.*

By G. Leslie Adkin.

[*Read before the Wellington Philosophical Society, 13th October, 1920; received by Editor, 8th December, 1920; issued separately, 4th July, 1921.*]

Plate XXXV.

Contents.

Introductory.

The inlet known as Porirua Harbour, a landlocked arm of the sea, is a unique geographical feature of the western coast of south-western Wellington (fig. 1). Along this coast all other indentations are the result of marine abrasion acting more effectively than elsewhere on the weaker sections of the coast, the more resistant portions, which are receding less rapidly under wave-attack, being left to form the intervening promontories and headlands. Marine abrasion has played only a minor part in the shaping of Porirua Harbour—a part, however, that was important in connection with the evolution of the shore-line of that inlet.

The outline of Porirua Harbour is characteristic of a drowned area where the sea has penetrated a branching valley-system of somewhat mature topographic development. Two of the principal branches of this valley-system are now occupied by tide-water and constitute the present harbour or inlet, while other former indentations have been reclaimed from the sea by the infilling accomplished by local streams.

One of the first to touch on the physiography of the Porirua area and to correlate it with that of Port Nicholson was Dr. J. M. Bell (1910), who expressed the opinion (*loc. cit.*, p. 539) that the surface of a tilted earth-block dips from near the crest of the scarp of the Wellington fault in the direction of Porirua and forms the slope which originally determined the course of the Porirua as a consequent stream. The validity of the first part of this statement is borne out by the existence of a peneplane surface —evidently referable to the Kaukau cycle of Cotton (1912)—which surmounts the valley of the Porirua Stream and slopes towards sea-level in a northerly direction. In the same paper Bell also referred to certain historical proof that the small uplift which affected the district round Wellington City during the 1855 earthquake extended into the Porirua area, inasmuch as the Pahautanui Stream became noticeably less navigable than formerly.

Dr. C. A. Cotton in a detailed paper on Wellington physiography (1912) referred to the Porirua area at rather greater length. He dissented from the view held by Bell that the Porirua Stream flows down the back slope of a tilted block, on the grounds that the Porirua occupied its present

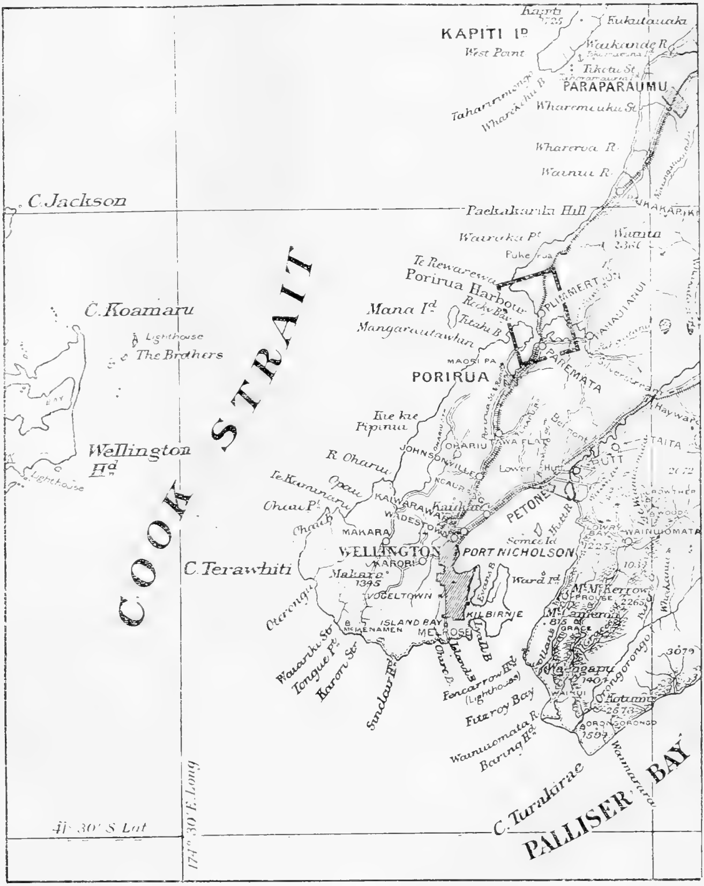

FIG. 1.—Locality map of south-western Wellington, showing places mentioned in text; also the area at Porirua Harbour shown in figs. 4, 5, and 6.

valley before the faulting and tilting took place. It does not necessarily follow, however, that the excavation of the Porirua Valley has been accomplished since the faulting and tilting, and that it was not in existence prior to those events. The drowning of the lower reach of the Porirua Stream to form one arm of the present inlet is ascribed by Cotton (*loc. cit.*' p. 257) to a downward movement of 30 ft. or 40 ft. subsequent to the general movement of elevation of the Wellington Peninsula, but no precise cause of the subsidence is proffered. Cotton also states that "at Porirua there appears to have been little or no movement either up or down in 1855. Raised rock platforms similar to those at Wellington are not found." I shall be able to show, however, that raised shore-platforms of wave-planed rock do occur along a very considerable part of the Porirua shore-line, and form one of its most conspicuous features.

The present writer had occasion to refer to the Porirua area in connection with an apparent deformation of the southern end of the Horowhenua coastal plain (Adkin, 1919, pp. 110–12). The deformation of the coastal plain was ascribed to its intersection by the subsiding, or downward tilting, of the earth-block, bounded east and west probably by flexures, which extends from Port Nicholson to Porirua Harbour, and thence northward past Pukerua inside the Island of Kapiti After a detailed examination of a large portion of the Porirua area the writer sees no reason for any modification of this solution of the problems involved.

The Land.

Since the present paper has for its main theme the description and interpretation of shore-line features, only the relevant elements of the land-surface of the Porirua district will be discussed, under two headings, as follow: (1.) Topography and Drainage; (2) Influence of Deformation on the Relief.

(1.) *Topography and Drainage.*

The country surrounding Porirua Harbour is one of moderate elevation but of high relief. This moderately elevated tract rises to a greater height inland, especially in a north-easterly direction, and consists of a series of fairly even-crested hill-ridges, which for the most part have a N.E. by N.–S.W. by S. trend, though a few of them are orientated more nearly north and south. The ridge-tops are commonly broad and undulating, and the ridges themselves are flanked on either hand by long branching lateral spurs that taper off as they descend to the bottoms of the intervening longitudinal valleys. The principal valleys have flood-plains in their lower portions, and graded bottoms extend practically to their heads. In their upper reaches, however, overlapping spurs are still a prominent feature. The valley-sides are well dissected by the numerous lateral gullies, but this dissection has not everywhere extended to the main ridge-crests, where what seems to be a more mature relict topography still prevails.

There is some evidence, in the form of a high-level bench, notably at the head of Taupo Creek and in the valley of the Kahao Stream, of an intermediate partial erosion-cycle, probably corresponding to the Tongue Point cycle of Wellington Peninsula, and in addition to this there are areas of rejuvenation due to coastal recession and other causes. A full consideration of these matters is beyond the scope of this paper, but it may be remarked that, while the topography is undoubtedly composite, indications of the intermediate erosion cycle or cycles have been practically obliterated except in the instances cited above. Broadly speaking, therefore, the topography of the Porirua area may be described as being just past early maturity—that is, in the stage when maximum relief is giving place to more subdued forms.

The main drainage-lines leading to Porirua Harbour have, with one notable exception, the same parallelism, trend, and longitudinal elongation that distinguish the intervening ridges. The one exception is the Pahautanui Stream, which, together with its drowned lower valley—viz., the broad eastern arm of Porirua Harbour—lies transverse to all the other topographical features of the district. The present Pahautanui Valley and its drowned lower portion is too widely-opened and ancient a feature to have had so recent an origin as to belong to a young stream consequent on a bounding flexure of the Port Nicholson – Porirua Harbour tilt-block, and must be regarded as antecedent to the adjacent longitudinal ridges and drainage-lines.

From what is now known of the morphology of other portions of the Wellington district, it is evident that the ridge-tops to the north-east of Porirua Harbour are the residuals of a peneplaned surface, in all probability belonging to the Kaukau cycle of erosion. In the Wellington Peninsula, however, the peneplaned surface of the Kaukau cycle has been uplifted uniformly, whereas the corresponding surface to the north-east of Porirua Harbour has a decided westerly or south-westerly tilt. This is clear evidence of the existence either (1) of one large block having a warped surface which changes from a uniform level in the south-west to a decided upward slope in the north-east, or (2) of two distinct earth-blocks differentially uplifted with respect to each other. The two blocks, or two parts of a single original block, as the case may be, are now divided by the subsided Port Nicholson – Porirua tilt-block already referred to.

(2.) *Influence of Deformation on the Relief.*

The rocks of the Porirua district are the well-known closely-folded greywackes and argillites usually referred to the Maitai formation of Trias-Jurassic age. The strike of the strata in this vicinity appears to have a general N.E. by E. to E.N.E. direction (N. 55° to 70° E. true = N. 38° to 53° E. magnetic), and the dip is for the most part vertical, indicating an isoclinal structure.

As stated above, the trend of the series of subparallel hill-ridges which form the moderately elevated country north-east of Porirua Harbour is usually N.E. by N., while the average strike of the rocks forming them is N. 62° E. (true). With ridges and strike intersecting each other at so large an angle (about 27°) it is difficult to understand the genetic relationship of the hill-ridges to the geological structure so far as the ancient folding is concerned.

Two theories have been advanced to account for the longitudinal features of the orography of the Maitai rocks of southern Wellington as exemplified by the Tararua Range and the lesser hills to the south-west. By one theory the longitudinal ridges and drainage-lines are regarded as being respectively dependent on, and in adjustment to, the original geological structure (Cotton, 1918, pp. 213–14); in the other, secondary deformation is held to be the determining factor in the production of these features (Adkin, 1920, p. 184).

It is extremely likely that both secondary deformation and adjustment to structure were of prime importance, each exercising a predominant influence, but in different localities. In the Wellington Peninsula where the secondary corrugation of the highest peneplaned surface was comparatively weak, and also where its axes appear to have coincided with the strike of the ancient folding, adjustment to structure was probably the factor that determined the trend of the ridges and valleys; but on the more elevated earth-block now known as the Tararua Range the secondary deformation exercised by far the most potent influence in the determination of the major features of the relief. The marked difference in the drainage-pattern of the Tararua Range and that of the Wellington Peninsula strongly supports this view, and the hilly tract situated to the north-east of Porirua Harbour doubtless forms a transitional area between the north-easterly strongly deformed and the south-westerly less affected surface of the uplifted pre-Miocene peneplain (Bell, 1910, p. 538; Henderson, 1911, pp. 312–13). In the transitional area just referred to, the strike of the ancient folds sweeps round and assumes a more easterly direction than it does in the Wellington Peninsula, and intersects the longitudinal ridges and drainage-lines at an angle of approximately 27°; hence the relief in this locality bears a closer relationship to deformation than to structure, though the influence of the latter may not be wholly wanting.

THE COAST-LINE.

(1.) *The Cliffs.*

The outer coast of south-western Wellington is characterized by a continuous line of bold cliffs rising to heights of several hundreds of feet. At and within the entrance to Porirua Harbour the cliffs are still of imposing aspect, but they diminish in height as the distance from the open sea increases. The cliff-cutting has been effected by marine abrasion mainly under the influence of the prevailing north-westerly wind, while the powerful but less-prevalent southerly wind has produced less extensive but similar results, especially on southward-facing sections of the coast-line within the confines of the harbour.

In itself the cliffed coast-line is a normal feature of marine abrasion, but at the present day it possesses the peculiarity of being beyond the reach of the waves; in other words, the cliffs do not belong to the present but to a former base-line of marine denudation.

With the exception of a few places on the outer coast between the South Head of Porirua Harbour and Titahi Bay, and at two or three headlands in the vicinity of Wairaka Point, where the sea is again undercutting the high land, the former cliffed coast is separated from the present shore-line by a strip of low-lying ground of a width usually from 5 chains to 10 chains, but in certain situations from a quarter to over half a mile. Along the greater part of its length the low-lying strip at the base of the cliffs is a raised rock platform—an uplifted incipient plain of marine denudation (Plate XXXV, and fig. 2, *a*); the remaining portion—situated principally at the seaward ends of the larger valleys opening into Porirua Harbour near its entrance—has been formed by the progradation of the shore brought about by the deposition of a superabundance of coarse waste which has been drifted down the outer coast and into Porirua Harbour and has been piled up above sea-level, in the first instance by the action of the waves, and raised still farther by the earth-movement responsible for the uplift of the adjacent stretches of shore-platform of wave-planed rock.

(2.) *The Raised Shore-platform.*

(*a.*) On the Mainland.

The raised shore-platform (Plate XXXV, and fig. 2, *a*) is one of the most interesting, and in some places also the most conspicuous, of the shore-line features of Porirua Harbour and of the neighbouring coast. The earth-

The raised shore-platform of the Porirua coast. Inland cliffs on left. The inner part of the shore-platform is covered with blown sand, and its outer margin is being destroyed by the marine abrasion of the current cycle.

movement responsible for its present position above high-tide level was undoubtedly the uplift that affected the eastern shore of Cook Strait during the 1855 earthquake, as shown by several lines of evidence: (1.) The similarity of the raised shore-platform and the raised beach-ridges of the Porirua area to the raised shore-platform fringing the shores of Miramar Peninsula at Port Nicholson, and to the 9 ft. beach (Crawford, 1869, pp. 320–21; Aston, 1912, p. 209; and writer's observations) of Turakirae Head, respectively; in the latter localities these features have always been attributed to the uplift of 1855. (2.) The historical proof of the shallowing

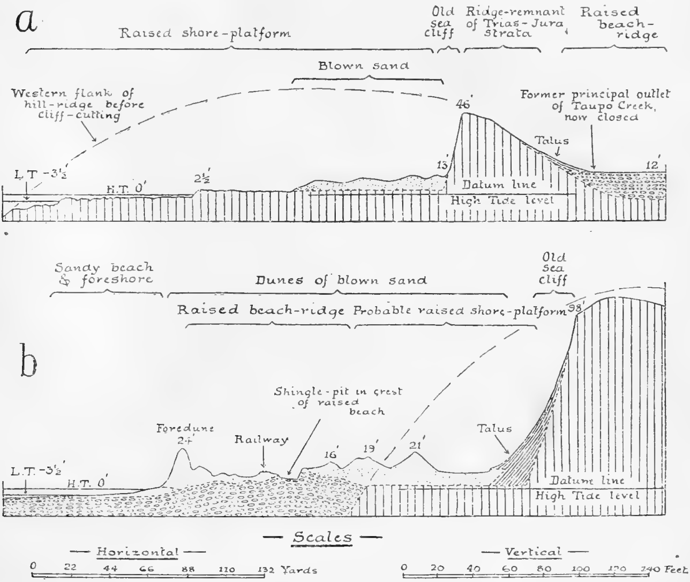

FIG. 2.—Sections of the Porirua coast: (*a*) at Taupo Point, showing the raised shore-platform and inland cliffs; (*b*) half a mile south of Taupo Bay, showing the raised beach-ridge, inland cliffs, and dunes of blown sand. Scale, vertical to horizontal, 3 : 1.

of the Pahautanui Stream as cited by Bell (*loc. cit.*, p. 538). I have also received details of a statement made by Mr. James Jones, an old Pahautanui settler, to the effect that after the earthquake the tidal flats at Pahautanui were permanently raised above high tide, and were for a time noisome on account of putrefying shell-fish and other marine matter.* (3.) The persistence of a considerable proportion of what is practically the original surface of the raised shore-platform, in spite of the effects of powerful

* Mr. Jones stated that an area of at least 100 acres was raised above sea-level, and his estimate of the amount of uplift was 3 ft. This agrees with my own estimate based on observations of the raised shore-platform. Mr. Jones also referred to the shallowing of the Pahautanui Stream, thus confirming in all details the historical evidence cited by Dr. Bell.

marine abrasion acting under very favourable conditions, points to the extremely recent date of the uplift of the rock platform and of the initiation of the present cycle of marine denudation.

As is well known, the earth-movement of 1855 was of the nature of a tilt to the west or north-west affecting both sides of Cook Strait. The hinge-line of the tilt was evidently situated along the bed of the strait, since its western shore was depressed and its eastern uplifted. The locality of maximum uplift was Cape Turakirae (see fig. 1), the amount being 9 ft. At Port Nicholson the uplift amounted to 5 ft., and at Porirua Harbour entrance 3 ft. Even at Wanganui there was a slight uplift (Field, 1892, p. 573), indicating that the hinge-line of the tilting block did not intersect the coast of the mainland south of that place.

As already indicated, the raised shore-platform is being rapidly demolished by wave-action, so that only a portion of the original surface remains. This rapid demolition is due to several causes, the principal of which are the low altitude of the platform, the thin-bedded character of the rocks forming it, the presence of numerous faults and closely-spaced joints, and—perhaps most potent of all—the very effective tools at the disposal of the waves—viz., a plentiful supply of exceedingly hard greywacke boulders. The raised shore-platform has, naturally, suffered greatest destruction along its outer margin (see Plate XXXV), but in some places, owing to the presence of a broad band or a series of narrower bands of the weaker argillite, it has been entirely removed to within perhaps a few yards of the old sea-cliff, and replaced by a tiny bay. This effect of the weaker strata is often very striking, as also is the influence of bedding, joint, and fault planes which determine the position of deep grooves across the platform.

The raised wave-cut shore-platforms of south-western Wellington are especially suggestive and instructive in connection with the subject of intermediate incipient or partial erosion-cycles which go to make up the composite topography characteristic of many New Zealand landscapes. At Porirua Harbour the raised shore-platform, which, as elsewhere, represents a small interruption in the geographical cycle, is being rapidly destroyed. In many cases a pronounced interruption in the geographical cycle may well be the sum of a series of small interruptions each of which has been obliterated in turn, thereby giving the whole the false appearance of a single great interruption. This is probably the key to the origin of occasional isolated hillside or shore-line benches and other similar indications of intermediate erosion-cycles—fragments preserved in exceptionally favourable localities long after all other traces of the cycles to which they belong have been obliterated.

(*b*.) The Reef.

The Reef is the name given to a pair of interesting rock shoals situated in mid-channel at the entrance of Porirua Harbour. At high tide the higher rocks reach uniformly to 3 ft. above sea-level. This uniform level corresponds in every respect to the surface of the raised shore-platform that fringes the mainland. The Reef marks the former site of an island, or pair of islands, which were completely planed off by marine abrasion prior to the uplift of 1855. At low tide the two groups of higher rocks are surrounded by a much more extensive area of low rocks just awash. This lower surface is the present plane of marine denudation, and is the level to which the 3 ft. surface has been cut down since 1855. The evidence furnished by the Reef is supplementary to and confirmatory of that afforded by the raised shore-platform on the mainland.

(*c*.) Potholes formed by Wave-action.

An interesting minor phase in the destruction of the raised shore-platform is the formation of potholes by wave-action. I have nowhere come across a reference to the formation, in any part of the world, of potholes by wave-action, and, though this phenomenon may have been previously noted, its occurrence is probably very rare.

The conditions requisite for the formation of such potholes are: (1) The presence on the shore-line of a fairly level surface of relatively soft rock; (2) waves of sufficient power to perform the work required; (3) cobbles of relatively hard rock to act as the cutting instruments.

The necessary combination of conditions and factors as above occurs at Porirua Harbour near Plimmerton (see Plate XXXV and fig. 1). At Plimmerton, because of the low altitude of the hills and their mature topography, the shore-platform is composed of comparatively soft weathered rock. Other important factors are the thin-bedded character and the vertical attitude of the rocks forming the platform, and the strike of the strata, the trend of which is here approximately at right angles to the shore. Being lines of weakness, the bedding-planes of the vertical strata have been hollowed out by the waves. Upon being washed into one of these grooves a travelling cobble or boulder of the extremely hard greywacke is propelled landwards until it becomes immovably wedged in a fissure or meets an obstruction preventing its farther progress. In the latter case its forward motion is changed to a circular one, and a pothole is initiated. This may grow to a considerable size unless interrupted by the breaking-away of one of the walls of the hollow. The largest pothole noted measured 3 ft. 6 in. by 2 ft. in diameter and 2 ft. in depth.

(3.) *The Raised Beach-ridges.*

The raised beach-ridges of Porirua Harbour have a narrower range than the uplifted shore-platform, being confined to the eastern coast at the harbour's entrance from near Te Rewarewa Head to the vicinity of the Paremata railway-bridge, and to the outer coast from Te Rewarewa Head northward to Pukerua Bay. Along these stretches of coast-line two conterminous series of shingle and boulder beaches may be distinguished: (1.) An older series which was in existence prior to the 1855 earthquake and was uplifted during that event, so that it is now beyond the reach of the waves and is not in the course of accumulation. This series of beaches is referred to herein as the raised beach-ridges. (2.) A younger series still being deposited along portions of the present shore-line within the limits defined. This is undoubtedly the post-earthquake equivalent of the older series.

The most northerly point of origin of the material of both series of beach-ridges is the coast at Pukerua and Wairaka Points, where great outcrops of intensely hard greywacke form headlands abutting on this very exposed portion of the coast. Some of the detritus derived from the abrasion of these greywacke headlands is carried eastward into Pukerua Bay, but the greater part is swept southwards down the coast-line by powerful waves acting under the influence of the prevailing north-westerly wind.

Immediately south of Wairaka Point (see fig. 1) there is a great embayment, which on account of its general appearance and for convenience of description I have named Desolate Bay. Along its entire length the shore-line of Desolate Bay is backed by an unbroken line of cliffs, probably 600 ft. to 700 ft. in height, and remarkable for the development of extensive screes. These, which consist of angular blocks of greywacke of all sizes, descend to the tide-level line and add greatly to the quantities of detritus which the sea is carrying down the coast.

At High Rock Point, which is the southern horn of the crescentic Desolate Bay, the last of the naked screes carries its quota of angular blocks to sea-level, and south of this spot the screes are "fixed" by vegetation. Here also the raised beach-ridge makes its first appearance, and extends as a flat-topped terrace at the foot of the cliffs as far as Te Rewarewa Head. North of Te Rewarewa the raised beach-ridge evidently rests upon the surface of the raised shore-platform; south of that headland it appears to follow the outer margin of the latter.

The most interesting development of the raised beach-ridges is found just within the entrance of Porirua Harbour, on its eastern shore. In its progress southward (prior, of course, to the uplift of 1855) the older accumulation of travelling shingle extended in the form of detached beaches or shingle-spits, piled up to 7 ft. above sea-level, right across the former

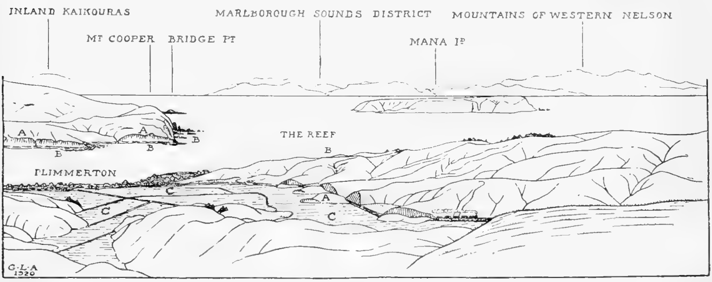

FIG. 3.—Panoramic view of the entrance of Porirua Harbour, looking south-west and west, showing the general topography and the relationship of the shore-line features. A, inland cliffs; B, raised shore-platform; C, deltaic flat of Taupo Creek; the line of houses at Plimmerton marks the position of the detached beach or spit which cut off the former Taupo indentation.

indentations now represented by the flat-bottomed lower valleys of Spring Creek, the Motuhara Stream, and Taupo Creek. (Compare figs. 4 and 5.) Continuing southward, the travelling shingle was piled up by the waves about sea-level and carried forward until it had reached the vicinity of the present Paremata railway-bridge. Here its farther progress was arrested by the strong currents caused by the ebb and flow of the tide in the extensive Pahautanui arm of Porirua Harbour.

The formation of this inner beach-ridge, which prior to the 1855 earthquake reached a maximum height of 8 ft. above high-tide level, was succeeded by the formation of an outer detached beach or shingle-spit (see fig. 5, at "The Narrows"), which branched off from the inner beach at a spot half a mile south of Taupo Bay, and was built forward by the waves as far as the present Paremata Point, when its farther progress was again arrested by the tidal currents. Unable to extend longitudinally, the spit was increased in breadth by additions of the travelling shingle until it presented the appearance of three parallel ridges, the highest of which was piled up to a height of 8 ft. above high-tide level.

The uplift of 1855 raised the shingle beach-ridges and spits, together with the other coastal features in this vicinity, a farther 3 ft. The uplift also raised the shallow shingly sea-bed between the inner and outer shingle-beaches at Paremata Point slightly above sea-level; and subsequently the formation of the younger series of beach-ridges added two more shingle-ridges to the outer margin of the raised Paremata Point spit.

(4.) *Deltaic Flats.*

The cutting-off from the open sea of some of the lateral indentations of Porirua Harbour in its initial form (fig. 4) by the formation of detached shingle-beaches across their entrances, and the conversion of these indentations into lagoons (see fig. 5), has led to the production of a considerable area of fertile flat land. This newly formed land comprises the flats of deltaic origin in the lower portions of the valleys that open on to the eastern shore of Porirua Harbour at its entrance.

In the valley of Taupo Creek, where the largest tract of deltaic flat occurs (see fig. 3), the sea formerly penetrated inland at least three-quarters of a mile farther than it does now, as is shown by the presence of old sea-cliffs of small size at that distance from the present sea-beach. The space between these inland cliffs and the raised beach-ridge upon which the village of Plimmerton has been built has since been reclaimed by the outward growth of the deltaic deposits of Taupo Creek and its tributaries. Other deltaic flats occur in the neighbouring valleys of Spring Creek and of the Motuhara Stream (see fig. 5). Flats of a somewhat similar deltaic character also occur in the lower valley of the Kahao Stream, as well as at the heads of the main arms of Porirua Harbour; but it is unlikely that deltas would have been formed, in the absence of the detached beach-ridges, in the more exposed lateral valleys nearer the entrance of the harbour.

(5.) *The Sandy Beaches.*

The sandy beaches, of which Taupo Beach at Plimmerton is the largest, are of very recent origin. The source of the sand appears to be the sediments of Porirua Harbour. After the formation of the tidal flats in the upper reaches of the harbour a bar was formed just within its entrance. On the bar the maximum depth of water is only 5 ft., while on either side of it the depth is 9 fathoms (Admiralty chart). The bar appears to have been formed by the checking of the sediment-laden ebb tide drawing out of the harbour by the waves raised by the prevalent north-westerly winds. Part of the deposited sediment would then be cast back upon either of the adjacent shores, and would accumulate at the heads of embayments to form sandy beaches. Dunes of blown sand derived from the sandy beaches cover small areas at several places along the shore of the harbour.

THE ORIGIN OF THE HARBOUR AND THE EVOLUTION OF ITS SHORE-LINE.

The deposition of the Trias-Jurassic sediments and their subsequent folding and uplift followed by peneplanation appear to have been the earliest diastrophic and physiographic events in the area under notice. These conditions held until the advent of a second period of diastrophism (the Kaikoura deformation). The peneplaned land-surface was first uplifted and then block-faulted on a large scale, the squeezing of the earth-blocks by the compressive forces within the earth's crust being in all probability

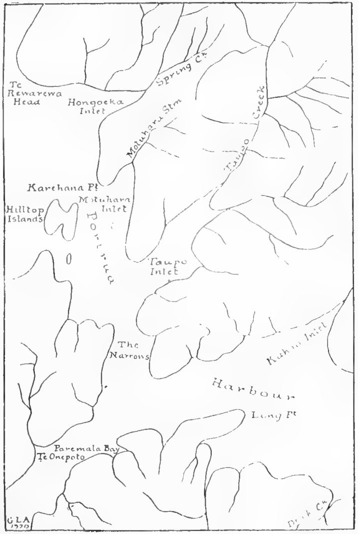

FIG. 4.

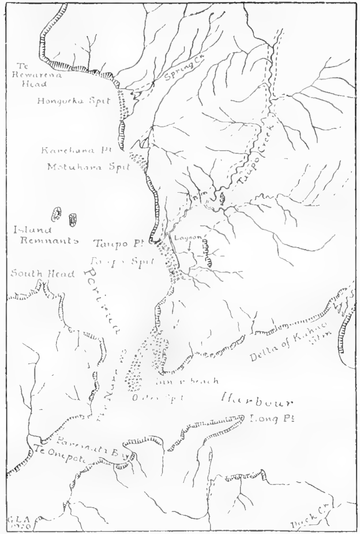

FIG. 5.

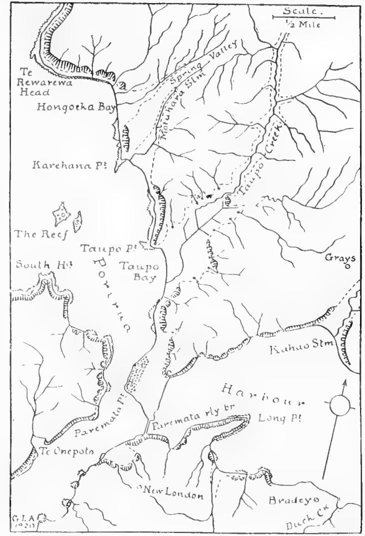

FIG. 6.

FIG. 4.—Evolution of the Porirua coast-line. Stage 1, a young drowned coast, caused by the drowning of the Pahautanui–Porirua valley-system.

FIG. 5.—Evolution of the Porirua coast-line. Stage 2, a submature coast, resulting from the cliffing of the headlands and the closing of the embayments by spits of shingle (detached beaches). The complete filling of the embayments with deltaic deposits and the formation of the outer shingle-spit at "The Narrows" took place towards the close of this stage.

FIG. 6.—Evolution of the Porirua coast-line. Stage 3, an uplifted coast. The uplift which took place during the 1855 earthquake produced the raised shore-platform (shown by the irregular line along the shore), inland cliffs, and uplifted beach-ridges which form conspicuous features of the present coast-line.

a factor in the elevation of the higher blocks. In what is now the southern part of the Wellington district the main earth-blocks have a N.N.E.–S.S.W. direction, this being the general trend of the principal fractures. The present high-standing blocks were in some cases uplifted uniformly, but more commonly tilted, the usual direction of the tilt being towards the west. The compression that accompanied the block-faulting and contributed to the uplift of the high-standing blocks was also responsible for the warping of the upper surfaces of these. The warping took the form of a series of broad anticlinal and synclinal flexures disposed longitudinally with respect to the N.N.E.–S.S.W. elongation of the earth-blocks. These longitudinal flexures, which determined the lines of the present longitudinal drainage, in some places coincide with the strike of the ancient folding, and in others intersect it at a considerable angle. The latter fact is accepted by the writer as unequivocal evidence that the secondary folding or warping, where operative, was the predominant factor in the determination of the present longitudinal drainage.

The degree of secondary folding sustained by the surfaces of the high-standing blocks was doubtless variable: in some instances it was pronounced; in others, again, perhaps insufficient to shape the initial drainage-pattern. In the latter cases the longitudinal drainage is possibly the result of adjustment to the ancient structure.

In the highest-standing block—viz., that from which the Tararua Range has been carved—the compressive forces acted in two directions at right angles to each other, with the result that the principal longitudinal folds were accompanied by transverse folds, or perhaps the latter were represented in part by dips in the main axes of folding. This accounts for the occurrence of the zigzag and trellis drainage-pattern solely characteristic of the Tararua Range in the area under notice. On some of the high-standing blocks of lesser elevation only longitudinal flexures were developed, and in others the warping appears to have been practically absent.

The last diastrophic event prior to the historical period was the inbreak of the Wellington fault and the resultant northerly tilt of the Port Nicholson – Porirua Harbour earth-block. This subsidence was the cause of the drowning of the maturely developed Pahautanui – Porirua valley-system, and of the creation of Porirua Harbour. In its initial stage the shore-line of the newly formed inlet had all the characteristics of infancy, such as are present when a drowned land-surface of the mature stage of topographic development is involved: the hill-slopes descended to the water's edge and continued without interruption below the level of the water-plane; in plan the outline of the shore was one of great irregularity, the projecting spurs forming prominent salients, and the drowned lateral valleys acute tapering indentations. Near the entrance of the inlet a few hilltop islands—the higher parts of a nearly submerged spur—lifted their rounded summits above the new sea-level. The general configuration and the outstanding topographic features of Porirua Harbour at this stage of its development are shown in fig. 4.

The initial stage of the Porirua shore-line was a very transient one. Under wave-attack, even in sheltered positions well within the harbour's entrance, the cliffing of the partially submerged hill-slopes was rapidly effected, and in addition detached beaches or shingle-spits were thrown across the mouths of certain of the indentations on the eastern shore, converting them first into tidal and later into brackish or fresh-water lagoons.

Fig. 5 shows the Porirua shore-line (at high tide) at a later stage of development than that represented in fig. 4: the coast-line has been straightened by cliff-cutting and by the closing of the bays by shingle-banks; delta deposits are rapidly filling the bays thus cut off; and the hilltop islands near the entrance of the harbour have been reduced to island remnants. The shore-line at this period appears to have reached a submature stage.

Before the interruption referred to below, the above processes were carried to an even more advanced stage than that depicted in fig. 5. The lagoons in the former embayments were completely filled with deltaic deposits, and converted into salt and, later, into fresh-water marsh. The island remnants also disappeared, having been cut down to sea-level by continued marine abrasion; at low tide their former sites were marked by rock reefs.

The progress of the shore-line towards complete maturity was interrupted by the earthquake of 1855. The narrow shore-bench or incipient plain of marine abrasion, to the between-tides level of which the hill-slopes of the initial shore-line had been cut down in the process of cliff-cutting prior to 1855, was raised on that date to a height at Porirua Harbour of 3 ft. above high-water level (see Plate XXXV, and fig. 2, *a*).

The above considerations clearly indicate that the Port Nicholson and the Porirua areas belong to one and the same physiographic district, since it has now been demonstrated that even the last diastrophic event—viz., the small uplift of 1855—was common to both.* The principal divergence in the parallelism of the life-histories of the two areas is the difference in form and origin between their respective harbours: one of these is of tectonic origin—a complicated graben-like depression subsequently modified by the various mechanical agents of change; the other is the result of the partial drowning of a normal valley-system modified since the submergence by the several phases of marine abrasion and deposition.

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* Contrary views have been held by some—*e.g.*, Sir Charles Lyell, quoted by C. A. Cotton (1912, p. 257).

ART. XVIII.—*An Account of the Geology of Green Island Coalfield.*

By L. I. GRANGE, M.Sc., A.O.S.M.

Communicated by J. Henderson, M.A., D.Sc., B.Sc. in Eng. (Metall.).

[*Read before the Wellington Philosophical Society, 13th October, 1920 ; received by Editor, 31st December, 1920 ; issued separately, 4th July, 1921.*]

Plate XXXVI.

CONTENTS.

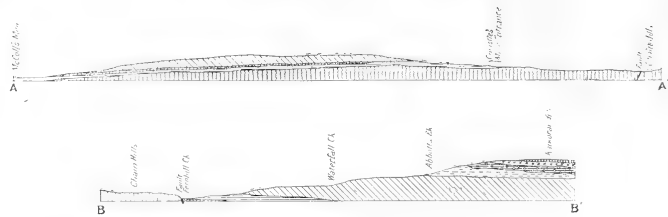
INTRODUCTION.

THE area described is the Green Island coalfield, which lies at its nearest point four miles south-west from Dunedin. The Kaikorai Stream forms the southern boundary from the Burnside marl-pit to the sea, whence the border follows the coast to Brighton Creamery. A line due north from the marl-pit to Abbott's Hill Road makes the eastern border, the western being formed by a line north from Brighton Creamery to the Chain Hills. The northern boundary is the Chain Hills and Abbott's Hill Road. The area includes Freeman's, Fernhill, Green Island, and Jubilee Collieries, as well as the Brighton Mine.

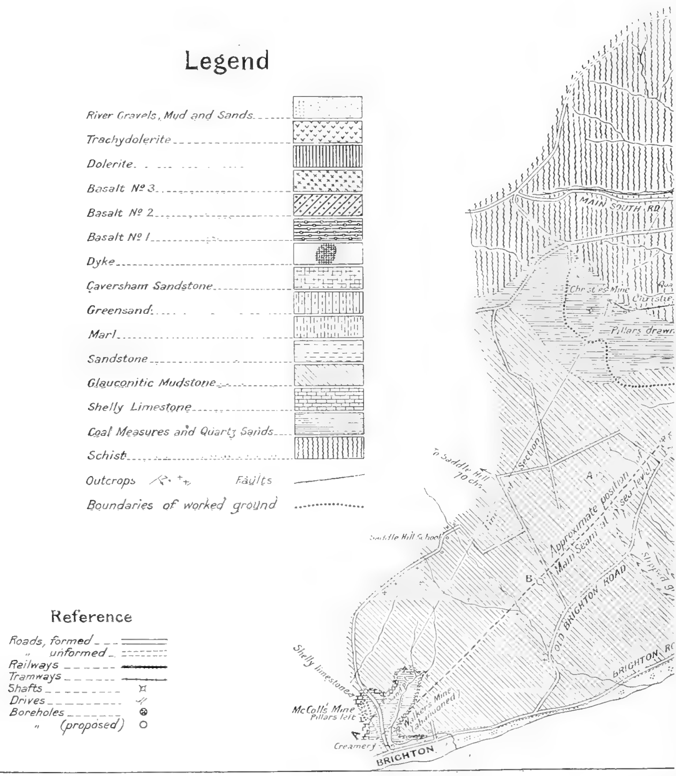
To Mr. P. G. Morgan, Director of the Geological Survey, the writer is indebted for allowing Mr. G. E. Harris to draw the accompanying map.

OUTLINE OF GEOLOGY.

The oldest rocks of the district are the schists which form the Chain Hills. Overlying the basement rock with great unconformity are the Notocene sedimentaries. The lowest beds are the coal-measures and quartz sands which outcrop in Fernhill and Christie's Creeks, and at Brighton ; at the last-mentioned locality a shelly limestone overlies the terrestrial beds. Resting with disconformity on the quartz sand or shelly limestone, and comprising the greater part of the area mapped, is a series of marine beds of which the upward succession is glauconitic mudstone, sandstone, marl, greensand, and Caversham sandstone. There is evidence of a local unconformity between the marl and greensand. All the Notocene sedimentary



——— Natural Scale – Same as map. ———



GEOLOGICAL MAP
OF
GREEN ISLAND COAL FIELD

Scale

CHAINS 10 0 40 80 CHAINS

FEET 1000 500 0 5000 FEET

rocks have a dip approximating 1 in 8 (7°) in a direction varying between 20° and 55° south of east. In the north-eastern part volcanic rocks rest on an eroded surface of the marine beds and form the caps of the ridges. The upper part of Saddle Hill, which is just outside the western border, is composed of basalt. Beds of clay represent the principal deposit formed since the cessation of volcanic activity.

PREVIOUS OBSERVERS.

The earliest reference to the Green Island area may be quoted from Hutton (1875, p. 13): "In January, 1862, Dr. W. Lauder Lindsay delivered a lecture in Dunedin on 'The Place and Power of Natural History in Colonization,' in which he mentions the volcanic rocks of Dunedin, Saddle Hill, &c. . . . He considered the sandstones of Green Island and Caversham to be either Tertiary or Upper Cretaceous."

Hector first reported on the field in his "Departmental Report of the Geological Survey of Otago" of 1864, and subsequently in the *Reports of Geological Explorations during 1871–72*.

Hutton (Hutton and Ulrich, 1875, p. 47) gave a brief account of the geology, in which he placed the sedimentary rocks and coal-measures of Green Island in his Oamaru formation. In his "Geology of New Zealand" (1885, p. 206) he refers to the belemnites from Green Island, but maintains that other palaeontological evidence argues for a Tertiary age for the rock in which it occurs.

McKay (1877, pp. 59–60) searched unsuccessfully in the vicinity of the Chain Hills and Abbott's Creek for fossils. At Green Island he obtained a number of fossils from a shaft sunk on Mrs. Shand's property. The Brighton calcareous beds were also visited, and a collection made therefrom.

Marshall (1906) describes the volcanic rocks of the area, and mentions the Brighton beds as being Tertiary in age.

Park (1910B ,pp. 90, 120–35) includes the belemnite bed in his Waipara series, of Cretaceous age He describes and gives sections of the marine and terrestrial rock exposed between Saddle Hill and Dunedin, classing them in his Oamaru series, the coal-measures corresponding to the lowest beds at Oamaru

Morgan (1916, p. 14) argues that the coals of Brighton and Green Island are of the same age—*i.e.*, Cretaceous—and that in some upper horizon an unconformity exists.

TOPOGRAPHY.

The chief point of interest is the evidence of elevation and depression of the land in post-Tertiary times. The Kaikorai Stream indicates depression of the land, for it has a wide flood-plain and is tidal several chains up-stream from its junction with Abbott's Creek. From Abbott's Hill and Kaikorai Hill the slopes to the middle of the valley are in places fairly steep; waterfalls and rapids are found in the upper parts of the creeks. Kaikorai Stream and the creeks to the west of Stony Hill show a mature form in their lower reaches. Abbott's Creek is at sea-level where it crosses the Main South Road, Christie's Creek reaches the level of the sea on crossing the old Brighton Road, and the Kaikorai is at sea-level 10 chains above the junction with Abbott's Creek From the Main South Road to the sea the flood-plain of the Kaikorai has an average width of about 60 chains. Plains composed principally of gravel stretch far up the creeks. Obviously, the physiography points to a depression of the land.

Terraces about a chain wide and 15 ft. above sea-level occur on the right bank of the Kaikorai Stream, about one mile and a half from the sea. They have been cut out of the glauconitic mudstone, and are in an excellent state of preservation. A few chains to the east of the Saddle Hill railway-bridge over Abbott's Creek a cutting exposes slightly consolidated sand, as much as 15 ft. above sea-level, resting on a green-coloured mud which contains a few fresh-looking sea-shells. At about the 200 ft. contour-line in the Abbotsford Valley, and to the north of Green Island Station, the country takes on a mature form that is lost at a lower level.

This break in topography is independent of structure. Evidently, then, the sea at one time stood 15 ft., and at another 100 ft. above its present level, but good evidence is wanting to determine the sequence of the diastrophic events. The freshness of the 15 ft. terraces suggest that an elevation of that amount took place after the depression.

GENERAL GEOLOGY.

The following table shows the classification adopted :—

Rocks.	Probable Age.
River gravel, mud, sand, and clay ..	Notopleistocene.
(Unconformity.)	
Basalt	Post-Awamoan.
Dolerite	
Basalt No. 3	
Basalt No. 2	
Basalt No. 1	
(Unconformity.)	
Caversham sandstone	Awamoan, Hutchinsonian, and Ototaran.
Greensand	
(Disconformity.)	
Marl	Waiaiekan.
Sandstone	Paparoan and Kaitangatan.
Glauconitic mudstone.	
(Disconformity.)	
Shelly limestone	Piripauan.
Quartz sand and coal-measures.	
(Great unconformity.)	
Schist	Triassic.

TRIASSIC FORMATION.

This rock forms the Chain Hills. The junction of schist and Tertiary rocks near Freeman's colliery occurs along Fernhill Creek. Farther south a bluff of rock extends from the Chain Hills into the valley in which are situated the Saddle Hill mines. This mass of metamorphic rock extends south along the hills forming the southern border of Taieri Plains to Otakaia.

The schist is not as completely metamorphosed as that of Central Otago. There is not the frequent lamination of quartz and mica. Thin sections show muscovite, feldspar (albite), and quartz. Dolomite is occasionally found occupying small cavities. The dip of the formation varies. In the railway-cuttings on the east side of the tunnel the following dips were obtained : 20° to the south-east, 40° to the south-east, and 70° to the south-west. Near the lower entrance to Freeman's mine the beds are almost horizontal. A quartz reef 7 ft. wide, and striking 14° south-east, outcrops on the schist spur projecting towards Christie's Creek.

Diverse opinions have been held as to the age of the schists of Otago : Marshall (1918, p. 29) ; Trechmann (1918, p. 171). Provisionally the rocks of Chain Hills which show a similarity to those of Lawrence (Marshall, 1918, p. 29) may on the same grounds be placed in the Triassic.

NOTOCENE SEDIMENTARIES.

Piripauan.

Rocks of the Piripauan group crop out along a narrow strip which, from near the junction of North Taieri and Abbott's Hill Road, follows Fernhill Creek, then Abbott's Creek to Samson's and Loudon's mines, crosses the Main South Road, and bends round the bluff of schist near Christie's Creek. Isolated outcrops occur on either side of the valley leading north from the Brighton Creamery. The downward succession is: Shelly limestone (absent from Fernhill outcrop), quartz sands, coal-measures.

Coal-measures.

The coal-measures are composed of quartz sands, fireclay, shales, and seams of coal. Generally six seams of coal are present. The seam above the lowest is the thickest, and is the only one worked.

The coal is close to the schist, so that it is only natural that there will be considerable differences in the thickness of strata below the main seam.

The thickness of the coal-measures is between 100 ft. and 140 ft. The dip is 1 in 8, and is fairly constant over the whole area, but the direction varies within 35°. At Brighton the coal dips about 55°, at Fairfield 20°, and at Abbotsford 32°, all south of east. The main seam averages 16 ft. in thickness, reaching a maximum of 30 ft. near Christie's upper-mine mouth. To the west of Christie's Creek the bed worked splits into two seams, each with a thickness of 2 ft.

The coal of the main seam may be classed as a good lignite, taking a lignite as a coal that contains over 20 per cent. of water. Analyses of the coal are given in the *Dominion Laboratory Reports*, 1907, p. 59, and Gordon Macdonald's "Brown Coal of Otago," *Colliery Guardian*, 22nd November, 1912.

The upper seams in places reach a thickness of 6 ft., but everywhere are inferior to the main seam in quality. Very frequently pebbles of quartz and bands of iron sulphide are met with in the coal. The iron sulphide quickly oxidizes, and is probably chiefly marcasite.

Quartz Sand.

The quartz sand, which is well exposed in five quarries, has a thickness of 50 ft., consists of loose well-rounded quartz-grains and rarely small fragments of schist. The rock-fragments from which the sands were derived must have suffered a great deal of attrition before only the quartz remained.

In all exposures may be seen two textures of sand—fine and coarse—generally showing current-bedding. Near the top is usually a band of gravel or conglomerate, 1 ft. thick. Clay lenses occur in most of the outcrops.

The lower half of the sand at Gray's pit consists of coarse sand containing pebbles ranging up to ½ in. diameter. Above is 4 ft. 6 in. of fine sand, succeeded by a cemented band of fine sand 1 in. thick and 1 in. of clay. The clay is followed by 6 ft. of coarse sand, and then by fine sand up to the band of conglomerate near the top.

The pit owned by Freemans is rather spoilt by fireclay, which occupies fissures that have been formed in the sand. Mr. E. R. Green informs the writer that 5 chains to the north-west of this pit the fireclay was found to have been intruded vertically through the coal-seams. A fissure had been formed, the fireclay softened by water and squeezed up into the opening by the pressure of the overlying rocks.

The lower 20 ft. of Loudon's pit is composed of alternating bands of coarse and fine sand; above rests a coarse sand with pebbles up to 1 in. diameter, followed by a cemented band 1 in. thick, which in turn is overlain by a layer of fine material.

The old sand-pit near the Southern Trunk Railway consists of bands of coarse and fine sand alternating in a regular manner.

The Jubilee sand-pit has a bed of white well-rounded sand. A layer of gravel forms the uppermost portion of this deposit at Brighton.

Shelly Limestone.

This formation outcrops in vertical cliffs in the valley above Brighton Creamery, where it has a thickness of 50 ft., but no outcrop of the limestone was found at any other locality.

McKay (1877, pp. 59–60) in his report for 1873 says that his Green Island fossils were obtained from a concretionary greensand.

The collection contains, besides fossils from the greensand, pieces of shelly limestone similar to that occurring at Brighton. The shaft to which the collector refers was in all probability Clarkson's, which was situated from 10 to 15 chains east of Walton Park Colliery.

The limestone, which is the only bed giving an indication of the age of the series, has yielded few good specimens. The following have been obtained: *Pecten* n. sp., *Belemnites* sp., *Ostrea* sp., *Venericardia* sp.

The *Pecten* the writer obtained has a strong midrib, and is unlike any New Zealand species hitherto described. The bad state of preservation of the *Belemnites* makes its determination difficult. Hector (1874, p. 356), taking as his holotype the dibranchiate cephalopod from the greensand of Amuri Bluff, described the form in the Brighton and Amuri beds as *Belemnitella lindsayi*, but in his *Progress Reports* of 1873–74 (p. xii) expressed the opinion that the fusiform bodies were true *Belemnites*, and termed them *Belemnites lindsayi*. Later (1887, p. xxix) he again identified the Brighton fossil as a *Belemnitella*. Park (1910B, p. 90) sent specimens to Dr. Bather, who pronounced them to be true *Belemnites*. Marshall (1917, pp. 459–60) sent them to authorities on *Belemnites*. Professor Stolley, of Brunswick, stated they belong to *Hibolites;* Professor Steinmann, of Bonn, and Professor Holzapfel, of Strassburg, regarded them as similar to *Belemnites minimus* of the Chalk; and Lissajous reported that they belong to the genus *Neohibolites* Stolley. The ages given by these authorities range from Upper Jurassic to Cretaceous. The determinations make the fossil a belemnite or a subgenus of *Belemnites* that does not reach the Eocene. Trechmann (1917, pp. 338–39) compares the Brighton form with the belemnites in the Upper Senonian of Selwyn Rapids.

Tentatively the shelly limestone and the coal-measures that underlie it may be placed in the Piripauan.

By Park (1910B, pp. 90, 112) and Hutton and Ulrich (1875, pp. 46–48) the coal-measures of Green Island and Abbotsford were thought to be Tertiary in age. The first-named writer placed the Brighton coals in the Cretaceous, but Hutton (1885, p. 266), considering the identification of the fusiform bodies of the shelly limestone doubtful, uses other palaeontological evidence and finds no Cretaceous rocks in the area.

Marshall (1906, p. 389) gives a Tertiary age to all the coal-measures of the Green Island coalfield, on the ground that the cephalopod is *Actinocamax*, but later (1916, pp. 117–19) accepted Hector's determination, *Belemnites lindsayi*, and correlated the Brighton beds with the Wangaloa beds.

Morgan (1916, p. 14) advocates a Cretaceous age for the coal of Brighton and Green Island.

Unfortunately, McKay's fossils from Green Island do not settle the question as to whether the coals of the whole area are of the same age, for doubt might well be expressed whether the shelly limestone of his collection really came from Green Island. In his report there is no mention of this rock, but only of the concretionary greensand. All the specimens show some weathering on one side, as if they had been collected from an outcrop. This would indicate that he did not separate the fossils obtained from the greensand from those obtained at Brighton. On the other hand, it is difficult to think such a mistake has been made, when it is known that McKay himself drew up the list of fossils for Green Island and included in it the belemnite. The weathering observed on the limestone could have been produced while the specimens were exposed on the surface a few years. Hector's *Progress Report* (1877, p. xiii) on McKay's journey reads as if the belemnite was collected from Green Island. The uncertainty may be dispelled if Christies sink a shaft in the neighbourhood of Walton Park.

Other considerations will show that the coal-measures of Green Island and Brighton are of the same age. There is a lithological similarity between the coal-measures and quartz sands of the two places. The main seam, containing the best coal, is the second seam from the base. Also, the quartz sands are everywhere about 50 ft. thick, and have a band of conglomerate or gravel in the uppermost portion. The sequence as interpreted by Park finds no parallel in Otago. If the coals were of different ages the Brighton beds would be limited to that locality, for the shaft put down in the Saddle Hill Colliery workings did not encounter another set of coal-bearing beds.

Glauconitic Mudstone.

This formation, which is 800 ft. thick, has a fairly wide extent. It forms the main part of the valley of Abbott's and Waterfall Creeks, the hill above Loudon's mine, and the land around Stony Hill and above Brighton.

The dip, determined from the outcrop as a whole and single exposures, is found to be the same as that of the underlying coal. The basal part of the formation is more sandy than the average mudstone. High up in the beds—*e.g.*, by Saddle Hill and in Abbott's Creek—there is a close resemblance to a marl. In Waterfall Creek, 7 chains below the waterfall, the uppermost portion is represented by the following: Cemented glauconitic sandstone, 1 ft. 6 in.; micaceous marl, 9 ft.; cemented glauconitic sandstone, 2 ft.; glauconitic sandstone, 80 ft.

Thin sections of the cemented greensand show angular quartz-grains 0·4 mm. by 0·4 mm., muscovite, green glauconite exhibiting pleochroism, and oligoclase twinned on the albite law. The position and shape of some of the grains of glauconite indicate that the mineral was deposited in the chambers of Foraminifera, and that subsequently the shell was dissolved away (see Plate XXXVI, fig. 1). The oligoclase could not have been derived from the schist, because the latter has its plagioclase feldspar twinned on Carlsbad but never on the albite law.

On the under-surface of a projecting ledge of cemented glauconite sandstone in Waterfall Creek crystals of gypsum about 2·5 mm. in length were obtained. They can be recognized by the pinacoidal cleavage (010) and the typical minus-unit pyramids (111). Sulphuric acid, which is produced during the weathering of the iron sulphide contained in the sandstone, has reacted on the calcite of the shells to form calcium sulphate.

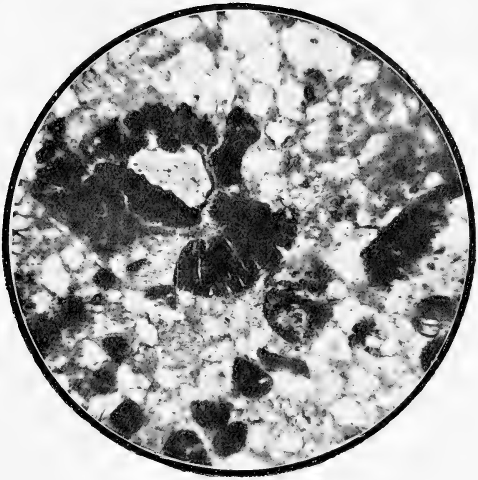


Fig. 1.—Section of cemented greensand of Waterfall Creek. Shows glauconite in the chambers of a shell. × 45.

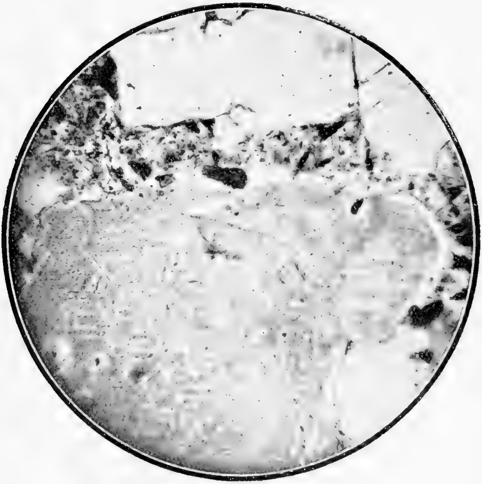


Fig. 2.—Crystal of sodalite with inclusions. From the trachydolerite

The glauconitic mudstone outcropping on the bank of Abbott's Creek near its junction with Waterfall Creek contains septarian nodules. The boulders are perfectly spherical to the eye, and are about 4 ft. in diameter. They resemble the well-known Moeraki boulders.

An inspection of the contact of the glauconitic mudstone with the underlying beds shows it to be disconformable. The shelly limestone, taken as a whole, has a fairly even surface, but in places an irregular contact has been observed. At the point marked *x* on the map, 13 chains north-east of the Brighton sand-pit, a glauconitic sandstone lies fully 5 ft. below the level of the limestone at 10 ft. on either side; and 4 chains east of this junction a quartz sand, consisting at its base principally of clay, rests on an irregular surface of the Cretaceous strata. The sand grades into a glauconitic sandstone, which higher up is replaced by a glauconitic mudstone. At Green Island, in exposures at the Jubilee sand-pit and 30 chains to the north-west of Fernhill sand-pit, the sandy base of the glauconitic mudstone contains quartz pebbles up to ½ in. in diameter, and a lens of rock of the nature of a greensand, 30 ft. long and 2 ft. thick, containing quartz pebbles, occurs in the upper part of the quartz sand in the Jubilee pit. Gray's pit shows a similar body, but it is not accessible. Since glauconite is not likely to form where pebbles ½ in. in diameter are deposited, the lower portion of the glauconitic mudstone has most probably been rewashed. The evidence indicates a small erosion interval.

SANDSTONE.

Sandstone beds stretch from the source of Waterfall Creek to Abbott's Creek, round the lower slopes of Kaikorai Hill, and down to Green Island Station. In many places they are exposed in cliffs owing to slipping. The sandstone, which varies from 170 ft. to 200 ft. in thickness, rests conformably on the underlying beds. It is composed of quartz-grains and scales of muscovite, slightly compacted. An excavation made close to one of a line of springs marking the junction of sandstone and mudstone, near Samson's house, showed a sand made up of well-rounded quartz-grains, similar to that occurring above the coal-measures.

MARL.

The marl occupies a strip from the southern slope of Kaikorai Hill to the railway-line near Green Island Station. It attains a thickness of 170 ft., and has a dip of 1 in 8 40° south of east. The mud has a light-blue colour when freshly exposed, but weathering soon produces a cream tint. The lower part of the bed is somewhat sandy, and contains glauconite. Pyritic concretions occur in the Burnside pit.

GREENSAND.

A greensand 2 ft. thick rests on the marl at the Burnside pit. About 15 chains to the south-east, in the Kaikorai Stream, a more accessible outcrop of the bed is visible. Here the base of the greensand, which is 6 ft. thick, contains flakes and small pieces of marl up to 1 in. in greatest diameter. Some 9 in. above the contact in a layer 2 in. thick of phosphatic nodules, succeeded 10 in. above by another band with a similar thickness. The nodules appear to be quite similar to those dredged by the "Challenger" Expedition (*Deep Sea Deposits*, p. 396) south of the Cape of Good Hope. An analysis of a nodule by the Dominion Analyst showed it to contain: Insoluble in acid, 16·68 per cent.; lime (CaO), 38·38 per cent.; carbonic anhydride (CO_2), 12·55 per cent.; water and organic matter, 3·83 per cent.

Under the microscope the greensand is seen to be made up of grains of glauconite and calcite, with occasional crystals of quartz. The glauconite-grains, which are the most abundant, are rounded, and up to 0·2 mm. in diameter. The Dominion Analyst supplies the following partial analysis of the greensand: Potash (K_2O), 2·72 per cent.; phosphorus pentoxide (P_2O_5), 4·32 per cent.; calcium carbonate ($CaCO_3$), 39·87 per cent. Considering the amount of glauconite present, the percentage of potash is low. The only other analysis of New Zealand greensand the writer can find is that of a sample from Iron Creek, Broken River, Canterbury (*52nd Ann. Rep. Dom. Lab.*, p. 28), which also contains a low percentage of potash—namely, 1·35 per cent.

After the deposition of the marl, elevation caused its erosion, as is shown by the presence of pieces of the marl in the greensand. The bands of phosphatic nodules point to elevation to allow some of the glauconite to be washed away and the concretions concentrated into layers.

Caversham Sandstone.

The Caversham sandstone outcrops about 25 chains to the east of the Burnside marl-pit, whence it extends to Burnside and Caversham beyond the area mapped. The rock which is exposed near the Burnside pit is a compact calcareous sandstone. Outside the area the formation is fully 300 ft. thick.

Fauna and Age of the Beds above the Piripauan.

Mr. P. G. Morgan, after inspecting the fossils obtained by McKay from the glauconitic mudstone, informed the writer that the collection as a whole is unlike any from Oamaru. Mr. J. Marwick, of the Geological Survey, who examined the same collection, reports that the specimens, with the exception of a *Dentalium*, which is nearest *D. pareorense* Pilsbry and Sharp, are casts for the most part indeterminable, and comments in the same manner as Mr. Morgan.

The fauna comes from the base of the bed. *Odontaspis elegans* Agassiz occurs in the mudstone at Abbotsford Station. The cemented greensand at the top of the glauconitic mudstone yielded *Dentalium solidium* Hutton and a leaf which resembles the dicotyledon *Daphnophyllum australe* von Ettingshausen (1891, p. 275).

The marl of the Burnside pit contained the following teeth: *Isurus retroflexus* Agassiz, *Notedanus marginales* Davis, *Odontaspis elegans* Agassiz, and *O. attenuata* Davis.

The Geological Survey forwarded a collection of Foraminifera from the Burnside pit to Mr. F. Chapman, of Melbourne, who determined the following*: *Haplophragmium latidorsatum* Born, *H. emaciatum* Brady, *Cyclammina incisa* Stache, *Gaudryina reussi* Stache, *G. pupoides* d'Orb., *Nodosaria radicula* (L.), *N. raphana* (L.), *Marginulina asprocostulata* Stache, *Cristellaria rotulata* (Lam.), *Truncatulina ungeriana* (d'Orb.), and *Rotalia soldanii* var. *nitida* Reuss. Commenting on their age, Chapman states: "In regard to the Foraminifera of the Burnside marls, they show some affinity with the fauna described by Stache (Whaingaroa), and also with our [Victorian] Balcombian beds. They are therefore low in the series."

The following is a list of fossils from the Caversham sandstone taken from Hutton (1875, pp. 51–52) and given modern names: *Atrina distans* (Hutt.), *Amusium zitteli* (Hutt.), *Cucullaea attenuata* Hutt., †*Fulgoraria arabica* Hutt. (Mart.), *Galeodea senex* (Hutt.), †*Glycymeris laticostata* (Q. & G.),

* Communication to Mr. P. G. Morgan, received September, 1920.
† Still living.

Lima paucisulcata Hutt., *Pecten beethami* var. B Hutt., *P. huttoni* (Park), *Turritella cavershamensis* Harris, *Pericosmus compressus* Tate.

Mr. J. Marwick looked over Hutton's specimens and obtained as well: *Chione chiloensis truncata* Sut., *Chione* sp. ind., *Malletia australis* (Q. & G.), and *Venericardia pseutes* Sut.

Mr. Morgan collected *Pachymagas parki* (Hutt.) from the base of the Caversham sandstone near Green Island Cemetery.

All the mollusca occur in the Awamoan, and *Pachymagas parki* ranges from the Ototaran to the Awamoan at Oamaru.

There can be little doubt that the Waikouaiti and the Caversham sandstone are the same horizon. Marshall (1906, pl. xxxvi) maps the sandstone of the latter locality continuously to the north of Blueskin Harbour, where volcanic rocks make a separation from the sandstone of the former locality. J. A. Thomson (1918, pp. 196–97) collected from the Waikouaiti sandstone *Pachymagas abnormis* Thomson, which he states does not occur below the Hutchinsonian at Oamaru. The Caversham sandstone with the greensand appears to represent the Awamoan, Hutchinsonian, and Ototaran stages.

The Balcombian beds are regarded by Chapman as Oligocene (1914, p. 46), an age that J. A. Thomson (1920, p. 323) thinks corresponds with the Waiarekan. The marl, then, may be placed in the Waiarekan stage, leaving the Paparoan and Kaitangatan for the underlying beds.

VOLCANIC ROCKS.

The following igneous rocks are described below: Basalt No. 1, basalt No. 2, basalt No. 3, dolerite, trachydolerite, basalt dyke.

BASALT NO. 1.

This rock occurs on the slopes of Abbott's and Kaikorai Hills. It is the lowest volcanic outpouring in the Abbotsford Valley, and rests on an eroded surface of the marine sedimentaries. There are two good outcrops—one in a cliff below Kaikorai Trig., and the other at the back of Mr. Meechan's house. At the former place the basalt, which is traversed by vertical and horizontal joints, is well weathered. At the latter locality the upper portion is so greatly weathered that it would be difficult to recognize it were it not for the more solid rock below.

Macroscopically the rock is dark grey in colour. Where weathered the augite crystals can be seen, but they do not protrude. This basalt may be microscopically described thus:—

Phenocrysts.—Labradorite (2·6 mm. × 0·66 mm.) is twinned on the albite law, but at times there is a combination of the albite and pericline twinning. Frequently it has magnetite inclusions in the centre. Augite is in large idiomorphic crystals (3·3 mm. × 1·5 mm.), and of a very light brown colour. It exhibits slight pleochroism. Often this mineral has orthopinacoidal twinning. Some crystals show zoning, the outer border being a little more inclined to a violet colour, owing probably to the presence of titanium. Olivine (1·5 mm. × 1·2 mm.) is allotriomorphic. Along fracture-lines the mineral has changed to serpentine, and some crystals have been entirely altered to this mineral. One crystal has inclusions of microlites of feldspar. Magnetite occurs in grains. The ferro-magnesian minerals are not plentiful, and there is a greater amount of augite than olivine. Spherosiderite, with its irregular pleochroism, is in patches, and in one section is seen as a narrow vein.

Groundmass.—Feldspar laths (0·24 mm. × 0·88 mm.) are of labradorite twinned once or twice. They show a flow-structure. A few grains of olivine and magnetite are also present.

The following is an analysis of the basalt:—

Silica (SiO_2)	..	50·20
Alumina (Al_2O_3)	..	19·70
Ferrous oxide (FeO)	..	7·35
Ferric oxide (Fe_2O_3)	..	6·80
Lime (CaO)	..	8·72
Magnesia (MgO)	..	3·71
Soda (Na_2O)	..	2·97
Potash (K_2O)	..	1·47
Water (H_2O)	Moisture	1·08
	Combined	2·65
		99·65

Basalt No. 2.

Basalt No. 2 occurs on the north-east of the Chain Hills, where it rests on the schist. In the water-race to the west of Abbott's Hill Road the rock, which is in the form of hexagonal columns, has at its base a bed of agglomerate. Owing to the absence of outcrops of basalts Nos. 1 and 2 to the west of Abbott's Hill, it has not been found possible to ascertain the position of No. 2 in the sequence of eruption. Thin sections show—

Phenocrysts.—Occasional crystals of olivine, and more rarely of augite. The former is idiomorphic, and usually has a border of iddingsite.

Groundmass.—The groundmass contain a great abundance of violet-coloured irregular grains of augite. The feldspar is labradorite which approaches a lath shape. Olivine is not common.

Basalt No. 3.

Basalt No. 3 is found above basalt No. 1 on Kaikorai and Abbott's Hills. There are no outcrops—its position and extent have been determined from boulders. The weathered rock has a distinctive steel-grey colour. Under the microscope, slices show—

Phenocrysts.—Labradorite (1·6 mm. × 0·8 mm.) often containing magnetite in the centre. Olivine allotriomorphic, and changed along fracture-lines to serpentine. Not infrequently a border of iddingsite is present. There are a few idiomorphic crystals of augite of a light-brown colour. A cross-section of a crystal showing prisms and both pinacoids has inclusions of microlites of feldspar.

Groundmass.—The groundmass has feldspar laths (labradorite) (0·7 mm. × 0·24 mm.) set in a mass of very fine-grained feldspar. Grains of olivine and augite are not common.

The composition of the rock is as follows:—

Silica (SiO_2) ..	48·36
Alumina (Al_2O_3) ..	15·85
Ferrous oxide (FeO) ..	8·46
Ferric oxide (Fe_2O_3) ..	4·90
Lime (CaO) ..	10·80
Magnesia (MgO) ..	6·18
Potash (K_2O) ..	1·37
Soda (Na_2O) ..	1·18
Combined water (H_2O) ..	2·13
	99·23

DOLERITE.

The word "dolerite" is used in the sense in which Marshall (1906, p. 410) employs it—namely, "as a term covering all the types of coarse basic rocks, irrespective of age, if they are of effusive character." Dolerite caps Kaikorai and Abbott's Hills. The rock weathers to spheroids, leaving in the spaces white bands of sepiolite and reddish-black bands of iron oxide. The dolerite can easily be distinguished in the field, since the augite projects on the weathered surface. In fresh samples the augite, olivine, and feldspar can be distinguished. Steam-pores are abundant, and often filled with amygdules of secondary calcite.

Phenocrysts.—Labradorite (1·05 mm. × 0·3 mm.) is not plentiful. Augite occurs in large idiomorphic crystals (3·1 mm. × 1·25 mm.), and is of a violet colour showing strong pleochroism. Twinning is frequent. One crystal has zonal banding, successive layers differing in tint indicating differences in the titanium content; another shows hour-glass structure. The augite commonly encloses olivine in a poecilitic fashion. Olivine (2·1 mm. × 0·48 mm.) is sharply idiomorphic, and is altered to serpentine along practice-lines, but not to the same extent as in the basalts. Of the olivine and augite, the former was the first to crystallize.

Matrix. — The matrix is coarse, being made up of feldspar laths, (labradorite), augite, magnetite, and a little olivine.

There is little distinction between the groundmass and the phenocrysts

The following analysis shows the composition of the rock :—

Silica (SiO_2)	44·86
Alumina (Al_2O_3)	13·05
Ferric oxide (Fe_2O_3)	8·82
Ferrous oxide (FeO)	6·90
Lime (CaO)	9·94
Magnesia (MgO)	11·60
Potash (K_2O)	1·46
Soda (Na_2O)	2·10
Combined water (H_2O)	1·49
	100·22

TRACHYDOLERITE.

The trachydolerite of this area is found on the northern slope of Abbott's Hill, whence it stretches for many miles to the north towards Flagstaff. A contact with the other lava-flows could not be found. Trachydolerite in the Dunedin district occurs both as a hypabyssal and as an effusive rock, with no distinctive character that would serve to discriminate them under the microscope. The wide extent of the rock above Abbotsford suggests that it is a lava-flow. In no place in Dunedin is the trachydolerite intercalated with other lavas (Marshall, 1906, p. 407). It probably followed the eruption of the dolerite.

In hand-specimens the rock is readily distinguished by the large crystals of feldspar that project on the weathered surface. Microscopically it shows the following :—

Phenocrysts.—Large idiomorphic crystals of oligoclase (3·2 mm. × 5·8 mm.) with extinction angle of 10°. It is twinned on the Carlsbad law. The nepheline (0·2 mm. × 0·8 mm.) is clear and often shows hexagonal outline. Rarely light-blue sodalite occurs. A special feature of this mineral is the great number of inclusions, most of which are arranged in lines with two directions crossing at an angle of 60°. The inner part of the crystals contains more inclusions than the outer (Plate XXXVI, fig. 2). Owing to the small size of the bubbles, it is difficult to determine whether they are filled with gas or liquid. Olivine (0·2 mm. × 0·2 mm.) is not common. It contains inclusions similar to those in the sodalite, but they are not arranged in lines. Augite (0·4 mm. × 0·4 mm.) is of a light-violet colour exhibiting pleochroism. Usually the olivine and augite are mantled with aegirine. The olivine is frequently bunched, as also is the augite. Iron-ore grains are present.

Matrix.—The feldspar is not resolvable. Aegirine occurs in grains. At times it is decomposed, leaving a pseudomorph of magnetite.

The composition of a sample of the rock was as follows :—

Silica (SiO_2)	51·85
Alumina (Al_2O_3)	15·72
Ferrous oxide (FeO)	5·30
Ferric oxide (Fe_2O_3)	6·21
Lime (CaO)	4·36
Magnesia (MgO)	3·06
Potash (K_2O)	4·75
Soda (Na_2O)	7·06
Combined water (H_2O)	2·64
	100·95

Basalt Dyke.

Stony Hill is formed of a basalt dyke elliptical in horizontal and wedge-shaped in vertical section. The basalt has been intruded through the glauconitic mudstone formation, which here is of a sandy nature. The joints of the igneous rocks near the contacts are parallel to the plane of cooling, and only about 2 in. apart. A band 6 in. thick of the mudstone has been baked to a cream-coloured rock showing feldspar and augite. Thin sections of the basalt may be described thus :—

Phenocrysts.—Large crystals of labradorite, in places containing inclusions of magnetite. There are smaller crystals of olivine and augite. The former is distinctive in that, besides containing a great number of small round grains of magnetite, it shows under crossed nicols a mosaic of colours.

Groundmass.—The groundmass consists of sharply outlined labradorite laths, augite, olivine, and magnetite grains.

The baked mudstone, under the microscope, is seen to consist of large idiomorphic crystals of feldspar (orthoclase and andesine) and augite set in a groundmass of well-outlined feldspars of the same composition as the larger ones.

NOTOPLEISTOCENE DEPOSITS.

This includes the clays, muds, and gravels deposited after the close of the Notocene. The clay deposits, owing to their wide extent in the low-lands, have not been mapped. For the greater part the clays are mixed with volcanic boulders, which occur either as a band near the base or throughout the bed. At Abbotsford Station 20 ft. of clay, with a band 2 ft. thick of water-worn pebbles 3 ft. from the base, rests unconformably on the glauconitic mudstone. Similar successions occur in a cutting near the Saddle Hill railway-siding, and in an exposure on the Fernhill Coal Company's railway near the crossing of Waterfall Creek. These clay deposits all occur at a height of from 120 ft. to 160 ft. above sea-level.

The Abbotsford Tilery Company work a deposit of pure clay that reaches a thickness of 35 ft. Towards Abbott's and Kaikorai Hills the number of boulders in the formation increases. In a railway-cutting near Freeman's mine large boulders are mixed with no order throughout its depth of 15 ft. Park (1910B, p. 200) states that moa-bones have been discovered at the bottom of the clay at Abbotsford.

A difference of opinion exists as to the origin of the deposit. Beal (1871, p. 276) and P. Thomson (1874, p. 312), mistaking structural marks brought out by weathering on a basalt for glacial striae, conceived a glacial origin for the clays containing boulders at Green Island and Dunedin. Hutton and Ulrich (1875, pp. 69–70) considered that the deposit had been formed by the ordinary weathering of the volcanic rocks. Park (1910A, pp. 593–94) classed this formation as a boulder-clay. Marshall (1910, p. 337) says, "In the clays about Dunedin the only recognizable mineral grains that they contain are those of the most resistant minerals contained in the underlying rock—a matter that at once suggests it has been formed *in situ*. . . . There are a few places at relatively low levels where there is a layer of well-rounded pebbles and boulders beneath the clay. These mark old shore-lines. . . . The clay that covers the boulders in the localities referred to has been washed down the hillside on to them."

The presence at Abbotsford of well-rounded boulders consisting of dolerite, basalt, trachydolerite, and rarely phonolite rocks at the base, all of local origin, is very damaging to the idea of classing the deposit as a boulder-clay. Had the beds a glacial origin boulders of schist would naturally occur, since that rock outcrops at no great distance from the clay. The bed of gravel from 120 ft. to 160 ft. above sea-level, together with the break in topography at about the 200 ft. contour, signify that the clay accumulated when the land was about 100 ft. lower than it is at present. The mud of the raised beach on the Saddle Hill Railway contains *Chione stutchburyi* (Gray), a common form on the present-day beach.

The formation of the gravel forming the flood-plains of the creeks, and the sand and mud of the lower part of the Kaikorai Stream, commenced when the land was depressed.

ECONOMIC GEOLOGY.

COAL.

History and Mining.

The history of coal-mining in the Green Island coalfields may be found in Hutton and Ulrich's *Geology of Otago*, Gordon's *Handbook of New Zealand Mines*, the New Zealand Mines Reports, and Denniston's "Report on the Green Island Collieries, Otago" (1877, pp. 143–73).

Thickness of Seam, Faults, &c.

The greatest thickness of coal is met with in the Saddle Hill mine, where it averages 20 ft. At Freeman's it averages 14 ft., while at Brighton and Green Island mines the general thickness is 10 ft.

The main seam is practically free from fireclay. Lenses about 4 in. long are in places met with in the upper part of the seam. Two bands of pyrites ¾ in. thick, one near the floor and the other 5 ft. 3 in. from the floor, run through the coal of the Saddle Hill mine.

The faults which have been encountered in the workings have the same strike as the coal, and usually a throw of less than 6 ft. A fault striking east 65° south, with a throw to the west of about 100 ft., separates the Jubilee and Walton Park Collieries.

Coal mined and available.

Most of the coal within a few hundred feet of the surface has been extracted. The Saddle Hill and Jubilee mines have taken practically all the coal from the outcrop in Christie's Creek to the line indicated on the map. The distance to the west that the coal could be worked was found to be limited because of the splitting of the seam.

The Jubilee Company has now turned its attention to an outcrop about 20 chains south of the railway-siding. Here the amount of coal is small, as the boundary to the dip is the Old Brighton Road. Christie Bros. intend drawing the pillars in the Walton Park area and mining the ground to the south of it. In Freeman's mine most of the pillars from a strip about 20 chains wide back from the outcrop in Fernhill Creek have been extracted. The Fernhill people have worked a block about 4½ acres in extent to the north of their entrance. The greater part of the working still contains pillars. The other companies have taken small amounts from areas indicated on the map.

To the end of December, 1919, 2,438,453 tons had been won from the Green Island coalfield, but about 48,000,000 tons remain in this area mapped.

The life of Freeman's mine in its present position is limited. Later a shaft with a depth of at least 300 ft. will have to be sunk in the neighbourhood of Abbott's Creek to reach the dip coal. Christies have many years ahead of them in the field previously mentioned. The Jubilee has at present the triangular area to the south of the railway-siding. The Green Island Company has yet about 900,000 tons to extract. Much coal probably lies to the rise in the Fernhill and Brighton mines.

An unprospected field lies between Brighton and the area wrought alongside Christie's Creek. Bores put down at A and B would reach the coal-measures at about 300 ft. and prove the area.

GOLD.

Hutton and Ulrich (1875, pp. 141–43) give an account of the Saddle Hill reef near Christie's Creek. About 2,000 tons of stone were crushed for an average yield of 5 dwt. of gold per ton—a yield that is unpayable.

SAND.

Good outcrops of sand free of the overlying formation for a few chains back, are found in many parts. The conglomerate band and lenses of clay give little trouble. In all the pits two classes of sand occur—a sharp sand used for cement-work, and a clean, white, rounded sand used by plasterers. At present each coal company works the deposit on its ground.

CLAY.

The clay of this area is one of the best of the province. The deposit near Abbotsford Station owned by the Abbotsford Tilery Company is 35 ft. thick, is singularly free from boulders, has a fine texture, and makes an excellent tile. A detailed examination of the clay was made by the Dominion Analyst, who reports as follows :—

"Only one sample was forwarded by the Inspector of Mines, but as this appeared to have been taken from two different seams it was divided into two samples.

Analysis.	(1.)	(2.)
Silica (SiO_2)	66·80	66·10
Alumina (Al_2O_3)	16·16	16·40
Iron oxide (Fe_2O_3)	4·20	3·48
Titanium dioxide (TiO_2)	0·94	0·92
Lime (CaO)	2·10	1·80
Magnesia (MgO)	0·97	1·15
Soda (Na_2O)	2·26	1·60
Potash (K_2O)	1·74	2·02
Water at 100° C. (H_2O)	0·90	2·10
Combined water and organic matter	4·25	4·10
	100·32	99·67

Rational Analysis.	(1.)	(2.)
Feldspar	33·16	26·99
Quartz	27·10	27·89
Clay substance	39·79	45·17

"Small briquettes and tiles were made from the samples, and the physical tests on these showed that good bricks and tiles could be obtained between the temperatures 1050° and 1100° C. At 1140° C. the bricks and tiles showed distinct signs of overburning. The porosity of small tiles made at 1060° C. appeared quite satisfactory.

Temp. C.	Air Shrinkage.	Total Shrinkage.	Water-absorption, Three Days.	Colour.	Hardness.	Remarks.
				No. 1.		
100	6·25	..	..	..	..	Easily moulded.
970	..	6·25	13·22	Red ..	Scratch with file	Good brick.
1060	..	6·25	15·88	" ..	"	"
1140	..	15·62	1·78	Dark red	"	Slightly overburned.
1270	..	12·50	..	Very dark red	Completely vitrified	..
				No. 2.		
100	6·87	..	..	..	..	Easily moulded.
970	..	7·81	9·77	Red ..	Scratch with file	Good brick.
1060	..	7·81	11·56	" ..	"	"
1140	..	12·50	1·92	Dark red	Not scratched ..	Slightly overburned.
1270	..	12·50	..	Very dark red	Completely vitrified	Decidedly overburned.

"Microscopically the samples showed the following composition :—

"*No. 1.*—Large irregular crystals of iron-stained quartz. No free crystals of magnetite or rutile, but the quartz in some cases penetrated by capillary or acicular crystals of what appears to be rutile. Feldspar plentiful ; some fairly elongated crystals.

"*No. 2.*—Not quite so coarse in texture as No. 1, and not so much iron-stained quartz. A little magnetite and a few crystals of rutile. Feldspar plentiful and elongated."

A large brick-kiln was erected by Gray, of the Fernhill Colliery ; but the clay, besides containing a great number of boulders, was found to be unsuitable for brickmaking. Bricks were made some years ago from a bed, about 15 ft. thick, near the Walton Park shaft.

The clays associated with the coal-seams were tested at the Abbotsford Tileries, and found not to withstand a sufficiently high temperature to be called fireclay.

Other Materials of Economic Value.

The Burnside marl-pit was opened in 1903, and works were erected near by. An attempt to produce an hydraulic cement proved unsuccessful. The Milburn Lime and Cement Company now use the marl from this pit to mix with the lime from Milburn to form a cement.

The limestone of Brighton was burnt many years ago for its lime, but the rock proved to be of too low a grade.

The greensand contains constituents that have value as fertilizers (Ries, 1905, pp. 155–56), but the thickness of the deposit near Green Island is not sufficiently great to warrant mining.

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Fig. 1.—General view of striated rocks at Circle Cove.

Fig. 2.—Near view of striated rocks.

[Face p. 175.

ART. XIX.—*On an Ice-striated Rock-surface on the Shore of Circle Cove, Lake Manapouri.*

By J. M. FOWLER.

Communicated by Professor J. Park.

[*Read before the Otago Institute, 9th November, 1920; received by Editor, 31st December, 1920; issued separately, 4th July, 1921.*]

Plate XXXVII.

ON the 16th May, 1919, in the stratification of a series of low-lying bush-clad hills known as "The Peninsula," Mr. Guy Murrell and the writer discovered a series of rounded, though fairly flat, rocks on the shore of Circle Cove, which is the first little inlet to the left after rounding Stony Point. On these rocks were marks quite different from anything that could be attributed to jointing or fracturing, and which there was no difficulty in attributing to ice-action. The marks run parallel for the length of the rock-exposure, and follow all the undulations. In places they are lost from view, as the hollows between the exposed parts either dip below water-level or are filled with gravel which has drifted into them.

The striated shelf extends along the shore about 150 yards, and is about 20 yards in width, at the summer level of the lake.

The marks are of all sizes, from sharply cut narrow lines to a trough about 2 ft. deep and 30 ft. or 40 ft. long, the bottom of which is polished as smooth as glass. The freshness of the marks is very noticeable.

The rocks as seen on the shore consist of beds of conglomerate, sandstone, fine silt, and thin seams of lignite. The conglomerate consists of granitic boulders set in a matrix of exactly the same material, so that when freshly broken it looks like homogeneous rock, but where weathered its components show out. The ice-marked shelf seems to be simply the lower stratum of the shore-rock, from which the overlying beds have been eroded. The scratches are sometimes in the conglomerate and sometimes on the other strata, according as the contour rises or falls. All, however, are polished so smooth that it is only where a face appears that the different layers can be distinguished.

Art. XX.—*Notes on New Zealand Mollusca: No. 1, Descriptions of Three New Species of Polyplacophora, and of* Damoniella alpha.

By Miss M. K. Mestayer, Dominion Museum.

[*Read before the Wellington Philosophical Society, 22nd October, 1919; received by Editor, 21st December, 1920; issued separately, 4th July, 1921.*]

Plate XXXVIII.

In this paper four new species of Mollusca are described, the types of which are in the Dominion Museum, three of them belonging to the order Polyplacophora, or chitons. Two were obtained within a short distance of Wellington, but repeated search has failed to discover further specimens. *Damoniella alpha* is, unfortunately, the only specimen so far obtained; it was discovered by Dr. J. A. Thomson in the fossil-beds at Blue Cliffs, Otaio River. It adds a new genus as well as a new species to the New Zealand Tertiary fauna.

The excellent drawings from which the accompanying plate was prepared were done by Miss J. K. Allan, of Sydney, and hearty thanks are due to her for the careful, accurate work bestowed upon them.

PLAXIPHORIDAE.

Plaxiphora (Maorichiton) Iredale (1).*

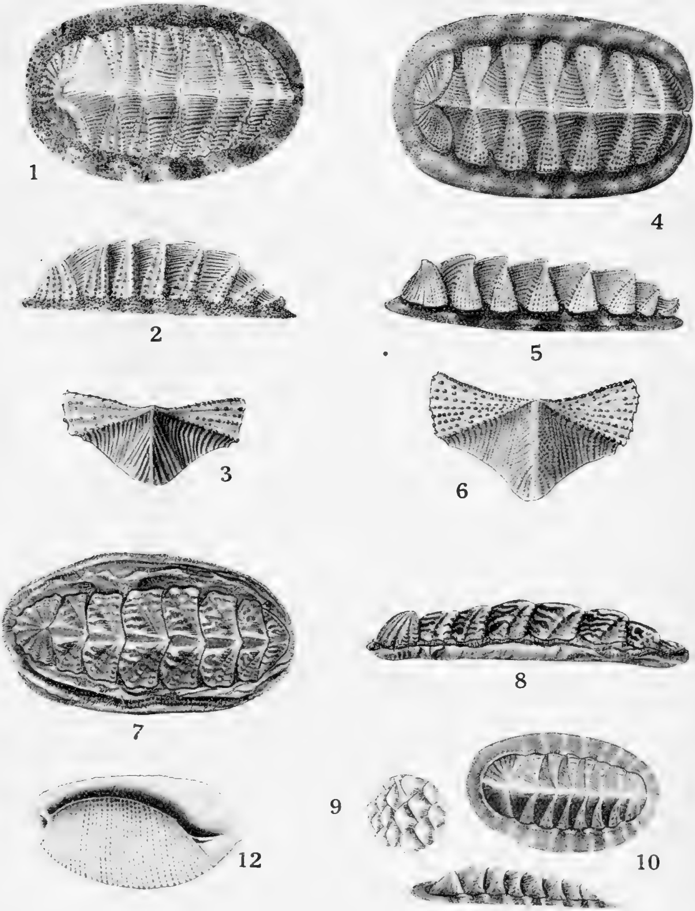
Plaxiphora (Maorichiton) lyallensis n. sp. (Plate XXXVIII, figs. 7–8.)

Lyall Bay, Cook Strait, N.Z.

Shell oval, flatly arched, side slopes straight, surface dull. Anterior valve with eight radial ribs, rendered slightly nodulous by the irregularly spaced growth-lines; the spaces between the radials appear smooth, but a strong pocket-lens shows traces of V-like sculpture. Median valves squarish, not beaked, nearly smooth; lateral areas raised, marked off by a strong semi-nodulous rib, the central portion covered with very fine V-like sculpture; the jugal areas with traces of microscopic striae and pitting; the pleural areas with a few horizontal wrinkles in a shallow groove anterior to the lateral rib; this groove is most distinct in valves 4 to 6. Posterior valve small, mucro terminal, slightly upturned, pleural areas bounded by a strong marginal rib, no sculpture. Interior deep blue-green, sutural plates white, sinus rather broad, convex in centre with a central dark-brown spot and a yellow tinge on either side of it. The anterior valve has eight slits, the edges of which are thickened and upturned, the insertion plates lightly grooved. The median valves also have the insertion plates grooved, and one slit. The posterior valve has a thickened rib-like insertion plate.

Colour: Ground-colour greenish-brown, irregularly barred with cream, the sixth valve cream with irregular zigzags of the ground-colour, the anterior valve uniform brown.

* This and other numbers enclosed in parentheses refer to the list of literature at end of paper.



[Miss J. K. Allan del.

FIG. 1.—*Lorica haurakiensis* n. sp.
FIG. 2.—*Lorica haurakiensis* n. sp.: profile.
FIG. 3.—*Lorica haurakiensis* n. sp.: second valve.
FIG. 4.—*Lorica volvox* (Reeve).
FIG. 5.—*Lorica volvox* (Reeve): profile.
FIG. 6.—*Lorica volvox* (Reeve): second valve.
FIG. 7.—*Plaxiphora* (*Maorichiton*) *lyallensis* n. sp.
FIG. 8.—*Plaxiphora* (*Maorichiton*) *lyallensis* n. sp.: profile.
FIG. 9.—*Rhyssoplax oliveri* n. sp.: girdle-scales.
FIG. 10.—*Rhyssoplax oliveri* n. sp.
FIG. 11.—*Rhyssoplax oliveri* n. sp.: profile.
FIG. 12.—*Damoniella alpha* n. sp.

Face p. 176.]

Girdle moderately broad, with a marginal fringe of soft short bristles, and about twenty tufts and pores adjoining the valves ; when alive it was a greenish colour.

Measurements : Length, 35 mm. ; breadth, 20 mm. ; but it would probably have been at least 5 mm. longer and broader in life.

Material : The holotype, in the Dominion Museum.

Remarks.—This specimen was obtained accidentally when gathering *Ulva*-covered pieces of rock ; a tuft came away readily, and I found it was on this chiton, which it had completely hidden. Having no idea is was a new species, it was not measured while alive, nor was the radula preserved. In spite of repeated searches in the same place, no further specimens have been obtained. It belongs to the group of *Plaxiphora* which has been placed by Iredale in the subgenus *Maorichiton*, with *Chiton caelata* Reeve as the type.

ISCHNOCHITONIDAE.

Lorica H. and A. Adams (2).

Lorica haurakiensis n. sp. (Plate XXXVIII, figs. 1–3.)

Lorica volvox Suter (*non* Reeve) (3).

Off Kawau Island, Hauraki Gulf, N.Z. ; 20 fathoms.

Shell ovately oblong, steeply elevated, dorsal ridge acute, side slopes very slightly convex. Anterior valve erect, lightly curved forward, with fourteen irregularly spaced radial ribs, smooth for about two-thirds their length, but bearing near the girdle from four to six low, steeply rounded nodules ; the interstices show faint concentric growth-lines ; posterior angles of the apex finely vertically ribbed. Median valves : The first of these is considerably larger than the others. the jugal area sculptured with oblique radial ribs which form inverted "V" up it (Plate XXXVIII, fig. 3) ; pleural areas finely horizontally ribbed. In valves 3 to 8 the horizontal ribbing is continued across the jugal tract. The number of ribs varies with the age of the shell ; the holotype has nineteen horizontal ribs, the interstices rather wider and perfectly smooth. The lateral areas raised, somewhat variable, some having two or three more-or-less-decided radial riblets, but they may be obsolete on one or more of these areas. A few low, steeply rounded nodules are rather irregularly scattered over the riblets. Posterior edges of valves denticulate, and showing traces of fine vertical striae at the apex. The concentric growth-lines are clearly visible. Posterior valve the smallest, horizontally ribbed, bounded by a strong slightly upstanding rib, bearing a few nodules. In some specimens there are traces of fine vertical riblets on the posterior angle. The mucro is terminal. The valve rather deeply grooved posteriorly.

Girdle medium width, closely set with smooth convex scales, which vary slightly in size. There are no tufts of bristles ; the posterior slit extends the whole width of the girdle. Unfortunately this is not shown in fig. 1.

Colour reddish-brown with a fairly broad creamy-yellow bar along the centre of the shell. The girdle about the same colour, with darker transverse bars. Individual specimens appear to vary somewhat in colour. Interior reddish, sutural plates almost white, sinus very narrow, rather shallow. Anterior valve with about eight slits, median valves one slit. Owing to the scarcity of specimens it has not been possible to disarticulate one.

Measurements: Holotype—length, 30 mm.; breadth, 20 mm. The largest paratype about 40 mm. by 30 mm.; but it is rather contracted, and therefore difficult to measure accurately.

Material: The holotype, presented by Mr. A. E. Brookes to the Dominion Museum, and four paratypes.

Remarks.—Hitherto this species has been confused with *Lorica volvox* (Reeve), though the resemblance is really only superficial, as careful comparison shows several decided differences between the two species. A study of figs. 2 and 5 on the accompanying plate reveals a striking difference in the general outline of the shells, *Lorica haurakiensis* having a much steeper outline than *Lorica volvox* (Reeve). Figs. 3 and 6 show the remarkable difference in sculpture of the second valve of each species, fig. 3 (*L. haurakiensis*) exhibiting no trace of the nodulous sculpture so characteristic of *L. volvox* (Reeve) (fig. 6) on the jugal tract. Also, the lateral areas of *L. haurakiensis* are very much less nodulous than in *L. volvox.* The pleural areas of the species differ in that *L. haurakiensis* has the interstices of the longitudinal ribs smooth, while in *L. volvox* the whole surface is rendered semi-nodulous by low heavy transverse corrugations.

There are also differences in the girdle characters, the new species being characterized by small close-set scales, and by the entire absence of the tufts of transparent bristles, which are numerous on *L. volvox.*

History.—In 1872 Hutton (4) described *Chiton rudis* from a specimen in the Colonial Museum, and stated "Locality unknown." That specimen has since been identified at *Chiton volvox* Reeve (1847), now placed in the genus *Lorica.* It is specifically inseparable from specimens presented by Mr. C. Hedley.

When inspecting the concrete sinker of the buoy off Whale Rock, Bay of Islands, a few years ago, Captain Bollons obtained two or three specimens, in about 20 fathoms, which the late Mr. Suter identified as *Lorica volvox* (Reeve) (3). Since then Mr. A. E. Brookes has obtained three more specimens off Kawau Island, Hauraki Gulf, in 20 fathoms, and he has generously presented his largest specimen, the holotype, to the Dominion Museum. There is a larger specimen, but his is the best preserved.

Careful comparison of the New Zealand specimens with *C. rudis* Hutton and with authentic New South Wales specimens of *L. volvox* (Reeve) showed *C. rudis* Hutton and the Australian specimens to be conspecific—indeed, in all probability Hutton's type is an Australian shell—and showed that the New Zealand specimens were a very distinct species not so far described.

In the *Manual of the New Zealand Mollusca*, 1913, p. 46, pl. 2, fig. 22, Suter records *Lorica volvox* (Reeve), giving *C. rudis* Hutton as a synonym, but his accompanying description does not accurately fit either *L. volvex* (Reeve) or *L. haurakiensis,* a specimen of which is in his collection. Mr. Murdoch, of Wanganui, points out that the description appears to be derived partly from his New Zealand specimen, partly from *C. rudis,* and partly from Reeve's description. As we have no record of *Lorica volvox* (Reeve) being obtained alive in New Zealand, and as the New Zealand species is specifically very distinct, I would suggest that *Lorica volvox* (Reeve) should be eliminated from our fauna, and *Lorica haurakiensis* take its place as the New Zealand representative of the genus.

An unfortunate numerical mistake has occurred on plate 2 of Suter's *Manual,* where *Lorica volvox* is fig. 24, and *Onithochiton undulatus* is fig. 22.

The true numbering is *Lorica volvox*, fig. 22 ; *Onithochiton undulatus*, fig. 24. So far as I can tell from the very poor figure, a specimen of *L. haurakiensis* is there shown, but accurate determination is almost impossible.

CHITONIDAE.

RHYSSOPLAX Thiele (5).

Rhyssoplax oliveri n. sp. (Plate XXXVIII, figs. 9–11.)

Huetataka, Lyall Bay, Cook Strait, N.Z.

Shell small, oval, smooth, with a subglossy surface, the side slopes almost straight. Anterior valve smooth except for six tiny nodules close to the girdle, and slight traces of radial riblets. The animal is dried inside, but the eight slits are easily seen under a pocket-lens. Median valves slightly beaked, the jugal and pleural areas smooth, lateral areas raised, well defined, with very faint traces of radial sculpture. Interior one slit, sinus hidden by the animal, colour bluish, insertion plates probably white. Posterior valve, mucro central, moderately prominent, posterior slope rather steeply concave, bounded by a nearly smooth rib. Interior eight slits.

Colour : Ground-colour cream, mottled with dull green, and small longitudinal flecks of light brown ; the whole surface densely covered with microscopic white speckles.

Girdle : Scales very finely closely striate, rounded, the largest along the centre, the outer edge with three or four rows of very fine outstanding spicules, which are easily rubbed off. Colour creamy transversely banded with green and tinged with brown.

Measurements : Length, 10·5 mm. ; breadth, 7 mm.

Material : The holotype, obtained by W. R. B. Oliver, 13th January, 1918, and presented to the Dominion Museum.

Remarks.—This species appears to be more closely related to *Rhyssoplax translucens* (H. & H.), of Australia, than any other New Zealand member of this genus. It differs from *R. translucens* in being smoother and much smaller, while the girdle-scales are proportionately larger and rounder.

SCAPHANDRIDAE.

DAMONIELLA Iredale (6).

Damoniella alpha n. sp. (Plate XXXVIII, fig. 12.)

Shell small, narrow, elongately cylindrical, solid. Sculpture about thirty flat spiral ribs, with very narrow grooves between them. The grooves are rendered punctate by a large number of fine vertical growth-striae, which do not cross the spiral ribs. Aperture the entire length of the shell, narrow anteriorly, somewhat inflated posteriorly. Outer lip sharp, very slightly crenulated by the spiral grooves. Vertex pierced by a very narrow axial perforation. Columella short, vertical, slightly concave, very lightly reflexed towards the tiny umbilical chink.

Measurements : Length, 7 mm. ; breadth, 4 mm.

Material : The holotype, in the Dominion Museum, collected by Dr. J. A. Thomson at Blue Cliffs, Otaio River, South Canterbury, in 1917 (Awamoan).

Remarks.—This specimen was placed by the late Mr. Suter in the genus *Roxania* Leach (1847), but Iredale points out that this is invalidated by a prior use of *Roxana* for a genus of insects, and he proposes *Damoniella* in place of it, with *Bulla cranchi* Leach as genotype. So far as I can judge from the description and figures (7), this is a near ally of the new species; there is an Australian species, *Atys dactylus* Hedley (8), which also appears to resemble it, at least superficially.

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1. T. Iredale, 1915. The Chitons of the Kermadecs, *Proc. Malac. Soc. Lond.*, vol. 2, pp. 32–33.
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3. H. Suter, 1913. *Man. N.Z. Mollusca*, pp. 46–47, and p. 1082.
4. F. W. Hutton, 1872. On the New Zealand Chitonidae, *Trans. N.Z. Inst.*, vol. 4, p. 179.
5. T. Iredale, 1915. A Commentary on Suter's *Manual of the New Zealand Mollusca, Trans. N.Z. Inst.*, vol. 47, p. 426.
6. —— 1918. Molluscan Nomenclatural Problems and Solutions, No. 1. *Proc. Malac. Soc. Lond.*, vol. 13, pp. 28–40.
7. H. A. Pilsbry, 1893. Monograph of Tectibranchiata, *Man. Conch.* (1), vol. 15, p. 27, pl. 28, figs. 28–29.
8. C. Hedley, 1899. The Atoll of Funafuti, *Mem. Austral. Mus.*, No. 3, p. 484.

Art. XXI.—*Notes on New Zealand Mollusca: No. 2.*

By Miss M. K. Mestayer, Dominion Museum.

[*Read before the Wellington Philosophical Society, 27th October, 1920; received by Editor, 15th December, 1920; issued separately, 4th July, 1921.*]

Callochiton empleurus (Hutton).*

Foveaux Strait, N.Z.; about 15 fathoms.

A specimen of this rare chiton was recently found amongst a quantity of oyster-scrapings obtained from the New Zealand Trawling and Fish-supply Company, Wellington. The material came from the Foveaux Strait oyster-beds, and amongst it quite a considerable variety of Mollusca was found.

The specimen now exhibited is unfortunately badly broken, but as the anterior and posterior valves are practically perfect it is possible to supplement Suter's† description in some details which for lack of material he was unable to determine.

The anterior valve has 14 very shallow, irregularly-spaced slits; the teeth are comparatively solid, with their edges lightly grooved. The interior is white, and has an irregular squarish pattern, due to the intersection of the three concentric growth-lines, and of the slit-rays, which are traceable to the apex.

The posterior valve has 11 slits; the teeth are solid, are slightly thinner than the anterior ones, but are similarly grooved. The interior is white, with a bright pink patch under the mucro.

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* *Trans. N.Z. Inst.*, vol. 4, p. 178, 1872.
† *Man. N.Z. Mollusca*, pp. 12–13, 1913.

ART. XXII.—*Notes on New Zealand Chilopoda.*

By GILBERT ARCHEY, M.A., Assistant Curator, Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1920; received by Editor, 31st December, 1920; issued separately, 4th July, 1921.*]

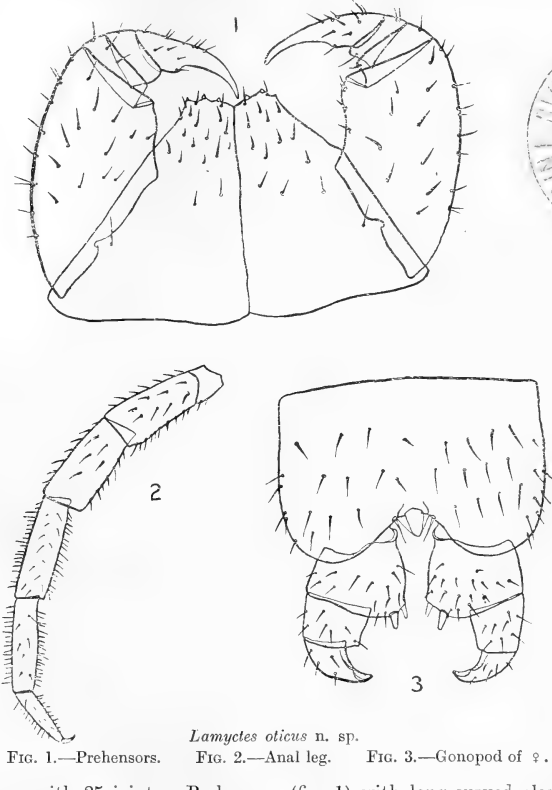
LITHOBIOMORPHA.

HENICOPIDAE.

Lamyctes oticus n. sp. (Figs. 1 to 3.)

Colour rich brown.

Major tergites with anterior and lateral raised margins, emarginate from the 8th caudad; minor tergites with broader, less distinct margin.



Lamyctes oticus n. sp.

FIG. 1.—Prehensors. FIG. 2.—Anal leg. FIG. 3.—Gonopod of ♀.

Antennae with 25 joints. Prehensors (fig. 1) with long curved claw, prosternum 1·78 times as wide as long, teeth 3 + 3. Coxal pores $\frac{3333}{3333}$. First tarsal joint of 15th legs (fig. 2) four times as long as wide; tibial spur on legs 1 to 12. Gonopods of ♀ (fig. 3) with straight basal spurs and curved sharp terminal claw.

Length, 8 mm.

Loc.—Otekaike (type) and Queenstown. Types in the Canterbury Museum.

This species differs from *L. neozelanicus* Archey by its darker colouring, its much stouter anal legs, and by the form of the prosternal teeth.

Paralamyctes validus Archey.

Paralamyctes validus Archey, *Trans. N.Z. Inst.*, vol. 49, p. 314, 1917.
P. dubius Archey, *ibid.*, p. 314.

A series of these forms has now been examined, and it is clear that they are the same species, the differences previously noted as separating them being those normal between slightly immature and fully-grown forms. The South Island representatives of this species do, however, differ slightly from the North Island forms, but the differences are scarcely of specific rank. There are also small sex variations to be seen in each variety, which may be expressed as follows:—

——	Sex.	Length.	Length of Antennae.	Coxal Pores.	Prosternal Teeth.
North Island ..	♂	18 mm.	½ body-length	$\frac{4444}{4444}$ or $\frac{4555}{4555}$	9 + 9 or 10 + 10.
,, ..	♀	19 mm.	⅓ ,,	$\frac{5666}{5666}$ ..	,,
South Island ..	♂	20 mm.	½ ,,	$\frac{3444}{3444}$ ..	8 + 8 or 9 + 9.
,, ..	♀	20 mm.	⅓ ,,	$\frac{4555}{4555}$ ..	,,

P. dubius therefore forgoes its specific rank and is retained only as a variety of *P. validus*, differing from it by the reduction in the number of coxal pores and prosternal teeth. Small specimens (10–13 mm.) of both forms have coxal pores $\frac{2222}{2222}$, and 5 + 5 or 6 + 6 prosternal teeth, those of 15 mm. length having coxal pores $\frac{3333}{3333}$, and 6 + 6, 7 + 7, or 6 + 7 prosternal teeth.

It should be noted that normally there is a tibial spur on all the legs, but occasionally this is missing on the last pair. The type of *P. validus* has a very low, rounded projection at the end of the tibia, but in other specimens the spur is quite distinct and sharp.

I have to thank Mr. T. R. Harris, of Ohakune, for his kindness in sending me a series of specimens of this species.

Haasiella insularis (Haase), 1887.

Henicops insularis Haase, *Abh. Zool. Mus. Dresden*, No. 5, p. 36, 1887. *Haasiella insularis* Pocock, *Ann. Mag. Nat. Hist.*, ser. 7, vol. 8, p. 449, 1901; Archey, *Trans. N.Z. Inst.*, vol. 49, p. 316, 1917.

I am now able to give Haase's diagnosis of this species. The locality is Auckland Islands, not Auckland as stated by Pocock and myself.

"Colour greyish-brown, tergal plates with dark margins and a median black patch, head reddish, ventral surface greyish. Head emarginate anteriorly. Prosternum of prehensors armed with 5 + 5 teeth. Tergal plates, especially the anterior ones, margined. Single coxal pores round and large. Length of body, 12 mm." (Haase.)

In addition, Haase describes the penultimate pair of legs as the longest, with 2-jointed metatarsus and 3-jointed tarsus; the last legs have an undivided metatarsus and a peculiar club-shaped tarsus, formed, it is thought, by the fusion of the terminal claw with the tarsus. Only a single much-mutilated specimen is known.

SCOLOPENDROMORPHA.

These notes on the Scolopendromorpha are intended as a preliminary revision of the New Zealand members of the order, and therefore descriptions of New Zealand species published in papers abroad are quoted in full. The species recorded herein are from very few localities, and many more areas must be searched before anything like a complete revision can be attempted. That the South Island is better represented than the North Island with regard to the new species of *Cryptops* described is due to the energetic collecting of Mr. T. Hall and Mr. T. B. Smith, to whom my thanks are due.

CRYPTOPIDAE.

Genus CRYPTOPS Leach, 1814.

Cryptops Leach, *Trans. Linn. Soc.*, vol. 11, p. 384, 1814; Newport, *Trans. Linn. Soc.*, vol. 19, p. 407, 1845; Kraepelin, *Mit. Mus. Hamburg*, vol. 20, p. 32, 1903.

KEY TO NEW ZEALAND SPECIES OF CRYPTOPS.

I. First tergite with a transverse sulcus anteriorly, or with its anterior end overlapped by the head.
- *A.* Coxopleural pores 50 or more, reaching to the hinder end of the coxopleura .. .. *C. spinipes* Poc.
- *B.* Coxopleural pores 20 at most, not reaching to the hinder end of the coxopleura.
  - 1. Head with sulci, 1st tergite without transverse sulcus .. .. *C. zelandicus* Chamb.
  - 2. Head without sulci, 1st tergite with transverse sulcus .. .. *C. megalopora* Haase.

II. First tergite without sharply defined transverse sulcus anteriorly, always with its anterior margin overlapping the hinder edge of the head.
- *A.* Anal tibiae armed ventrally with many teeth arranged in several rows; 1st tergite with Y-shaped sulcus .. .. .. *C. polyodontus* Att.
- *B.* Anal tibiae armed ventrally with only one row of at most 16 teeth; 1st tergite without sulcus.
  - 1. Coxopleurae with only 30 pores.
    - *a.* Anal femur bare dorsally .. *C. australis* Newp.
    - *b.* Anal femur dorsally with spinescent setae .. .. *C. galidus* n. sp.
  - 2. Coxopleurae with more than 30 pores.
    - *a.* Dental formula of anal legs approximately $1 + 9 + 4$.
      - *a*¹. Anal metatarsus with ventral dilatation .. *C. ignivia* n. sp.
      - *a*². Anal metatarsus with straight ventral edge *C. algidus* n. sp.
    - *b.* Dental formula of anal legs approximately $1 + 12 + 7$.
      - *b*¹. Coxal pores 40 to 50.
        - α Anal legs slender *C. dilagus* n. sp.
        - β Anal legs stout *C. akaroa* n. sp.
      - *b*². Coxal pores 100 or more .. .. *C. pelorus* n. sp.
    - *c.* Anal legs with $6 + 5$ teeth .. *C. lamprethus* Chamb.

Cryptops spinipes Pocock.

Cryptops spinipes Pocock, *Ann. Mag. Nat. Hist.*, ser. 6, vol. 8, p. 156, 1891. *C. setosus* Pocock, *ibid.*, p. 157. *C. spinipes* Kraepelin, *Mit. Mus. Hamburg*, vol. 20, p. 49, 1903; *Arkiv. Zool.*, vol. 10, No. 2, p. 2, 1916; Chamberlin, *Bull. Mus. Comp. Zool.* vol. 64, p. 4, 1920.

The following is a translation of Kraepelin's description (1903):—

"Hinder end of the head overlapped by the anterior end of the 1st tergite, or conversely with its hinder end overlapping the edge of the 1st tergite, more or less distinctly punctured, generally with two median longitudinal sulci. First tergite with curved outline, with the collar-sulcus parallel to the anterior border, punctured like the other tergites; often with a small median depression just behind the middle, without median longituninal sulci. Median longitudinal sulci first beginning on the 3rd or 4th tergite, lateral sulci on the 4th. Median keel not prominent. Anterior margins of prosternum of toxicognaths lightly convex with 5 or 6 setae on either side. Sternites normally punctured. Spiracles slit-like, that of the last segment narrow-oval. Coxopleurae caudally roundly truncated, with scattered spines or setae, pores numerous, reaching to the hinder end. Legs, in the hinder segments, armed with spinescent setae. Ventral surface of the femur of the anal legs with bare longitudinal area between the spines, patella the same, dorsally without longitudinal groove, produced at the end into a small tubercle. Tibia ventrally with 8, 1st tarsal joint with 3 or 4 teeth, the end of the tibia dorsally with a distinct spine on each side. Colour ochraceous. Length, 24 mm. Australia (Sydney), New Zealand. . . .

"*C. setosus* Poc. from New Zealand is only established through its greater hairiness and puncturing, both characters of such great variability that they cannot be considered specific."

I have only one specimen of this species, collected at Cheviot by Mr. J. B. Mayne.

Cryptops zelandicus Chamberlin.

Cryptops zelandicus Chamberlin, *Bull. Mus. Comp. Zool.*, vol. 64, p. 9, 1920.

"Type, M.C.Z. 1922. New Zealand: Wellington, 18th August, 1914 (W. M. Wheeler).

"Colour fulvous. Cephalic plate with caudal margin free, overlapping the 1st dorsal plate, a short median sulcus in frontal region and a pair of short submedian sulci in front of caudal margin. First dorsal plate without either transverse or longitudinal sulci. Second tergite with paired longitudinal sulci; much shorter than the first. Last dorsal plate with caudal portion triangular, the median angle narrowly rounded. Prosternum with anterior margin convex on each side, edge chitinous, bearing on each side 3 or 4 setae. Ventral plates not roughened; last one caudally truncate. Coxopleurae short, caudally rounded; caudal margin bearing several spinescent setae; pores few (near 20), partly covered, not reaching the caudal margin. Penult legs with 3rd and 4th joints beneath with numerous spines, corresponding ones on other legs becoming fewer and more slender in going cephalad. Anal legs with similar spinescent setae; metatarsus armed beneath with 6 teeth, 1st tarsal with 2. Length, 13 mm." (Chamberlin.)

I have not seen this species.

Cryptops megalopora Haase.

Cryptops megalopora Haase, *Abh. Mus. Dresden*, vol. 5, p. 80, 1887; Kraepelin, *Mit. Mus. Hamburg*, vol. 20, p. 51, 1903; Chamberlin, *Bull. Mus. Comp. Zool.*, vol. 64, p. 4, 1920.

The following is a translation of Kraepelin's description (1903):—

"Head-plate with its free hinder end only slightly overlapping the 1st tergite, not sulcate, with very fine and leathery wrinkling, sparsely hairy. First tergite with distinct collar-sulcus near the anterior margin, scarcely produced posteriorly, without median longitudinal sulci. Median and lateral sulci beginning on the 3rd tergite, indistinct and distorted. Prosternum in the middle shallowly depressed, without hairs (?). Sternites with cross-sulci, last one shortly rounded posteriorly. Coxopleurae with some reddish hairs posteriorly, also with 2 light inwardly-directed spinelets, with about 14 large pores scattered over the whole surface, but not reaching to the hinder end. Legs with short dark-brown spines and long reddish-yellow hairs. Femur and patella of anal legs provided ventrally with scattered hairs, without bare longitudinal area; tibia with 6, 1st tarsus with 3, teeth ventrally.

"Length, 18 mm.

"*Loc.*—Auckland Islands."

Cryptops polyodontus Attems.

Cryptops polyodontus Attems, *Zool. Jahrb. Syst.*, vol. 18, p. 106, 1903; Kraepelin, *Mit. Mus. Hamburg*, vol. 20, p. 53, 1903; Chamberlin, *Bull. Mus. Comp. Zool.*, vol. 64, p. 8, 1920.

The following is a translation of Kraepelin's description (1903):—

"Hinder end of the head overlapped by the anterior end of the 1st tergite, without sulci. The 1st tergite with Y-shaped impression. All tergites finely hairy, faintly punctured, median longitudinal sulci on the 5th to 7th segments developed only in the posterior third, complete from 8th segment onwards, lateral crescentic sulci beginning on 3rd (2nd) segment, on 19th segment all sulci indistinct, 20th and 21st tergites smooth. Prosternum with straight truncated anterior end, without marginal setae. Sternites strongly hairy, not punctured, cruciform sulci to 19th segment (here indistinct), absent from 20th and 21st segments; last sternite narrowly trapezoid with convex rounded hinder end. Spiracles long oval. Femur of anal leg ventrally low-keeled, moderately provided with fine hairs and stouter setae; similarly the patella, which ventrally bears at the end a short thick tooth, tibia ventrally for the whole length set with numerous teeth in several rows (4 rows terminally, less at the base), 1st tarsus concave at the base, then club-shaped, with 6 pectinate teeth. Colour dark brown; head and 1st tergite, &c., red.

"Length, 28 mm.

"Chatham, Stephens Island."

I have two specimens, with the anal legs missing, which I have referred to this species. They are labelled "Chatham Islands."

Cryptops australis Newport.

Cryptops australis Newport, *Trans. Linn. Soc.*, vol. 19, p. 408, 1845: Pocock, *Ann. Mag. Nat. Hist.*, ser. 6, vol. 11, p. 129, 1893: Kraepelin, *Mit. Mus. Hamburg*, vol., 20, p. 58, 1903; *Fauna sudw. Austr.*, vol. 2, p. 106, 1908; *Arkiv. Zool.*, vol. 10, No. 2, p. 2, 1916: Chamberlin, *Bull. Mus. Comp. Zool.*, vol. 64, p. 8, 1920.

The following is a translation of Kraepelin's description (1903):—

"Head posteriorly overlapped by the 1st tergite, punctured, without sulci. First tergite without sulci, punctured like the following ones, surface and sides somewhat wrinkled. Median longitudinal sulci extending from the 4th to the 18th segment, similarly the crescentic lateral sulci. Median keel scarcely raised. Prosternum of toxicognaths with slightly rounded anterior end, with only some diminutive hairs on the edge, the latter not swollen, without setae. Sternites with cruciform sulci, the longitudinal appearing shorter than the transverse (*i.e.*, the hinder arm short), disappearing completely on the 18th. Coxopleurae hairy around the edge, with only about 3 rows of altogether about 30 pores, scarcely reaching to the hinder end. Spiracles from slit-like to narrow-oval. Legs without 'dornspicula,' the penultimate pair with short white downy hairs. Femur and patella of anal leg ventrally narrowing out into a keel shape, dorsally altogether bare, ventrally on each side of the keel with numerous short setose hairs, without naked longitudinal area, and without deep longitudinal hollow; dorso-terminally without furrow or spiny processes. Patella at the end usually with sharp tooth. Tibia ventrally with 8 to 11, tarsus with 4 to 5, pectinate teeth. Colour ochraceous, head somewhat reddish, sides sometimes with trace of green margining.

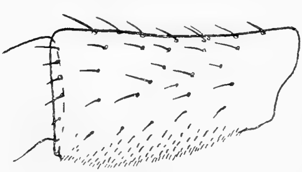
"Length, 30 mm.

"New Zealand."

This species is known also from Western Australia and Queensland. I have not seen any specimens, but the following species resembles it closely.

Cryptops galidus n. sp. (Figs. 4 and 5.)

Pale straw-colour, head slightly darker. Head overlapped by the 1st tergite. Tergal sulci extending distinctly from 4th nearly to the caudal



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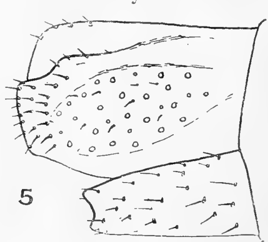

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Cryptops galidus.

Fig. 4.—Femur of anal leg. Fig. 5.—Coxopleura.

margin of the 20th segment. Anal tergite with caudal portion triangular, the apex broadly rounded. Prosternum with anterior margins slightly convex, meeting medianly in a gentle sinuation, 5 or 6 fine submarginal hairs on each side. Sternites with cruciform sulci from 2nd to 18th segments, the transverse arm recurved and more deeply impressed than the longitudinal. Anal sternite with strongly convex lateral margins, merging by broadly rounded angles to the slightly emarginate caudal margin. Coxopleurae (fig. 5) with a slightly rounded caudal margin, bearing 3 irregular rows of short setae, pores fairly large, not more than 30 in number, leaving very broad pore-free margins. Femur of penult legs (fig. 4) with setae above and a dense downy pubescence below. Anal legs: femur and prefemur with numerous short sharp setae; femur 2·1 times, prefemur 2·2 times, and tibia 2·0 times as long as broad; dental formula 2 + 9 + 4; the tooth-bearing margins of tibia and 1st tarsal joint quite straight.

Length, 28·5 mm.

Loc.—Mount Algidus (T. Hall).

This species differs from *C. australis*, as described by Kraepelin, in possessing spinescent setae dorsally on the anal femur, and in the extension of the tergal sulci nearly to the end of the 20th segment.

Cryptops dilagus n. sp. (Fig. 6.)

Pale straw-colour, head slightly darker. Head without sulci, overlapped by the 1st tergite. Tergal sulci: a pair of incomplete sulci converging cephalad on 4th and 5th, complete from 6th to 19th, and extending half-way along 20th. Anal tergite with straight converging sides, triangular projection medianly rounded, lateral angles rounded. Prosternum with

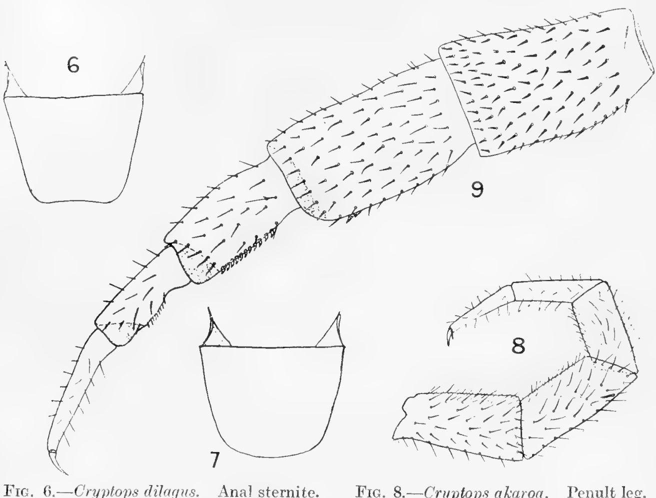


FIG. 6.—*Cryptops dilagus.* Anal sternite.
FIG. 7.—*Cryptops akaroa.* Anal sternite.
FIG. 8.—*Cryptops akaroa.* Penult leg.
FIG. 9.—*Cryptops akaroa.* Anal leg.

anterior margins slightly emphasized, vaguely convex, medianly gently sinuate, a few submarginal hairs but no strong setae. Sternites with cruciform sulci from 2nd to 18th; transverse arm recurved, longitudinal arm reaching to anterior margin, and half-way from transverse to posterior margin; posterior portion of the longitudinal arm less distinct. Anal sternite (fig. 6) with only slightly convex sides, converging caudad, angles broadly rounded, caudal margin gently emarginate. Coxopleurae with rounded caudal margin, pores large and small, about 50 in number, including a row of small pores partly concealed by the anal sternite, a broad pore-free margin bearing about a dozen setae. Femur of penult legs spinescent above and laterally, below with many short fine hairs, but not so finely pubescent as in the last species; 1·9 times as long as broad. Anal legs: femur 1·9 times as long as broad, covered with many spinescent setae, prefemur 2·0 times as long as broad, with less stout setae than the femur, tibia 1·8 times as long as broad; dental formula 1 + 13 + 7 (1 + 11 + 7 in paratype), no special raised keel for the teeth on the tibia, a moderate keel bearing the teeth of the first tarsal joint, but not extending beyond the dentate area, as in *C. ignivia* n. sp.

Length, 27 mm.

Loc.—Mount Algidus (T. Hall).

Cryptops akaroa n. sp. (Figs. 7 to 9.)

Colour dull yellowish-brown, head orange. Head without sulci, overlapped by the 1st tergite. Tergal sulci complete from the 4th segment, extending two-thirds along the 20th. Anal tergite with straight sides, slightly converging caudad, caudal portion triangular with blunt median angle. Prosternum with chitinized gently convex anterior margins, medianly slightly emarginate, bearing a few submarginal hairs. Sternites with transverse arm of cruciform sulci visible from 2nd, longitudinal arm visible from 4th to 19th segment; transverse arm recurved and more distinct than longitudinal, which extends from the transverse arm half-way to the anterior and posterior margins of the sternites. Anal sternite (fig. 7) with distinctly convex sides converging caudad, and merging by broadly rounded angles to the slightly convex caudal margin. Coxopleurae with 40 large and small pores, a wide pore-free margin with about 10 setae caudad. Femur of penult legs (fig. 8) 1·7 times as long as broad, with a few long sharp setae above and at the sides, and with numerous shorter more slender hairs below. Anal legs (fig. 9) very stout, femur 1·6 times as long as wide, covered with numerous stout spinescent setae, prefemur 1·75 times as long as wide, with longer setae than the femur, tibia 1·8 times as long as wide; dental formula 2 + 11 + 7.

Length, 25 mm.

Loc.—Akaroa (G. A.).

This species differs from the last in its stouter penultimate and anal legs, the form of the anal sternite, and the fewer coxopleural pores.

Cryptops ignivia n. sp. (Fig. 10.)

Colour light yellowish-brown, head darker. Head overlapped by 1st tergite. Tergal sulci faint but nearly complete on 5th, complete from 6th nearly to caudal margin of 20th. Last tergite with sides slightly converging, triangular process with median angle rounded. Prosternum with anterior margins chitinized, almost straight, with a very slight edentation at their junction; one or two very small submarginal hairs. Sternal sulci not deeply impressed, transverse recurved and more distinct than longitudinal, which reaches only half-way to front and hind margins of the sternites. Anal sternite with slightly convex, posteriorly converging lateral margins; angles rounded, caudal margin with the slightest trace of a median emargination. Coxopleurae truncated and setose caudally;

pores 60, a broad pore-free margin. Femur of penult legs with a few long strong setae above, with more numerous more slender setae below; 1·8 times as long as wide. Anal leg: femur with moderately long and fine

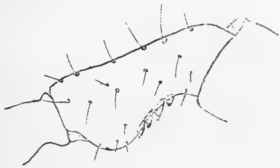


FIG. 10.—*Cryptops ignivia.* Anal metatarsus.

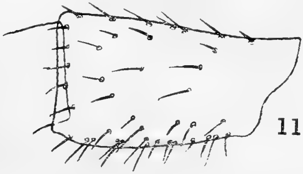
setae dorsally, changing to strong spinescent setae ventrally; prefemur with less spinescent setae; 1st tarsal joint (fig. 10) with a strongly developed rounded keel arising from the ventral surface distad of the teeth; dental formula 1 + 8 + 4. Femur 2·5 times, prefemur 2·3 times, and tibia 2·6 times as long as wide.

Length, 30 mm.

Loc.—Type, Routeburn (T. Hall); paratypes, The Remarkables (T. Hall).

Cryptops algidus n. sp. (Figs. 11 and 12.)

Colour yellowish-brown, head slightly darker. Head overlapped by 1st tergite. Tergal sulci complete from 7th to 18th segments, visible also on caudal half of 19th. Last tergite broadly triangular caudad, the apex rounded. Prosternum with anterior edges slightly thickened, slightly convex, a few (3 or 4) submarginal hairs. Sternites with transverse arm of cruciform sulci visible from 2nd, longitudinal arm visible from 3rd to 18th segment. Transverse arm wider and more strongly marked than longitudinal, and strongly recurved. Longitudinal arms reaching from



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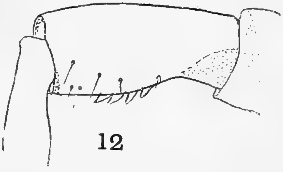

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Cryptops algidus.

FIG. 11.—Femur of penult leg. FIG. 12.—Anal metatarsus.

the transverse only half-way to the anterior and posterior margins of the sternites. Last sternite with convex converging sides, partly covering the coxopleurae, caudal margin gently emarginate, angles rounded. Coxopleurae caudally truncate, the margin bearing about 6 setae; pores large and small, 70 in number; a fairly wide pore-free margin. Femur of penult legs (fig. 11) with a few strong setae dorsally, and more numerous slightly slenderer spinescent setae below; 1·8 times as long as wide. Anal legs: femur 2·1 times, prefemur 2·0 times, and tibia 2·0 times as long as wide; femur covered with numerous stout setae, prefemur with less stout setae; dental formula 1 + 9 + 4. Metatarsus (fig. 12) without swollen ventral margin.

Length, 26 mm.

Loc.—Mount Algidus (T. Hall).

Subspecies *elidus* n. subsp. differs from the type in having more slender penult and anal legs (proportions, length to breadth, penul femur 2·0, anal femur 2·3, prefemur 2·4, tibia 2·3) and in having the tergal sulci continuous from the 7th to half-way along the 20th tergite.

Length, 33 mm.

Loc.—Cass (G. A.).

Cryptops pelorus n. sp.

Colour light orange, head darker. Head overlapped by 1st tergite. Tergal sulci complete from 6th to 19th segments, and extending a short distance along 20th. Anal tergite slightly narrowed posteriorly, caudal portion triangular with rounded apex. Prosternum with convex well-chitinized anterior margins, slightly inclined mesially, with 2 or 3 fine sub-marginal hairs. Sternites with cruciform sulci from 2nd to 18th segment, indistinct on 19th; transverse arm recurved and more distinct than longitudinal; the latter reaches the anterior margins of the sternites, but is only a short depression behind the transverse arm. Anal sternite with convex posteriorly converging sides, angles rounded, caudal border distinctly emarginate. Coxopleurae rounded posteriorly, pores 100, varying in size but not very large, about 10 short setae terminally, pore-free margin moderately wide. Femur of penult leg with a few spinescent setae above and at the sides, ventrally densely covered with rather short hairs; prefemur and tibia with a few long slender hairs above and dense short hairs below; femur twice as long as wide. Anal leg: femur 2·3 times as long as wide, moderately provided with spinescent setae at the sides and with rather long hairs above; prefemur 2·2 times as long as wide; tibia with straight dentate edge, 1st tarsal joint with strongly developed dentate keel; dental formula 2 + 10 + 7 (6).

Length, 27 mm.

Loc.—Type, Pelorus Valley (T. B. Smith); Ohakune (T. R. Harris).

Cryptops lamprethus Chamberlin.

Cryptops lamprethus Chamberlin, *Bull. Mus. Comp. Zool.*, vol. 64, p. 4, 1920.

" Type, M.C.Z. 1925. Paratype, M.C.Z. 2034. New Zealand: Plimmerton, Taumarunui, August, 1914 (W. M. Wheeler).

" Colour ferruginous. Cephalic plate without sulci. Paired sulci complete first on 8th dorsal plate. Prosternum presenting a straight chitinous anterior edge which is not at all or but vaguely and very slightly angulate at middle, without hairs. Sternites each with a cruciform impression, of which the longitudinal furrow is wider and deeper and the transverse one curved with concavity cephalad; last 3 or 4 plates lacking this impression. Last ventral plate without sulci, narrowed caudad, caudal margin straight or slightly incurved. Spiracles large, longitudinally elliptic. Coxopleurae short, caudally subtruncate, pores large and small, numerous, in numerous rows, not reaching caudal margin. Anal legs missing. Penult legs clothed ventrally with dense very fine hairs, in striking contrast with the much longer and coarser hairs and setae laterally and above.

" Length, 28 mm.

"The paratype does not show the pecularity in hair of the penult legs. The anal legs have 6 teeth on the metatarsal and 5 on the 1st tarsal. Femur and tibia densely clothed beneath with spinescent setae." (Chamberlin).

I have not seen this species.

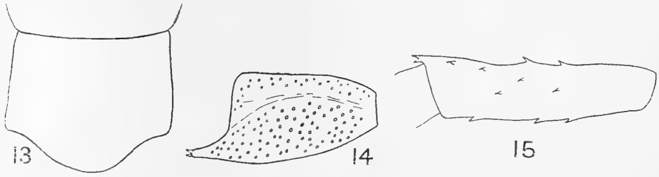
OTOSTIGMIDAE.

Genus OTOSTIGMUS Porath, 1876.

Otostigmus Porath, *Bihang Svensk. Ak. Handl.*, vol. 5, No. 7, p. 18, 1876; Kraepelin, *Mit. Mus. Hamburg*, vol. 20, p. 97, 1903.

Otostigmus chiltoni n. sp. (Figs. 13 to 15.)

Colour (in spirit) dull yellow. Antennae 17 joints, 3 basal joints comparatively bare dorsally, slightly more hairy ventrally. Head not punctured, with a slightly raised kidney-shaped lighter band between and slightly behind the eyes. Dental plates of prehensors armed with 4 + 4 teeth, the outer one on each side standing rather apart, femoral tooth simple and somewhat blunt.



Otostigmus chiltoni.

FIG. 13.—Anal tergite. FIG. 14.—Coxopleura. FIG. 15.—Inner surface of anal leg.

Tergites: The 1st not punctured and without sulci, median keel on segments 2 to 20, the keel on each segment widening posteriorly and flattening out in front of the posterior border. A longitudinal sulcus on each side of the keel (about half-way to the edge), extending throughout from the front of the 2nd to the end of the 20th tergite. Margining beginning indistinctly on the 7th, distinctly on the 12th, tergites. Last tergite (fig. 13) sparsely punctured, produced and evenly rounded posteriorly.

Sternites with two submedian parallel depressions from 3rd to 19th, increasing in distinctness up to the 13th and then becoming less distinct again. Last sternite narrowed posteriorly, and with slightly rounded posterior end.

Spiracles oval, with crenulated border; on segments 3, 5, 8, 10, 12, 14, 16, 18, 20.

Coxopleurae (fig. 14) with long narrow process bearing two divergent terminal spines. Pores numerous and evenly distributed, pore-area extending to upper half of coxopleurae and reaching to the base of the process.

Legs from 1st to 20th with 2 tarsal spurs, tibiae and tarsi unspined. Anal legs with 1 tarsal spur, femur (fig. 15) dorsal inner with 2 spines and a bifid angular spine, inner surface with 5 spines, ventral outer with 3.

Length, 20 mm.

Loc.—Three Kings Island (Dr. C. Chilton). Types in the Canterbury Museum.

Genus Ethmostigmus Pocock, 1898.

Heterostoma (nom. praeocc.) Newport, *Trans. Linn. Soc.*, vol. 19, p. 275, 1844. *Dacetum* (nom. praeocc.) C. L. Koch, *Syst. Myr.* p. 156, 1847. *Ethmostigmus* Pocock, *Ann. Mag. Nat. Hist.*, ser. 7, vol. 1, p. 327, 1898; Kraepelin, *Mit. Mus. Hamburg*, vol. 20, p. 155, 1903.

Ethmostigmus platycephalus Newport.

Heterostoma platycephala Newport, *Trans. Linn. Soc.*, vol. 19, p. 415, 1845. *H. platycephala* + var. *lugubre* Haase, *Abhandl. Mus. Dresden*, vol. 5, p. 92, 1887. *H. brownii* + var. *gracile* Haase, *ibid.*, p. 94. ? *H. viridipes* Pocock, *Ann. Mag. Nat. Hist.*, ser. 6, vol. 7, p. 56, 1891. *H. loriae* Silvestri, *Ann. Mus. civ. Genova*, vol. 34, p. 631, 1894. *H. platycephalum* Attems, Semon's *Forschungreise*, vol. 5, p. 509, 1898. *Ethmostigmus platycephalus* Pocock, Willey's *Zool. Results*, pt. 1, p. 62, 1898; Pocock, *Ann. Mag. Nat. Hist.*, ser. 7, vol. 1, p. 327, 1898; Ribaut, *Abhandl. Senckenb. gesellsch.*, vol. 34, p. 284, 1912; Kraepelin, *Mit. Mus. Hamburg*, vol. 22, p. 162, 1903; Attems, *Bijdr. dierk.*, vol. 20, p. 4, 1915; Chamberlin, *Bull. Mus. Comp. Zool.*, vol. 64, p. 21, 1920.

There is a dried specimen of this species in the Canterbury Museum, with, however, no record of locality. It was probably on account of this specimen that Hutton included the species in the *Index Faunae Novae Zelandiae*, and it seems more likely that it was an immigrant than a native species. It differs from the typical *E. platycephalus* in the following details: Fifth leg with 2 tarsal spines (1st to 4th legs missing); the left coxopleura with 3 spines dorsally, the right with 2. (The coxopleurae extend beyond the last sternite by twice the length of that sternite, and meet together behind in the usual manner.)

Ethmostigmus rubripes (Brandt).

Scolopendra rubripes Brandt, *Bull. Sci. St. Petersb.*, 1840, p. 156. *Heterostoma sulcidens* Kohlrausch, *Archiv naturg.*, vol. 47, p. 59, 1881. ? *H. crassipes* Silvestri, *Ann. Mus. civ. Genova*, vol. 34, p. 632, 1894. *Ethmostigmus rubripes* Pocock, *Ann. Mag. Nat. Hist.*, ser. 7, vol. 8, p. 459, 1901; Kraepelin, *Mit. Mus. Hamburg*, vol. 22, p. 161, 1903; *Fauna sudw. Austr.*, vol. 2, p. 108, 1908; Brolemann, *Records Austr. Mus.*, vol. 9, p. 44, 1912; Kraepelin, *Arkiv. Zool.*, vol. 10, No. 2, p. 8, 1916; Chamberlin, *Bull. Mus. Comp. Zool.*, vol. 64, p. 22, 1920.

The Canterbury Museum has a specimen found at Christchurch in 1901 among timber imported from Australia. *E. platycephalus*, noted above, was probably introduced into this country in a similar manner.

SCOLOPENDRIDAE.

Genus Cormocephalus Newport, 1844.

Cormocephalus Newport, *Trans. Linn. Soc.*, vol. 19, p. 419, 1844; Kraepelin, *Mit. Mus. Hamburg*, vol. 20, p. 184, 1903.

Key to New Zealand Species of Cormocephalus.

Ventral spines of anal femur 3 in number, in a single row .. *C. rubriceps* Newp.
Ventral spines of anal femur 4 in number, in two oblique rows.. *C. violascens* (Gerv.).

Cormocephalus rubriceps (Newport). (Figs. 16 to 18.)

Scolopendra rubriceps Newport, *Ann. Mag. Nat. Hist.*, vol. 13, p. 99, 1844. *Cormocephalus rubriceps* Newport, *Trans. Linn. Soc.*, vol. 19, p. 419, 1845; Pocock, *Ann. Mag. Nat. Hist.*, ser. 6, vol. 11, p. 128, 1893; Kraepelin, *Mit. Mus. Hamburg*, vol. 22, p. 198, 1903.

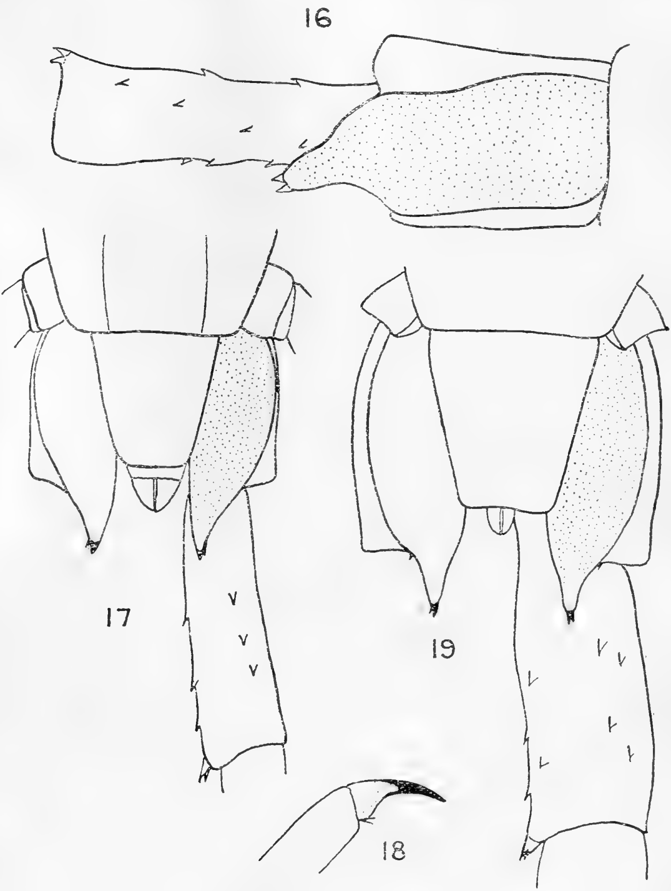


FIG. 16.—*Cormocephalus rubriceps.* Inner view of femur of left anal leg.
FIG. 17.—*Cormocephalus rubriceps.* Ventral view of anal segment.
FIG. 18.—*Cormocephalus rubriceps.* Terminal claw of anal leg.
FIG. 19.—*Cormocephalus violascens.* Last sternite, coxopleura, and femur of anal leg.

Colour: Head and 1st tergite reddish-brown, remainder dark olive-brown; legs yellowish on proximal half to green distally, distal portion of anal legs light blue, the blue and green fading out in spirit.

Head smooth, sparsely punctured, with 2 median longitudinal anteriorly diverging sulci extending from the posterior border nearly to the middle of the head. Post-cephalic plates moderately large and quite distinct. Posterior border of the head angular, the tip engaged under the 1st tergite. Antennae 17 joints, the proximal 5 smooth, the remainder pubescent. Prosternum of prehensors smooth, sparsely punctured, with irregular transverse sulcus in anterior third. Dental plates very slightly narrowing cephalad, teeth 4 + 4, the outer one slightly apart.

Tergites: the 1st smooth and sparsely punctured, 2nd to 20th distinctly bisulcate. Margining beginning faintly on the 5th (6th), distinctly on the 7th. From 4th or 5th the posterior border is slightly wrinkled and somewhat darker. Last tergite without median sulcus and produced roundly backwards. Sternites bisulcate from 2nd to 20th, the 21st with a weak median sulcus or depression, and strongly narrowed posteriorly. Spiracles very narrowly triangular, slit-like.

Coxopleurae (figs. 16 and 17) with narrow 2-spined conical process, generally without small lateral spine,* pore-area extending partly along process, the pores very fine and close-set. Anal legs: femur (fig. 17) outer ventral with a single row of 3 spines, inner ventral with an oblique row of 3 spines leading to 2-spined angular spur, inner dorsal 2 spines. Terminal claw with basal spur (fig. 18).

Length, to 110 mm.

Loc.—Whangarei, Ruapekapeka, Gisborne; a specimen was caught in 1901 at Southbridge, in a railway-truck containing timber from the Kaipara district.

Hab.—New Zealand, Tasmania, New South Wales, and Queensland.

Cormocephalus violascens (Gervais). (Fig. 19.)

Scolopendra violascens Gervais, *Insect. Apt.*, vol. 4, p. 275, 1847. *Cormocephalus violaceus* Newport (non Fabr.), *Trans. Linn. Soc.*, vol. 19, p. 424, 1845; Hutton, *Trans. N.Z. Inst.*, vol. 10, p. 289, 1878. *C. purpureus* Pocock, *Ann. Mag. Nat. Hist.*, ser. 6, vol. 8, p. 127, 1893. *C. huttoni* Pocock, *ibid.*, p. 128. *C. violascens* Pocock, Willey's *Zool. Results*, pt. 1, p. 60, 1898. *C. huttoni* Kraepelin, *Mit. Mus. Hamburg*, vol. 22, p. 202, 1903.

Colour uniform light brown, legs slightly lighter.

Head smooth, sparsely punctured, 2 median longitudinal anteriorly diverging sulci in posterior 3rd. Post-cephalic plates proportionally smaller than in *C. rubriceps*. Antennae 17 joints, the proximal 6 smooth, the remainder pubescent. Prosternum smooth, sparsely punctured, no irregular transverse sulcus in anterior 3rd. Dental plates and teeth as in *C. rubriceps*.

Tergites: 1st smooth and lightly punctured, 2nd to 20th distinctly bisulcate; margining beginning faintly on 7th and distinctly on 9th. No wrinkles on posterior border of tergites. Last tergite without median

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* Kraepelin (1903) writes "zuweilen mit winzigem Seitendorn"; but I have not seen this small spine in the specimens I have examined.

sulcus, produced roundly backwards. Sternites bisulcate from 2nd to 20th 21st without median sulcus, and very strongly narrowed caudad. Spiracles' narrowly triangular, scarcely slit-like.

Coxopleurae (fig. 19) with narrow conical 2-spined process, and a small lateral spine, pore-area extending half-way along the process, pores fine and close together but not to such an extent as in *C. rubriceps*. Anal legs: femur (fig. 19) outer ventral with two obliquely set pairs of spines, inner ventral distally with 2 spines, basally with 1 small spine, inner dorsal 2 spines and bifid angular spine. A median depressed area on the ventral surface. Terminal claw without basal spur.

Length, to 60 mm.

Loc.—Kapiti Island, Wellington; Hanmer; Kaikoura.

ART. XXIII.—*A New Species of Shark.*

By GILBERT ARCHEY, M.A., Assistant Curator, Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1920; received by Editor, 31st December, 1920; issued separately, 20th July, 1921.*]

Plate XXXIX.

ON the 12th June, 1920, Mr. C. W. Sherwood, of New Brighton, presented to the Canterbury Museum a small shark which he had found on the New Brighton beach. It is considered to be a new species of *Scymnodon*, a genus of small sharks living in deep water, and is named after its discoverer.

SCYMNODON Bocage and Capello, 1864.

Scymnodon Bocage and Capello, *Proc. Zool. Soc.*, 1864, p. 263. *Zameus* Jordan and Fowler, *Proc. U.S. Nat. Mus.*, vol. 26, p. 633, 1903. *Scymnodon* Tate Regan, *Ann. Mag. Nat. Hist.*, ser. 8, vol. 2, p. 48, 1908.

Scymnodon sherwoodi n. sp. (Plate XXXIX, and text-figs. 1 and 2.)

Dermal denticles (fig. 1) pedunculate, with 3 parallel keels, each ending in a point, the central keel being the longest.

Distance from mouth to snout less than half the distance between snout and first gill-opening (proportion 9 : 23). Nostrils oblique, distance between them three-fifths of preoral length of snout. Length of anterior labial fold about equal to its distance from the symphysis.

Anterior dorsal fin shorter than the 2nd, length of its base three-tenths of the distance between it and the 2nd dorsal. Anterior end of 1st dorsal distant from the snout by nearly half the total length of the fish. Posterior extremity of pectorals falls short of the anterior end of the 1st dorsal by more than its own length. Posterior extremity of claspers reaching to vertical from half-way along free posterior border of 2nd dorsal.

Total length, 803 mm. Colour dark brown, with two submedian lighter areas extending from below the gill-openings to the ventrals. Angles of gill-openings tipped with dirty-white, posterior angle and posterior border of pectorals with narrow dirty-white margin. The spines of the dorsal fins are scarcely discernible rudiments embedded in the fin.

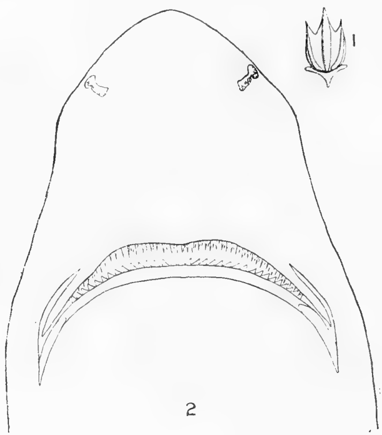


Fig. 1.—Dermal denticle. Fig. 2.—Lower surface of head.

This species differs from *Scymnodon squamulosus* (Günther)* in its shorter snout, the wider space between the nostrils, the more posterior position of the 1st dorsal, and the brown colour. A median dorsal silvery blaze extends from level with the spiracles to level with the hinder end of the base of the pectorals; it is caused through the denticles of the area being slightly raised and without the brown pigmentation of the other denticles, and is possibly not a natural condition.

Loc.—New Brighton.

Type in the Canterbury Museum.

The specimen is a male; its claspers are 1·8 in. long, and bear subterminally a curved sharp claw 0·6 in. long.

* *Centrophorus squamulosus* Günther, "*Challenger*" *Deep-sea Fishes*, p. 5, pl. ii, fig. B, 1887.

Scymnodon sherwoodi.

ART. XXIV.—*The Leaf-mining Insects of New Zealand: Part II.*

By MORRIS N. WATT, F.E.S.

[*Read before the Wanganui Philosophical Society, 24th October, 1920; received by Editor, 31st December, 1920; issued separately, 20th July, 1921.*]

Plates XL–XLIII.

PART II.—THE GENUS *NEPTICULA* (LEPIDOPTERA).

INTRODUCTION.

THIS genus is represented in New Zealand by the following eight species, four of which are dealt with in the present paper; it is probable that a number still remain to be found:—

Nepticula ogygia Meyr., *Trans. N.Z. Inst.*, vol. 21, p. 187, 1889.
—— *tricentra* Meyr., *Trans. N.Z. Inst.*, vol. 21, p. 187, 1889.
—— *propalaea* Meyr., *Trans. N.Z. Inst.*, vol. 21, p. 187, 1889.
—— *cypracma* Meyr., *Trans. N.Z. Inst.*, vol. 48, p. 419, 1916.
—— *oriastra* Meyr., *Trans. N.Z. Inst.*, vol. 49, p. 247, 1917.
—— *lucida* Philp., *Trans. N.Z. Inst.*, vol. 51, p. 225, 1919.
—— *perissopa* Meyr., *Trans. N.Z. Inst.*, vol. 51, p. 354, 1919
—— *fulva* n. sp., herein, p. 215.

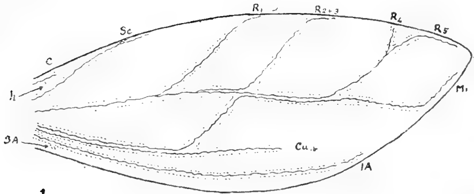
MAIN CHARACTERISTICS OF GENUS.

The main characteristics of the genus are as follows:—

The Imago.

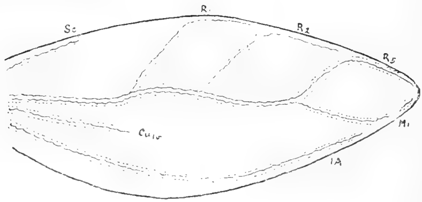
Head hairy, tufted; tongue rudimentary; antennae with basal joint enlarged to form an eye-cap; maxillary palpi rather long, folded; labial palpi short, slightly porrected. Forewings rather broad, short and coarse scales, the termen clothed with long cilia and shorter scales, these latter may be darker at their tips and so form one or more, more or less distinct "cilial lines." Hindwings lanceolate; frenulum multiple in both sexes.

Within the genus there are two types of venation in the forewing. In the more primitive one the media coalesces with the cubitus for a short distance from the base, then passes obliquely to the radius just beyond R_{2+3}, and anastomoses with the radius to beyond the middle of the wing. In the second type the media coalesces with the radius from the base to beyond the middle of the wing. All four species dealt with in this paper belong to this latter type. Forewing: Costal vein (C) small and insignificant, there is no costal trachea in the pupal wing except in the more primitive type, where it is extremely short; subcostal (Sc) in the more primitive type is connected to the costal near the base by a short oblique humeral cross-vein (*h*), the pupal trachea is distinct and in the latter type is branched near its tip; radius represented by three veins, R_1 and R_{2+3} running parallel to each other to costa, the third, R_{4+5}, to apex, bifurcated in the primitive type; media represented by an unbranched vein (M_1) reaching the wing-margin below the apex; cubitus (Cu_{1b}), unbranched, and becomes



1a.

1b.



1c.

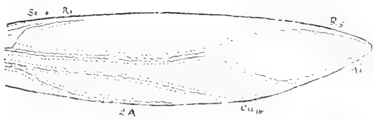


FIG. 1*a*.—Pupal forewing of the more primitive type of Nepticula. The wavy lines represent the tracheae, the dotted lines represent the veins that are found later.
FIG. 1*b*.—Pupal forewing of *N. tricentra* about one week before emergence.
FIG. 1*c*.—Pupal hindwing of *N. tricentra* about one week before emergence.

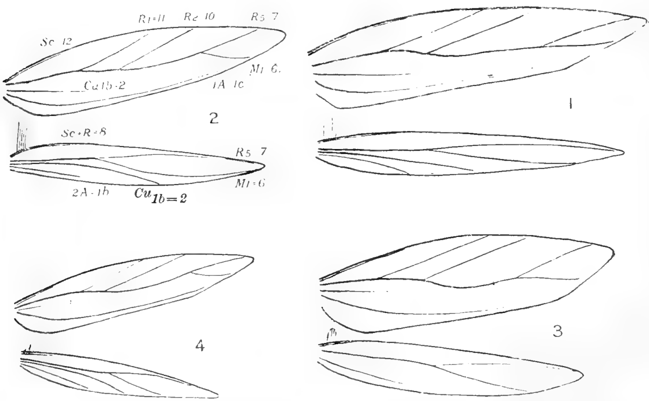


FIG. 1.—Wing-venation of *N. fulva*.
FIG. 2.—Wing-venation of *N. ogygia*.
FIG. 3.—Wing-venation of *N. perissopa*.
FIG. 4.—Wing-venation of *N. tricentra*.
(Camera-lucida drawings, all to same scale.)

obsolete at or before the middle of the wing; anal veins, 1A present, extending almost whole length of dorsum, 3A sometimes present in the more primitive type but extremely short. Hindwing: Costal vein (C) as in forewing, but there is no trachea to be found in the pupal wing; subcosta (Sc)—this contains both its own trachea and that of R_1; radius, in the pupal wing R_1 leaves the main stem near the base to become incorporated in the same vein-cavity as the subcostal, while the remainder of the radial sector is reduced to a single unbranched trachea (R_5) lying in its proximal half, in the same vein-cavity with the medial trachea; media, a single unbranched vein (M_1) to below apex; cubitus (Cu_{1b}), a single unbranched vein extending to dorsal wing-margin at or beyond $\frac{1}{2}$; anal veins one, 2A; in some species 3A may be present but is extremely short and has no trachea in the pupal wing.

The Pupa.

Libera, with segments and appendages free. Maxillary palpi exceedingly well developed, emerge from beneath the antennae and turn inwards forming the eye-collar which contains only the terminal joints, the others are concealed deeply; on dehiscence remain attached to the head-parts. The body is oval in outline, about one and a half times as long as broad, and slightly flattened dorso-ventrally. The mesothoracic spiracle is in the primitive position ventral to the caudo-lateral angles of the prothorax; the spiracles of the first abdominal segment are uncovered by the wings. Setae absent. Epicranial and fronto-clypeal sutures always present, though not conspicuous. Appendages free and segmented, and separate readily on slight violence; the thoracic appendages are widely separated to show all the coxae. Pupa in a cocoon; partly protrudes from cocoon before emergence of the imago; cast larval skin within the cocoon and frequently attached to the caudal extremity of the pupa. Tutt says (*Nat. Hist. of the British Lepidoptera*, vol. 1, p. 180), "the antenna-cases on dehiscence divide into the cover of the first and that of the remainder, each separate from the head, yet still held together sufficiently to keep their places fairly."

The Larva.

Head small, flattened; the front is narrowed caudad, the lobes of the epicranium extend caudad to a considerable distance behind the meeting-point of the front and vertical triangle, there is a single large and conspicuous ocellus on each side. Body when full-grown cylindrical, attenuated caudad, segmental incisions well defined; prothorax tumid; no true legs, but eight pairs of membranous prolegs without hooklets (some species without prolegs), two pairs on thorax and six on abdomen; dermis transparent. Mines in leaves, and lives on the parenchyma.

The Ovum.

Large for the size of the moth; flat and scale-like; roundish oval in outline; micropyle at one end. Laid singly and attached to food-plant.

Chief Characteristics in Each Stage.

The chief characteristics to be noted in each stage of the life-history as an aid to the identification of the species:—

The Imago.—(1) Colour of head, basal joint of antenna, and prothoracic collar; (2) colour and markings of wings and cilia, and presence of cilial lines; (3) colour of thorax, abdomen, and legs.

The Ovum.—(1) Where situated, whether any particular portion of the leaf or stem is favoured more than any other part; (2) size, colour, and sculpture.

The Larva.—(1) General colour of body during early stages and when full-grown; (2) the colour and shape of the head; (3) markings on the prothorax, visibility of cephalic ganglia and prothoracic shield; (4) colour and appearance of ventral nerve-chain; (5) colour of intestinal canal; (6) dorsal marks on last three abdominal segments; (7) saetal plan.

The Mine.—(1) The food-plant; (2) situation on stem or leaf, whether in upper or lower surface; (3) in what particular part of the leaf; (4) its course—straight, tortuous, or vermiform; (5) whether a simple gallery, blotch, or combination of both; (6) discoloration of surrounding leaf-substance; (7) the deposition of the frass—granular, lumpy or fluid, fine or coarse, colour, copious or scanty, how deposited in the mine.

The Cocoon.—(1) Situation, whether within the mine or without; (2) size, shape, and colour.

The Pupa.—(1) The relative lengths of the thoracic appendages; (2) the arrangement of the dorsal abdominal spines; (3) the relative lengths of the coxae; (4) relative size.

(9.) **Nepticula ogygia** Meyr. (The *Olearia* Gallery-Nepticulid).

Nepticula ogygia Meyr., *Trans. N.Z. Inst.*, vol. 21, p. 187, 1889; vol. 47, p. 231, 1915.

The Imago.

Meyrick's Original Description.—"♂. 7 mm. Head and palpi pale whitish-ochreous. Antennae grey. Thorax and abdomen grey, sprinkled with ochreous-whitish. Legs dark grey, apex of joints whitish. Forewings lanceolate; pale grey, coarsely irrorated with black; an obscure cloudy ochreous-whitish suffusion towards costa at $\frac{2}{3}$; an obscurely-indicated pale spot in disc before middle: cilia whitish-ochreous-grey, with an obscure line of dark scales round apex. Hindwings and cilia light grey."

The above description was taken from a single specimen, most possibly caught in the field. During the last few seasons I have been fortunate in rearing a good series of this rather rare little moth. There is a slight degree of variation in some of the specimens, principally in the amount of dark irroration in the forewing, which in some specimens is quite scanty, and the moth appears to the naked eye as light grey instead of black. The following description is taken from freshly emerged specimens:—

Head and palpi pale yellowish-ochreous, collar and basal joint of antenna whitish. Antennae pale grey, under 1, about $\frac{1}{2}$. Thorax grey, densely irrorated with black. Legs and abdomen light grey. Forewings pale grey, thickly irrorated with black scales; a small pale area on dorsum near tornus (this appears to be the most constant marking, and is quite conspicuous when the wings are folded at rest, when the two areas form a small saddle-shaped spot on the dorsum); in the female there is a second similar area on costa, and frequently the two may form an obscure light band across the wing; a very diffuse pale spot in disc at $\frac{1}{4}$, frequently absent; a series of four small black spots in middle of wing, one at $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, and the fourth less distinct near termen; these spots are definitely fixed as to position, but one or more or all may be absent, that at $\frac{1}{2}$ being the most constant: cilia pale grey with bluish reflections, a distinct black cilial line. Hindwings dark grey; cilia dark grey.

The imago of this moth is not very common in the field, though its mines may be found in large numbers on the food-plants. This may be accounted for by the fact that it rarely flies except in bright sunshine, the slightest dullness sending it to cover amongst dead vegetation, and in crannies in the bark of the food-plant, from which it requires fairly rough treatment to dislodge it, and even then will prefer to run to a new hiding-place rather than take to the wing. At rest its coloration is very protective, and in consequence it is a most inconspicuous object. In the sunshine its movements are quick and restless, and it rarely ventures far from its food-plant.

Distribution.

Meyrick records the original specimen from Dunedin in January: I have found it there during the last few seasons. Typical mines, but empty, were found at Dawson's Falls, Mount Egmont, in December of 1917, in *Olearia Cunninghamii* (?). Not being in Dunedin during the latter half of December and the first two months of the year, I have been unable to record the activities of this moth during these months. My first observations are dated July, 1919, when I obtained full-grown larvae, these pupating during the early part of the month, and beginning to emerge at the end of the first week of September. Larvae and cocoons were again obtained in July, 1920. In September of both years imagines were found, and many ova; a few larvae were found early in the month in 1919, these pupating in the second week and emerging during the first week of November, while numbers of larvae were pupating towards the middle of September, 1920, emerging towards the end of October. A number of imagines were obtained about the middle of November. There are therefore probably four, if not five, generations a year, but there is a fair amount of overlapping. Imagos may be looked for towards the end of June, early September, the end of October, and throughout November, and in January and possibly March. It is probable that hibernation takes place in the cocoon.

Food-plants.

Olearia nitida (now *O. arborescens* and *O. divaricata*) and *O. macrodonta*, the former apparently being the favourite. Chiefly around the margin of the bush. At Mount Egmont in *O. Cunninghamii* (?).

The Ovum and Egg-laying.

The Ovum.—Oval, wafer-like, flattened against the leaf where it is attached, rounded above. Micropylar end slightly broader than its nadir. Around the outer margin of the egg the shell is slightly produced so as to form a flattened foot or fringe closely applied to the surface of the leaf. This fringe is a slight degree wider at the micropylar end of the egg. A large number of eggs were measured, and their dimensions varied but little; in the fresh state this is the easiest way to distinguish the egg from that of *N. fulva*, which is larger. Average length of fresh egg, including fringe, 0·42 mm.; average transverse diameter, 0·30 mm.; average height, 0·12 mm. Empty shells are smaller than the above, and without including the fringe, which is inconspicuous, the average length and breadth is 0·40 mm. by 0·29 mm. There is a slight roughening of the shell, but otherwise no definite sculpture or reticulation. The micropyle is situated at the broader end of the egg, but its structure was not observed. The shell is only very slightly roughened; shiny, strong, transparent. The colour is bright blue when first laid. As the embryo develops, the blue colour becomes replaced by yellowish, especially at one end. Later the white embryo can easily be seen within the shell. After hatching, the shell becomes filled with particles of white frass. The egg is easily found, and the empty shell, which is strongly attached to the leaf, persists long after the larva has left the mine and pupated, the shiny white shells being quite conspicuous at the commencement of the galleries.

Egg-laying.—This naturally takes place during those months in which the imagos are to be found (see above). The ova are deposited singly, invariably on the upper side of the leaf with the one exception of the August–September brood mentioned below. The most favoured position for the egg is alongside the midrib of the leaf, and the locality next in favour is alongside one of the coarser veins or ribs. A number of eggs may be found on any one leaf, but it is likely that these have been deposited by several females. It has been noticed that in such cases the majority of the eggs were laid on the basal half of the leaf. When the August–September eggs are being laid the food-plant, *O. nitida*, is sending out its fresh spring buds, and on the hairy outer side (what will later be the underside) of the bud leaves many of the ova of this moth are attached, with peculiar consequences, as will be seen.

The Mine. (Plate XL.)

The mine is a narrow, usually more or less tortuous gallery, constructed entirely under the upper cuticle of the leaf. The larva burrows directly through the bottom of the egg into the leaf-substance; and following this there is no purple discoloration of the leaf in the egg area such as there is in the case of *N. fulva* on the same food-plants. The gallery is not a long one, its average length ranging from 4 cm. to 6 cm.; its course follows the coarser ribs of the leaf, these and the midrib forming a bar to progress across them. For this reason, and on account of the ova being usually

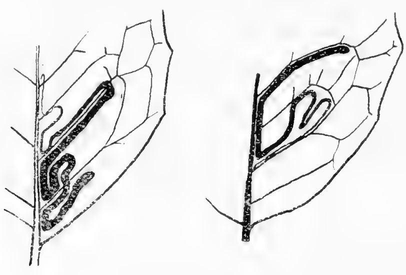


Fig. 5.—Mines of *N. ogygia* in leaf of *O. nitida.* Natural size.

deposited alongside the midrib of the leaf, most of the mines will be found to be within the primary loops formed by the veins—*i.e.*, those nearest the centre of the leaf. Towards the outer margin of the leaf neither the midrib nor the coarser veins form very serious obstacles, and may be crossed by the mines. The width of the mine increases very gradually, and at its terminal portion is not more than 1·5 mm. The frass (see Plate XL) is black and coarsely granular, abundant, and occupies an almost unbroken chain along the middle half or three-quarters of the gallery; it is entirely absent in the terminal half-centimetre of the mine; it is deposited against, and remains attached to, the roof of the mine. Individual leaves of *O. nitida* may contain many mines, but these never interfere with one another, and, however cramped the room at disposal, a gallery will seldom ever cross itself, tending rather to become closely vermiform, with its loops applied to, but not encroaching upon, each other. I have rarely found more than three or four mines in any one leaf of *O. macrodonta;* and frequently the mines on this plant cause the leaf-tissue in their immediate vicinity to become discoloured with a reddish tinge. The length of time occupied in constructing the mine is short—two or three weeks in all. I have several times noted ova, and on returning some three weeks later have found nothing but empty mines. The colour of the mine is light brown, and the black frass under the thin transparent cuticle causes it to become very conspicuous. On holding the leaf up to the light the mine is a pretty and striking object. When full-fed the larva emerges through a semicircular cut in the roof of the gallery at its terminal part, and makes its way to the ground. There remains a curious fact to be noted: In the case where the ova are laid on the leaf-buds of *O. nitida* it is not the upper surface of the leaf to which they are attached, this surface being snugly tucked away in the interior of the bud; it is to what will become the under-surface of the leaf, and amongst the thick covering of hairs that protect it at this time, that the ova are firmly cemented. No matter whether it be the upper or lower surface to which the egg is attached, the mine is always constructed close against the actual upper surface. The midrib here, even in these small succulent leaves, prevents, in all but a few cases, the larva from mining from one half of the leaf to the other; the consequence is the mine becomes closely looped backwards and forwards in the direction of the long axis of the growing leaf, so as to fill almost completely one half of the leaf. In this looped vermiform fashion the mine has progressed from the margin of the leaf towards the centre, as though the larva were aware that any other mode of tunnelling would cut off the sap-supply and leave it short of food. The mine usually progresses in a looped, vermiform fashion, from the margin of the leaf to the centre; but in very young leaves it often happens that when the thin half has been destroyed the tunnel actually enters the midrib. The course then taken is always downwards, the point of emergence lying 1 in. or less below the base of the leaf.

It is rare to find more than one larva mining in any one of these young leaves. These mines have a curious effect upon the subsequent growth and shape of the leaves. Practically one half of the leaf has been destroyed, but the other half has all the time had its sap-supply (even when the larva was in the stem, for the mine is very small, probably one-third of the transverse diameter of the stem), and has grown accordingly; the result of one half of the leaf growing and the other not has been to cause it to become curled around the axis. During November a large number of these curled leaves are to be found on the food-plant. Except in the very young leaves there is little of the mine to be seen on the under-surfaces; in the older leaves there may be a slight darkening of the colour along the track of the mine, and also the surface may be slightly elevated. The entire mine is in the spongy parenchyma of the leaf and leaf-stem.

The Larva.

Length when full-grown, about 4 mm. The ground-colour is very pale green, with a comparatively broad dark-green central line (intestinal canal containing food) commencing in the first abdominal segment, to the end of 6. A narrow dorso-lateral line on the last segment. Most of the internal organs can be distinguished. Headpiece pale amber-brown, darker round external margins, clypeal sutures, and mouth-parts. Head almost wholly retracted into the prothorax. No true legs or prolegs, but protrusible fleshy enlargements on the ventral surface of segments 2, 3, 4, 5, 6, 7, and on the mesothorax and metathorax. The larva is cylindrical, slightly flattened dorso-ventrally. The mesothorax has the greatest diameter, then the metathorax and segments 1 to 7, which are about equal; 8, 9, 10 attenuated; segment 9 about the shortest in the body; segments not deeply incised but evenly rounded. Ventral chain of fairly large somewhat elongated grey diamond-shaped ganglia, quite distinct with double connecting bands, the thoracic ganglia larger and more elongated than the abdominal ones. Cephalic ganglia dark grey, easily distinguished as backward extensions of the head-capsule into the prothorax, and when the head is retracted extend into the mesothorax and are not so easily distinguished. Head flattened, bluntly triangular. Skin covered with a fine pile; tubercles and setae present, setae comparatively long, the longer ones being about two-thirds the length of their respective segments. The details of the setal plan are left for a future paper. The colour of the larva when it leaves the mine is pale yellow throughout. The larva mines dorsum uppermost. It can easily be seen in the mine by holding the leaf up against the light. The frass-track ends abruptly, and the remainder of the mine is filled by the light-coloured larva, its dark central line making it at once conspicuous. Even under ordinary circumstances a practised eye can tell at once whether a mine is inhabited or not, by the nature of its wider extremity; in the empty mine this end is very light in colour and in strong contrast to the remainder of the gallery, is devoid of frass, and contains the conspicuous semicircular outlet cut by the escaped larva. In inhabited mines the wider extremity is lighter in colour than the rest owing to the absence of frass, the narrow dark central line of the larva taking the place of this latter; but most characteristic of all is the slightly domed roof of this portion of the mine, caused by the larva within. The colour of this part of the mine is a somewhat paler green than the rest of the leaf-surface, whereas in the empty mine it is yellowish or light brown, light grey, or very pale green, according to the length of time since it was vacated.

The Cocoon.

Somewhat ovate, mussel-shaped, ends rounded, anterior end slightly flattened and broader than its nadir. The outlet of the cocoon is guarded by a pair of flattened closely-applied lips extending across the whole front of the cocoon. Length averaging 3 mm., width 2–2·5 mm., height 1–1·5 mm. Colour at first whitish, changing to light green, to dark brown; occasionally the cocoons retain their green colour throughout. Interior of cocoon whitish. Texture thin but dense, forming a kind of skin, and surrounded outside, except where attached to external objects, by a small amount of light floccy silk. Situated amongst dead herbage on the ground in the neighbourhood of the food-plant. Two days are usually occupied in the construction of the cocoon. After the last larval moult the cast skin remains attached to the caudal end of the pupa; in many other genera it is extruded from the cocoon. Pupal period, of course, depends on local climatic conditions. A number of specimens pupated 1st July, 1919, and emerged 8th September, 1919—seventy days; another batch pupated 15th September, 1920, and emerged 24th October, 1920—thirty-nine days. It is possible that the larva hibernates in the cocoon.

The Pupa.

Female.—Ventral view: In outline the front is rounded and bluntly prominent; laterally there is a small incisura between it and the base of the antenna; this latter occupies the lateral outline for only a very short distance. The upper half of the lateral outline is evenly curved convex, and is formed by the forewing; the lower half is also curved convex but is interrupted by the depression between each segment, it is occupied by segments 3 to 10 inclusive; a small amount of the prominent spiracles appears on the lateral aspect of each segment, those on the eighth being especially prominent. The last abdominal segment is bluntly rounded and is slightly notched caudad; the genital opening can be detected on its ventral surface. Only a little of the eye is freely exposed, its upper third being covered by the base of the antenna, and its lower third by the maxillary palpus. The maxillary palpus is well developed, its expanded base resting against the antenna, and its bluntly pointed mesial extremity touching the labrum. This latter broad and rounded. Labial palpi narrow, and reach just below the lower extremities of the maxillae. The maxilla is broad above, its base resting against the mesial half of the maxillary palpus and portion of the labrum between it and the labial palpi; its caudal extremity does not reach quite so far as that of the labial palpus. First legs broad and short, reaching from the maxillary palpus above to about half-way between the caudal extremities of the first and second coxae; a slight slip of the femur is interposed in the upper third between the base of the leg and the maxilla; appearing as a short extension caudad is the tibia of the second leg, reaching to the caudal extremity of the second coxa. Second legs narrow in their upper third, and occupy a position between the antennae laterally and the first legs, second tibiae and second coxae mesially; at their upper extremity they rest against the maxillary palpus and become fairly broad about their middle, extending caudad to about the middle of the fourth abdominal segment, which is here exposed; appearing from beneath the extremity of the second leg is a short process, the tibia of the third leg. Third legs appear from beneath the forewings in the angle between them and the third tibiae; they soon meet in the mid-line and extend to the upper border of the last abdominal segment. Antenna narrow, plainly segmented, lies close against but terminates slightly higher than the second leg. The coxae of all three legs are broad and of about equal length. Between the third coxae above and the third legs below a small area of the ventral surface of the third, fourth, and fifth abdominal segments can be seen. It is here and about the eyes and labrum that the first colour-changes take place. Forewing somewhat narrow, terminates caudad in a fairly acute point on a level with the caudal extremities of the third legs. In some specimens a very slight slip of the hindwings appears at the caudal extremity of the forewing, between it and the third leg.

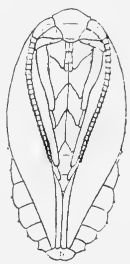


FIG. 6.—Pupa of *N. ogygia.*

Dorsally: The prothorax is a very narrow strip; the mesothorax and metathorax fairly large; only a small portion of the hindwings is exposed; spiracles on all the abdominal segments 1 to 8 inclusive, and situated on prominent elevations, the greatest being on the second segment; segments 3, 4, 5, 6, 7, bear a single row of small stout brown spines near their upper margin, this line is interrupted in the centre by the medio-dorsal ridge and extends laterad to within a short distance of the spiracular elevation; segment 10 bears a pair of fairly prominent upcurved hooklets, dark brown in colour. The surface of the abdominal segments is slightly roughened dorsally by a minute pile when viewed with a ½ in. objective. Head-sutures not very distinct. A slightly elevated medio-dorsal ridge extends from the eighth segment to the prothorax. Free movement between all the abdominal segments except the two caudal ones.

Laterally the head is situated somewhat ventrad. The ventral outline is slightly convex, almost straight. Dorsal profile well rounded; mesothorax slightly prominent anteriorly; first abdominal segment somewhat sunken; abdomen well rounded; spiracular eminences very prominent, in descending order of magnitude from above down, the second being the largest. The two upturned hooks on segment 10 conspicuous. Forewing occupies about one-third of the whole lateral body-surface. Head and thoracic appendages occupy the cephalo-frontal third, the abdomen the caudo-dorsal third. Colour at first pale green, later changing to dark grey.

Male.—The abdominal segments 3, 4, 5, 6, 7, and 8 bear the dorsal row of spines; the antennae are slightly longer than the second legs, and the forewings slightly longer than the third legs, these latter extending as far as the caudal extremity of the last segment. The chief sexual differences are the presence of the dorsal spines on segment 8 and the greater length of the antennae.

Average Measurements of Pupa.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Upper border of maxillary palpi	0·28	0·69	0·52
Bottom of labial palpi	0·55	0·96	0·69
Bottom of first legs	0·89	1·00	0·71
Bottom of second legs	1·44	0·93	0·83
Bottom of third legs	2·17	0·41	0·38
Extreme length	2·28	..	..

Dehiscence.

The pupa is extruded from the cocoon to a level a little below the end of the second legs. Splitting takes place vertically on the dorsum along the mid-dorsal ridge of the vertex, prothorax, and mesothorax, and transversely along the epicranial suture as far laterad as the antennae. Cephalad the basal joint and rest of the antennae become detached in one piece, but this remains attached to the narrow strip of the vertex which keeps it from becoming displaced and lost; the antenna usually remains more or less attached to the other appendages caudad. The headpiece remains attached ventrad to the mandibles and other structures.

After emerging the moth usually rests upon some horizontal surface while the wings attain their full length; this accomplished, they are thrown perpendicularly over the back, their dorsal surfaces in contact, and remain thus for ten to fifteen minutes, after which they are dropped to their normal position and the imago becomes active. The imagines emerge in the daytime.

(10.) **Nepticula perissopa** Meyr. (The Rangiora Nepticulid).

Nepticula perissopa Meyr., *Trans. N.Z. Inst.*, vol. 51, p. 354, 1919.

The Imago.

Meyrick's Original Description.—"♂♀. 6–7 mm. Head and eye-caps whitish-ochreous, centre of crown dark grey or blackish. Thorax dark violet-fuscous. Abdomen grey. Forewings broad-lanceolate; pale greyish-ochreous, more or less suffused (especially in ♂) with violet-grey, and coarsely and irregularly strewn with dark-fuscous scales, especially towards apex, where in ♀ they form a suffused dark blotch occupying $\frac{1}{4}$ of wing; an elongate dark-fuscous spot on fold at $\frac{1}{4}$; an elongate blackish spot in disc beyond middle, in ♀ surrounded by a nearly clear space: cilia pale greyish-ochreous, basal $\frac{2}{3}$ coarsely irrorated with blackish round apex and upper part of termen. Hindwings grey: cilia light ochreous-grey."

General Description.—Female. 6–8 mm. Head light yellowish-brown; base of antennae whitish, antennae about $\frac{1}{2}$, dark grey. Thorax and abdomen dark grey to black. Forewings broad, ground-colour whitish with a pale-violet reflection in a bright light, irrorated with black scales; at about $\frac{2}{3}$ the whitish scales predominate slightly so as to form a fairly broad and sometimes quite distinct pale transverse bar across wing; the black scales predominate in the terminal $\frac{1}{4}$ of the wing, and near the apex surround a distinct round spot, black in some lights, golden-brown in others; a similar but smaller spot in centre of wing a little beyond $\frac{1}{2}$, the light transverse bar before mentioned separating the one from the other. In some specimens there may be slight evidence of a second light transverse bar across wing to the inner side of the central spot. A black cilial line; cilia dark grey with violet and reddish reflections.

In the male the black scales greatly predominate, and there is little or no evidence of light transverse bars. The central spot is sometimes missing.

Distribution.

Two specimens were caught by Mr. Hudson on Mount Egmont in February. It was here also that I first found mines with larvae and pupae—at Dawson's Falls, 23rd December, 1917, at an elevation of 2,500 ft. I have also found it since in the Botanical Gardens in Wellington, where it is fairly common. I noted the following dates: 19th June, 1919, larvae and cocoons found; 20th September, 1919, larvae, cocoons, and one imago; first week of October, 1919 and 1920, larvae, pupae, and imagines found. There are probably three broods. Old mines have been found both at Aberfeldy and at Long Acre, in the Wanganui district.

Food-plant.

Brachyglottis repanda (rangiora).

The Ovum.

I have not yet seen the egg in the fresh state; the following description is taken from a number of empty shells persisting at the commencement of the mines:—

Class: Flat (?). Shape: Wafer-like, oval, slightly broader at the anterior end, domed above. Dimensions: Length, 0·51 mm.; transverse diameter, 0·38 mm. Sculpture: Nil. Micropyle: Not observed. Shell: Shiny, smooth, transparent, strong; is firmly cemented to the leaf, and persists at the commencement of the mine for many weeks filled with frass. Colour: The empty shell appears white and shiny, and is easily found.

Egg-laying.

The ova are laid singly, and there are rarely more than one or two to a single leaf. In all the cases I have come across the egg is attached to the upper surface of the leaf, and with a marked preference for a situation in the vicinity of the midrib or one of the coarser veins. I have noticed that in the great majority of the species of leaf-miners which construct fairly long galleries there is a preference for this site near the midrib or one of the coarser veins, and the larva almost invariably commences to mine along this boundary towards the outer margin of the leaf, in the region of which the greater part of the mine will be constructed. In cases where the egg is laid in more open spaces on the leaf there is no such immediate choice of direction towards the outer margin, but once the larva reaches either the midrib or one of the coarser side veins it will mine along it until it reaches the outer portions of the leaf. The advantages of mining in the outer parts are obvious; but if the eggs are deposited with a definite idea it is puzzling to account for their not being laid near the outer margin of the leaf in the first place. It appears that it is really immaterial where the egg is laid, as the larvae do not seem to suffer any inconvenience through the egg not being attached to one or other of the ribs; one is therefore led to believe that the choice of any particular part of the leaf is not made out of consideration for the future larva.

The Mine. (Plate XLI, figs. 1, 2.)

The mine is a long narrow gallery terminating in an expanded blotch, and is constructed immediately beneath the upper cuticle of the leaf. Its general direction is, as a rule, from within towards the margin of the leaf. The gallery portion in its earlier part has a beaded appearance when viewed under a low power, owing to the actual width of the mine being somewhat

Fig. 7.—Mine of *N. perissopa* in rangiora-leaf. Natural size.

smaller than the diameter of the cells through which it passes; all the leaf-substance within the cell is eaten, and so the margin of the mine is slightly scalloped in appearance. This early part of the mine is, as a rule, far less tortuous than the later portions. The latter two-thirds of the gallery is frequently very tortuous, and it may at times even cross the

Mine of *N. ogygia*, showing character of frass-deposition. Camera-lucida drawing by transmitted light; slightly diagrammatic; enlarged.

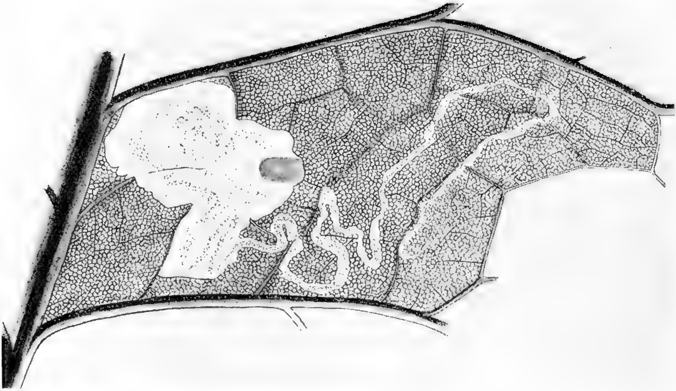


FIG. 1.—Mine of *N. perissopa.* Camera lucida; transmitted light; slightly diagrammatic; enlarged.

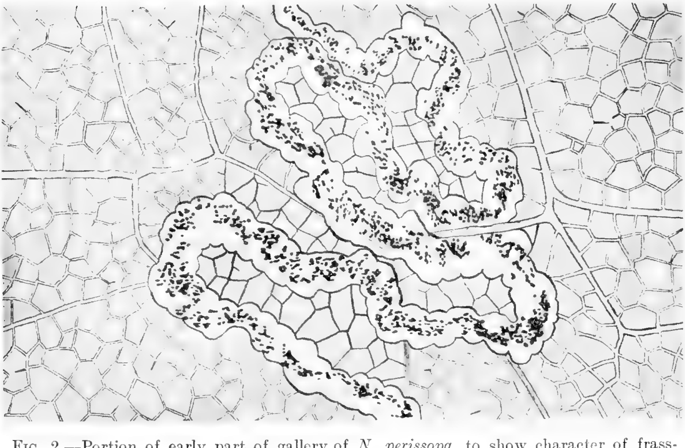
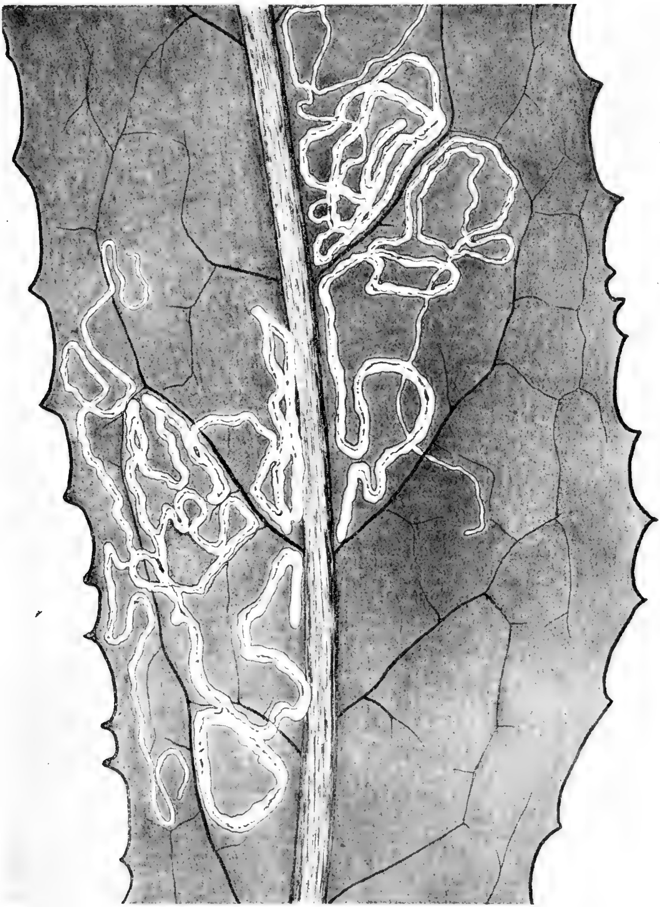


FIG. 2.—Portion of early part of gallery of *N. perissopa*, to show character of frass-deposition. Camera lucida; diagrammatic; greatly enlarged.



Early portions of four mines of *N. tricentra*. Camera lucida; transmitted light; enlarged.

FIG. 1.—Mine of *N. fulva* in leaf of *O. nitida*, as seen on upper surface of leaf. × 3. Photo.

FIG. 2.—Mine of *N. fulva* in leaf of *O. nitida*, as seen from underside of leaf with the under-cuticle removed, showing frass-granules packed in central portion of blotch. × 7. Photo.

midrib of the leaf, usually an effectual barrier except in its upper sixth. Occasionally in large leaves the course of the gallery will be but little deflected. The gallery may average 6 in. in total length. I have found that the Wellington mines are as a general rule much larger and less tortuous than the Egmont ones, which are frequently so tortuous as to be almost confined to about a square inch of the leaf-surface exclusive of the blotch; in such cases the leaf-substance between the convolutions of the gallery soon becomes dead and of the same colour as the gallery, and so simulates a blotch which may be separate from or coextensive with the actual blotch. The blotch is irregular in shape, its margin fairly even, and may average $\frac{3}{4}$ square inch in area; its construction occupies about a week.

Frass is plentiful, finely granular, black, and in the gallery is deposited in the central three-fourths of the mine; a tendency is sometimes seen for the frass to be deposited in a double row, but this is infrequent and generally not very marked. In the blotch the frass is found chiefly in the earlier portion, and is arranged in rows or shallow loops, convex forwards, across the mine in the track taken by the larva. The last act of the larva is to prepare an outlet at the margin of the blotch, and just within this it constructs its cocoon.

The early part of the gallery frequently follows the midrib, margin, or one of the coarser veins of the leaf, but these latter do not form very serious barriers to the young larvae. The width of the gallery, though irregular, increases gradually till it suddenly expands into the blotch. The average width would be about 1 mm. The blotch is frequently against the margin of the leaf, and always includes a small portion, $\frac{1}{2}$ in. or so, of the terminal portion of the gallery. The midrib and veins are more effectual barriers to the blotch than they are to the gallery. Colour of the mine in the freshest portion pale green, but the cuticle rapidly becomes dead and brown over the roof of the mine. Frequently irregular portions of the gallery become reddish-brown, but the darkest discoloration is in the immediate neighbourhood of the ovum and the first 1 mm. or 2 mm. of the mine. The blotch becomes brown very rapidly, even while the larva is at work. The mine becomes very conspicuous in consequence of these colour-changes. In the blotch, before the cuticle dies, the frass rows are clearly discernible. The frass is deposited against the upper cuticle, to which it adheres; sometimes in the gallery it may occupy a narrow, more or less uninterrupted central line.

On the underside of the leaf the mine can hardly be seen, its presence being sometimes made known by a slight swelling of the under-surface along its course. Beneath the blotch, however, the under-cuticle becomes loose and wrinkled, and loses its slightly roughened appearance.

The Larva.

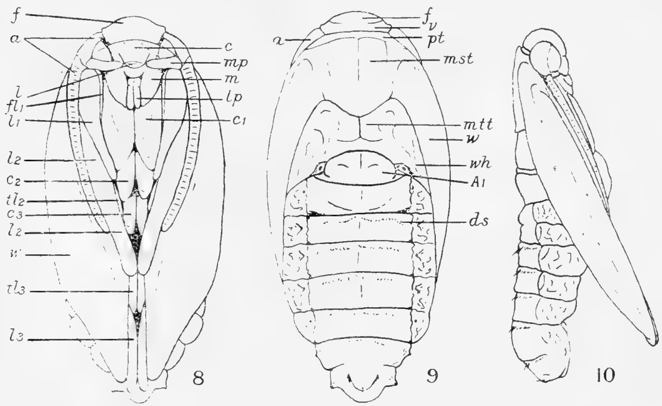
When young the larva is white in colour, flattened, moniliform; alimentary canal greyish-brown. In the fully-fed larva the body is cylindrical, only very slightly flattened dorso-ventrally; length about 5 mm.; head flattened, retractile, rounded, in the younger larvae bluntly triangular; segments well rounded but not deeply incised, the mesothorax has the greatest diameter, the metathorax and first seven abdominal segments being about equal, segments 8 to 10 acutely attenuated; there is a deep constriction between 8 and 9; 9 is very small. Ground-colour palest green, almost white; central marking fairly broad, light yellow from the head to the eighth abdominal segment ; head pale yellowish-brown, sutures and mouthparts reddish and darker. Cephalic ganglia not noticeable ; ventral chain not noticeable ; no conspicuous markings ; the thin brown lateral lines on the dorsum of the last segment are situated so far laterally as to be almost out of sight when the larva is viewed dorsally. Surface of body covered with a very minute pile. Setae inconspicuous ; main setae about half as long as their respective segments. The larva mines dorsum uppermost. It is a frequent prey to minute hymenopterous parasites, the pupal duration of which is about fifteen days.

The Cocoon.

The cocoon is constructed within the blotch close against its outer margin, where the larva, previous to the construction of the cocoon, cut a slit-like opening through the lower cuticle ; this slit may be 4 mm. to 5 mm. in length, but is very inconspicuous. The presence of the cocoon is made known by this slit and by a slight bulging of the under-cuticle where it is situated. It is rarely noticeable from above, though sometimes the cuticle covering it may become slightly lighter in shade where the cocoon is attached. The cocoon can easily be found by holding the mine against the light. It is attached to both the roof and the floor of the mine, but more firmly to this latter, from which it is almost impossible to detach it completely. When seen against the light the anterior third is lighter in colour than the rest, as the pupa is situated farther back and the structure of the cocoon is here somewhat less dense. At the anterior end of the cocoon its floor and roof can easily be split apart ; this is the prepared outlet for the pupa. The cocoon is oval in shape, broader at its anterior end, 4·5 mm. by 2 mm., flattened top and bottom 1 mm. The silk on the outside is pale-yellowish and compact, and within this is an inner cocoon of white silk which also has its prepared anterior outlet. When the imago is ready to emerge the pupa is thrust out the anterior end of the cocoon and through the slit in the under-cuticle, the anal segments being retained within the cocoon. The presence or absence of the empty puparium indicates the state of affairs within the cocoon. Emergence takes place on the under-surface of the leaf.

The Pupa.

Ventral view : Outline oval ; front bluntly rounded ; a slight incisura between front and base of antenna, this latter slightly prominent. The last six abdominal segments occupy the lower third of the lateral profile. Spiracles prominent, especially on 8. Last segment rounded with a slight caudal notch ; genital opening showing on the ventral surface. The eye is covered over its cephalo-lateral third by the base of the antenna, and slightly caudad by the maxillary palpus. Fronto-clypeal suture not very distinct. Maxillary palpus well developed ; reaching from the antenna laterad to the labrum, of which it sometimes falls slightly short ; broadest at its base against the antenna. Labial palpi narrow, slightly bulbous in their caudal half ; extend caudad farther than the maxillae. Maxilla broad cephalad ; occupies the mesial half of the maxillary palpus ; pointed caudad. First legs fairly short and stout, broader cephalad ; extend to just below the first coxae ; the femur occupies a small narrow strip between their upper half and the maxilla, and abuts on the maxillary palpus cephalad. Second legs may not reach so far cephalad as the maxillary palpus, but extend caudad as far as the junction of the fourth and fifth abdominal segments. From beneath them, and extending farther caudad to meet in the mid-line, are the tibiae of the third legs. The tibiae of 2 appear from beneath the caudal extremity of the first legs and reach about half-way between the caudal extremities of the second and third coxae. Third legs appear from beneath their corresponding tibiae. They meet in the mid-line and extend as far caudad as the upper border of the last segment. Antennae narrow, slightly tapering, segmented but not deeply; terminate in the female between the caudal extremities of the third coxae and second legs; in the male extend, together with the forewings, to the caudal extremity of the last abdominal segment. Coxae of all three legs broad, the first longer than the second and these longer than the third. A small area of the ventral surface of the abdomen is disclosed between the caudal extremities of the last coxae. Forewings in female terminate



Pupa of *N. perissopa.*

FIG. 8.—Ventral view. *a*, antenna; *mp*, maxillary palp; *l*, labrum; *c*, clypeus; *f*, front; *lp*, labial palpi; *m*, maxilla; l_1, first leg; l_2, second leg; l_3, third leg; fl_1, femur of first leg; c_1, first coxa; c_2, second coxa; c_3, third coxa; tl_2, tibia of second leg; tl_3, tibia of third leg; *w*, wing.

FIG. 9.—Dorsal view. *v*, vertex; *f*, front; *a*, antenna; *pt*, prothorax; *mst*, mesothorax; *mtt*, metathorax; *w*, forewing; *wh*, hindwing; A_1, first abdominal segment; *ds*, dorsal spines.

FIG. 10.—Lateral view.

in a pointed extremity just above the caudal extremity of the third legs; in the male extend to the lower margin of the last abdominal segment. Hindwings—occasionally a very narrow slip of these is to be seen between the third legs and forewings, and extending very slightly caudad to these latter.

Dorsally: Front shallow; prothorax very narrow; mesothorax large; metathorax about half the length of the mesothorax. Hindwings extend caudad as far as the second abdominal segment. Spiracles on prominent elevations, segments 1 to 8 inclusive, the largest being on 2. Segments 3, 4, 5, 6, and 7 in the female bear a row of small spines somewhat irregularly distributed so as almost to form two transverse lines at the upper extremity of each segment; the male has these on segment 8 also; they are interrupted in the mid-line by a slight medio-dorsal ridge. Under a fairly high power the body-surface is seen to be roughened with light transverse rugae. Segment 10 bears a pair of short brown upturned spines. It should be noted that the figure was taken from a dried specimen, and so does not show the rounded fullness of the fresh pupa. Movement can take place between all the abdominal segments with the exception of the soldered caudal ones.

Average Measurements of Pupa.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Upper border of maxillary palpi	0·28	0·76	0·55
Bottom of labial palpi	0·55	0·93	0·66
Bottom of first legs	1·00	1·10	0·69
Bottom of second legs	1·55	1·07	0·71
Bottom of third legs	2·31	0·41	0·48
Extreme length	2·50	..	..

Dehiscence.

The pupa is extruded as far as its caudal segments through the slit. Dorsal splitting takes place along the central vertical line of the mesothorax, prothorax, and vertex; transversely along the epicranial suture. The antennae become detached and are retained only by a small slip of the vertex dorsally; in this manner the headpiece is freed both dorsally and laterally, but is held ventrally by the mouth-appendages.

(11.) Nepticula tricentra Mey. (The Groundsel Nepticulid).

Nepticula tricentra Meyr., *Trans. N.Z. Inst.*, vol. 21, p. 187, 1889; vol. 47, p. 231, 1915.

The Imago.

Meyrick's Original Description.—" ♀. 6 mm. Head and palpi grey-whitish. Antennae, thorax, and abdomen grey. Legs dark grey, apex of joints whitish. Forewings lanceolate; pale grey, irrorated with darker; two or three small round black dots in an irregular longitudinal series towards middle of disc: cilia light grey. Hindwings and cilia light grey."

General Notes.—The amount of dark irroration varies greatly, in some specimens being very light and the three black spots very conspicuous, in others it is very dense and in places leaves irregular paler areas on wing, these tending to form a pale transverse bar across wing at $\frac{3}{4}$ and in the region of $\frac{1}{3}$. The male is a most minute moth, 4–5 mm., but otherwise differs in no marked particulars from the female. It might be more correct to say that the ground-colour of the wing was light yellowish-brown, and irrorated with dark grey to black scales more or less condensed into three rather diffuse transverse bars across wing, one in the region of the base, one somewhat constricted in the middle at $\frac{1}{2}$, and the third occupying the terminal $\frac{1}{4}$ of the wing; in the middle of each of these bars the scales are condensed to form a small spot. In perfect specimens there is a black cilial line. In some specimens the dark irroration is regularly distributed throughout the wing, and in such cases there is no evidence of transverse marking.

Distribution.

I have found this moth in Wellington and in Dunedin, where it is common. Larvae were found in May, July, August, November, and December. Meyrick records one specimen from Christchurch, in March.

Food-plant.

Senecio bellidioides. It is usually only the lower leaves that are attacked.

The Ovum and Egg-laying.

The egg is most inconspicuous. It is, however, like all the other Nepticulid eggs, relatively large; oval, wafer-like, domed above, and rather wider at the micropylar end. Colour pale greenish-yellow. Laid singly and well attached to the under-surface of the leaf, usually against one of the coarser veins, but otherwise in no fixed position. The shell is shiny, unsculptured, transparent, and extremely fragile. After the hatching of the larva it crumples up, rarely persisting long at the end of the mine. Average dimensions are 0·30 mm. by 0·20 mm. Laid singly, often a number on one leaf.

The Mine. (Plate XLII.)

This is a simple, narrow, exceptionally tortuous gallery, more closely applied to the upper than to the lower surface of the leaf. It is not till about half-way through the larval stage that the mine becomes at all conspicuous. In the earlier half of the mine the larva may cross its tracks time and again, and those of neighbours also if these happen to be in the way. Viewed under the microscope by transmitted light this early part of the mine is a beautiful object. On the upper surface of the leaf it has a silvery appearance when held in the light, otherwise is greyish in colour. A number of mines may be constructed in a single leaf and the entire leaf-substance consumed. In the last 2 cm. of the mine the gallery is

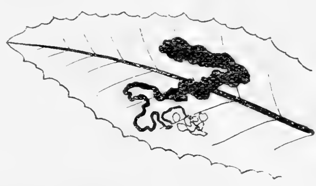


FIG. 11.—Mine of *N. tricentra* in leaf of *S. bellidioides.* Natural size.

considerably widened, its edges scalloped and irregular, and owing to its tortuousness this part frequently resembles a blotch. The frass is black, fairly copious, and occupies a more or less unbroken central line; it is homogeneous in consistency, and rests on the floor of the mine. The midrib of the leaf is a barrier in the early stages, but the final part of the gallery frequently crosses it. Average length of the mine, 3 in. to 4 in.; final width, 2 mm. to 4 mm. The larva makes its exit through the upper cuticle. I have rarely found the mine more than 12 in. to 18 in. from the ground. In one specimen under observation the final 2 cm. of the gallery were mined in four days.

The Larva.

Length when fully fed, 4–5 mm. Ground-colour bright grass-green; dorsal band yellowish-brown, more greenish in younger larvae. Segments not deeply incised; body cylindrical, caudal attenuation gradual. Head light amber-brown. Cephalic ganglia and ventral chain not noticed in any specimens. Prolegs as in other Nepticulid larvae. The dorsal linear structures in segment 10 are situated caudo-laterad and are not very noticeable dorsally. Setae relatively short, about one-third the length of the corresponding segment. Body-pile relatively coarse. The larva mines dorsum uppermost.

The Cocoon.

This is of the same shape as that of *N. ogygia;* mussel-shaped, with flattened anterior lip. Constructed of fine silk closely woven to form a thin weatherproof skin. Average size, 2 mm. by 2·5–3 mm. Is surrounded by a scanty amount of loose silk. The cocoons are spun amongst dead herbage around the food-plant, a favourite place being between the stem and the base of the leaf-stalk of the food-plant itself. Colour on construction white, changing to green and later to dark brown. All cocoons found in the open were brown, whereas the great majority constructed in captivity in a dry box were white or very pale green, and these when placed in a moist atmosphere weeks later turned brown within twelve hours, so there is no doubt that moisture affects the colour of the silk. In captivity a number of cocoons were very minute, being only about half the normal size; these were most likely constructed by poorly nurtured larvae, since it was not a matter of difference of sex. The imagines in these cases were very minute. The larva remains dormant in the cocoon for about a week before the final moult.

The Pupa.

Ventral view: Front prominent, bluntly rounded in the male, somewhat bluntly pointed in the female. Last segment usually hidden behind the caudal extremities of the third legs and forewings. Eye two-thirds covered by the basal joint of the antenna and maxillary palp. Maxillary palpus reaching from the antennae to the labrum, of which it sometimes falls rather short; covers the caudal margin of the eye. Labial palpus narrow, extends slightly farther caudad than the maxillae. Maxillae triangular, with the base against the lower border of the maxillary palpus. First legs stout, broadest in their upper half, extend as far as the caudal extremities of the second coxae in both sexes. The femur occupies a small narrow slip separating the upper extremity of the first leg from the maxilla, more noticeable in the male. Second legs reach to about half-way between the caudal extremities of the first and second, their narrowed cephalic extremity reaching the lower border of the maxillary palp. The second tibiae do not appear; the third appear only very slightly from beneath the tips of the second legs. Third legs meeting in the mid-line shortly after appearing from under the antennae lateral to the extremities of the second legs, thereafter extend in both sexes as far as the lower border of the last abdominal

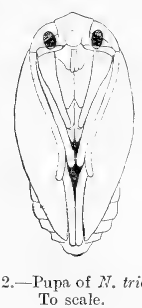


Fig. 12.—Pupa of *N. tricentra.* To scale.

segment. Antennae narrow, segmented, extend slightly beyond the second legs in the female, slightly farther in the male to the point where the third legs meet in the mid-line. Coxae—the first relatively large, the second and third very narrow, the second smallest and greatly reduced by the first legs. The amount of ventral abdominal surface showing between the last coxae and the legs is small. Forewings terminate in both sexes a short distance above or below, or on the same level with, the third legs. Hindwings not seen on this surface in either sex.

Dorsally: Prothorax almost obliterated in the mid-dorsal line. Spiracles prominently elevated on all segments 1 to 8. Dorsal spines forming a relatively broad band, three or four deep, transversely across the upper third of segments 3 to 7 inclusive in the female, and 3 to 8 inclusive in the male. Each band is interrupted in the mid-dorsal line. The pair of small upturned dorsal hooks is situated on segment 10 in the male, on 9 in the female. Movement takes place between all the abdominal segments excepting the last three. Colour at first bright green, becoming somewhat yellowish, and later dark grey to black. The only note I have regarding the pupal duration is "Pupated 25th May, 1919; emerged 14th July, 1919: forty-nine days."

Average Measurements of Pupa.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Upper border of maxillary palpi	0·34	0·67	0·51
Bottom of labial palpi	0·48	0·77	0·57
Bottom of first legs	1·07	0·94	0·64
Bottom of second legs	1·41	0·80	0·67
Bottom of third legs	2·07	0·20	0·10
Extreme length	2·10	..	..

Dehiscence.

The pupa emerges as far as the sixth or seventh abdominal segment. The headpiece is separated laterally by the separation of the antennae, and dorsally by splitting along the epicranial suture. Vertical splitting takes place along the central line of the mesothorax and prothorax, and vertex dorsally. The antennae remain attached by a small slip of the vertex only.

(12.) **Nepticula fulva** n. sp. (The *Olearia* Blotch Nepticulid).

The Imago.

Female. 8 mm. Head and prothorax light yellowish-brown; antennae under 1 and over ½ dark brown; abdomen dark grey; legs light-brownish. Thorax and forewings pale-whitish densely irrorated with darker brown scales; a small irregular black spot in wing near dorsum at ¼, another in centre a little beyond ½, a third in centre of wing near termen; the central spot is the most constant. Cilia light brown, a brown cilial line found only in very perfect specimens; the whole wing and cilia with bronzy reflections, seen only in some lights. Hindwings and cilia grey-brownish. In the male the brown scales in the forewings are largely replaced by darker grey ones, and the central spots, though still present, are not so prominent.

Distribution.

I have come across this moth only in Dunedin, where its mines are very numerous, and the food-plants are often badly infected. In the last two years I have found larvae in each month except January and February, when I have been out of Dunedin; they may be found at almost any time during the year. Ova were found to be most abundant in April, May, September, and October. The imagines may be found at any time during the summer months; they are active in the sun about the food-plant.

Food-plants.

Olearia Traversii (akeake), *O. nitida* (now *O. arborescens* and *O. divaricata*), *O. macrodonta*, *O. Cunninghamii* (heketara), *O. Colensoi* (tupare), *O. avicenniaefolia* (akeake). Of these, *O. nitida* and *O. macrodonta* are the ones most attacked.

The Ovum and Egg-laying.

The egg is relatively large, and when newly laid is bright blue in colour. Empty shells are white and filled with frass. In shape oval, wafer-like, domed above; a narrow flattened and somewhat ragged fringe surrounds the foot. The shell is strong, transparent, shiny, devoid of sculpture except for a slight roughening. Dimensions are—total length, 0·48 mm.; width, 0·38 mm.; height, 0·12 mm. It is strongly attached to the surface of the leaf, and persists for a considerable time even after the mine has been vacated. The eggs are laid singly, but a considerable number may be deposited on one leaf. They are laid on the upper surface, but otherwise have no fixed locality, though the upper and outer two-thirds of the leaves appear to contain the majority of the mines. Some ova may be found laid on entirely dead portions of the leaf, over long-disused mines, and even sometimes upon or overlapping one another, when the larvae must perish. The egg-capacity of the moth is not known. The period of incubation may be anything from seven days to a month, or longer, according to local climatic conditions.

The Mine. (Plate XLIII, figs. 1, 2.)

This is a blotch on the under-surface of the leaf. The hatching of the egg is made known by the leaf-tissue in its immediate vicinity becoming dark purple. This dark-purple spot is the chief naked-eye characteristic of this period distinguishing this species from *N. ogygia*, being absent in the latter. The larva immediately eats its way through the bottom of the shell into the leaf and descends to the lower cuticle. The first portion of the mine is a narrow, fairly straight gallery (fig. 13), which can be traced on the under-surface of the leaf by a slight prominence of the cuticle; on the upper surface a trained eye can follow its course, as this is marked out by a number of very minute white dots, these being small areas of dry cuticle where the larva has eaten nearer the surface. The average length of this preliminary gallery is about 1 cm., and it now abruptly expands into a relatively large blotch, which at first is more or less roughly circular in shape, but in most cases soon becomes rectangular owing to the coarser ribs of the leaf confining it within their boundaries. The area occupied by the blotch is from 2 to slightly over 3 square centimetres. The larva does not readily attack the coarser cell-walls of the internal leaf-substance, but, separating the lower cuticle from these cells, it attacks the substance within them, thus causing the characteristic external appearance of the mine on the upper surface of the leaf, and when the under-cuticle is stripped off the mine gives it the honeycomb appearance. The preliminary gallery often becomes absorbed into the blotch. The larger leaves may contain a considerable number of mines; I have found from twenty-six to thirty on one leaf of *O. nitida.* They occur in any part of the leaf, but the majority in the outer portions. Leaves on all parts of the tree are equally attacked. Neighbouring mines sometimes coalesce and become continuous with one another. The frass is black and granular, and fairly plentiful in the blotch, where it occupies the central two-thirds, being packed into the excavated cell-spaces in the roof of the mine. Many of these cells are entirely emptied of their contents by the larva, and the upper cuticle soon

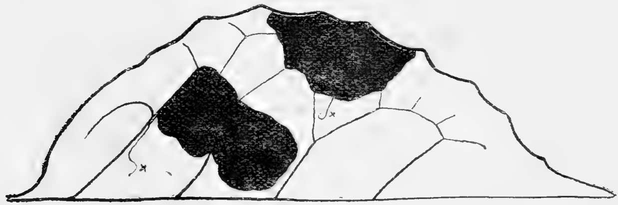


FIG. 13.—Mine of *N. fulva* in *O. nitida.* Natural size.

dries and becomes white externally. As the blotch enlarges, more of these minute dots appear, closer together and more numerous in the central portion of the mine. On the under-surface the blotch can be made out more clearly, owing to the detachment and consequent looseness of the cuticle over the part. In mines still tenanted by the larva the under-surface is more or less bulged, and is slightly lighter in colour than the rest of the leaf. When full-fed the larva eats a small semicircular outlet at the margin of the blotch, through the lower cuticle, and descends to the ground to pupate. The mine is not conspicuous till after the larva has left it, when the part of the leaf affected becomes dead and shows in violent contrast to the rest.

The Larva.

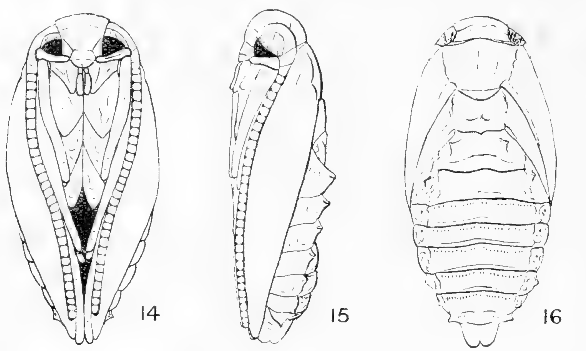
Length when full-grown, about 5 mm. Ground-colour pale green; central marking dark olive-green in its first half, darker in its caudal half. Head pale greyish-brown; darker reddish-brown sutural lines; almost acutely triangular in shape; retractile. Cephalic ganglia and ventral chain not observed. Segments well rounded, moniliform; last three abdominal segments extended, the tenth directed dorsally with narrow dark dorso-lateral lines. Setae fine, fairly long. Body covered with a minute pile. Saetal plan has been left for a future paper. Fleshy protuberances take the place of prolegs. The larva mines dorsum uppermost.

The Cocoon.

This is constructed outside the mine amongst dead foliage at the foot of the food-plant. The colour of the cocoon blends with that of its surroundings and makes it most difficult to find. In the breeding-jars the cocoons are always constructed between two fairly closely applied surfaces in the darkest corners at the bottom of the jar, and they are fairly firmly attached. The construction of the cocoon usually occupies about two days, after which the larva lays up for a week or more before the final moult; it is likely that the larva hibernates in this fashion. The silk is at first a very pale green, but in almost every case quickly becomes a dark brown. Some cocoons may be lighter in colour than others, and a few remain pale green throughout. The shape is somewhat more quadrilateral than ovoid, the length being about one and a half times the width at the middle; the ends are rounded, and the anterior end is considerably wider than its nadir, and possesses two flattened closely-applied lips which extend the full width of the cocoon. The cocoon is somewhat flattened above and below. The texture is very close, firm, and strong, the silk being so woven as to form a thin skin-like fabric without any pores or openings even when viewed under the microscope. The exterior of the cocoon is provided with a small amount of loose floccy silk, but this is not very noticeable. Average length, 3 mm. to 4 mm. There is no separate inner lining.

The Pupa.

Ventral view: Front bluntly rounded, in female somewhat pointed. Terminal segment in male somewhat quadrilateral in shape, slightly broader than long; in the female is bluntly rounded, about twice as broad as long, and fairly deeply notched anteriorly by the genital opening. Eye about two-thirds covered by the basal joint of the antenna and maxillary palpus. Maxillary palpus well developed and stretching transversely between the antenna and the labrum. Labial palpi slightly longer than the maxillae.



Pupa of *N. fulva.*

Fig. 14.—Ventral view. Fig. 15.—Lateral view. Fig. 16.—Dorsal view.

Maxilla broad above, abuts against the labrum, maxillary palpus, and femur of the first leg; sharply pointed caudad. First legs fairly stout, of almost even diameter throughout; extend from the maxillary palpi to slightly below the caudal extremities of the second coxae in the male, but falling slightly short of this in the female. Only a very small slip of the first femur appears medially at the uppermost extremity. Second legs extend from a narrow pointed cephalic extremity a little below the lateral extremity of the maxillary palpi to about half-way between the caudal extremities of the first and third legs; somewhat expanded opposite the second coxae; the tibiae of 3 appear from beneath their caudal extremities but only occupy a small area; they are somewhat more evident in the female and almost meet in the mid-line. The tibiae of 2 appear as a slight caudal extension of the first legs, and are more evident in the female. Third legs appear from beneath the caudal extremities of 2, and, meeting in the mid-line, extend in the male as far as the lower margin of the last segment, in the female to a little below the upper margin of the eighth segment. Antennae rather wide, segmented: in the male fall slightly short of the caudal extremities of the forewings and third legs; in the female extend only a slight distance beyond the second legs and third tibiae. Coxae relatively narrow; the first are the longest, and the third are slightly longer than the second. A variable amount of the ventral abdominal surface can be seen below the third coxae between these and the second and upper part of the third legs. Forewings occupy only a narrow strip ventrally, extending not quite so far caudad as the third legs. A very narrow slip of the hindwings may extend a short distance beyond their tips, more marked in the female.

Dorsally: Prothorax very narrow and almost obliterated in the mid-line. Spiracles on prominent elevations on segments 1 to 8. A single transverse row of small dorsal spines in the fore part of segments 3 to 7 inclusive in the female, 3 to 8 inclusive in the male; interrupted in the mid-dorsal line. The small pair of dorsal upcurved hooks appear to be on segment 10 in the male and segment 9 in the female. It appears that movement can take place between all the abdominal segments excepting the last three. Colour at first pale green, changing later to dark grey.

Pupal period varies according to climatic conditions. I have reared imagines towards the end of September from larvae that pupated in the middle of July. The following periods are from my note-book: One specimen pupated 28th March, 1920: emerged 30th May, 1919—sixty-one days. Larvae pupated 24th May, 1919: emerged 13th July, 1919—forty-nine days. Pupated 15th July, 1920: emerged 28th September, 1920—seventy-five days. During October and November, 1919, pupal period not longer than twenty-one days.

Average Measurements of Pupa.

Measurement at	Length from Extreme Front.	Transverse Diameter.	Ventro-dorsal Diameter.
	Mm.	Mm.	Mm.
Upper border of maxillary palpi	0·30	0·77	0·52
Bottom of labial palpi	0·61	0·98	0·63
Bottom of first legs	1·10	1·08	0·70
Bottom of second legs	1·70	0·90	0·77
Bottom of third legs	2·40	0·30	0·30
Extreme length	2·67	..	..

Dehiscence.

Vertical splitting takes place dorsally along the mid-line of the mesothorax and prothorax, and transversely along the epicranial suture. The antennae become almost completely detached, only a small slip of the vertex retaining them dorsally; thus the head is freed laterally and dorsally, but remains attached ventrally.

Before emergence the pupa is extruded from the cocoon as far as the fourth or fifth abdominal segment.

Art. XXV.—*Some New Zealand Amphipoda: No. 2.**

By Charles Chilton, M.A., D.Sc., M.B., C.M., LL.D., F.L.S., C.M.Z.S., F.N.Z.Inst., Hon. Mem. Roy. Soc. N.S.W.; Professor of Biology, Canterbury College, N.Z.

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Apherusa translucens (Chilton). (Fig. 1, A to K.)

Panoploea translucens Chilton, 1884, p. 263, pl. 21, fig. 3 *a–c*.
Apherusa translucens Stebbing, 1906, p. 308.

This species was described from three specimens taken in 1884 in Lyttelton Harbour, but, as the description was based on the female only, the species has remained somewhat obscure. It was at first placed under the genus *Panoploea* G. M. Thomson, owing to its supposed resemblance to *P. debilis* G. M. Thomson. This species, however, has proved to be identical with *Pherusa novae-zealandiae* G. M. T., and has been placed by Stebbing in the genus *Leptamphopus*. The genus *Panoploea* has been retained for the other species described by Thomson, *P. spinosa*, which belongs to another family. The species described as *Panoploea translucens* was thus left without a genus, and Stebbing has assigned it to the genus *Apherusa* A. Walker. This genus seems somewhat ill-defined and without well-marked characteristics, but so far as they go the characters of the species now under consideration agree with those of the genus. *Apherusa translucens* seems to be somewhat rare in New Zealand, and I have very few specimens, and all of these somewhat imperfect. Among them, however, is a male, and I am therefore now about to give the characters of this sex and an amended description of the species, as follows:—

Body smooth, back without any dorsal teeth. Head without rostrum. Pleon segment 3 with postero-lateral angle scarcely produced, posterior margin smooth, straight or slightly convex, except above angle where it is slightly concave, inferior margin with 5 spinules. Eye large, oval. Gnathopods 1 and 2 similar in structure, those of the male considerably stouter than those of the female, the first in each sex slightly larger than the second. In the male the first gnathopod with propod widest at the beginning of the palm, rather more than half as broad as long, anterior margin straight, palm about as long as the hind-margin, regularly convex and fringed with rows of setules but without special defining spine; hind-margin with 5 or 6 small tufts of fine setules. In the female the basal joint of first gnathopod showing a constriction about one-third its length from the base, remaining joints much more slender than in the male.

* For No. 1 of this series see *Trans. N.Z. Inst.*, vol. 52, pp. 1–8, 1920.

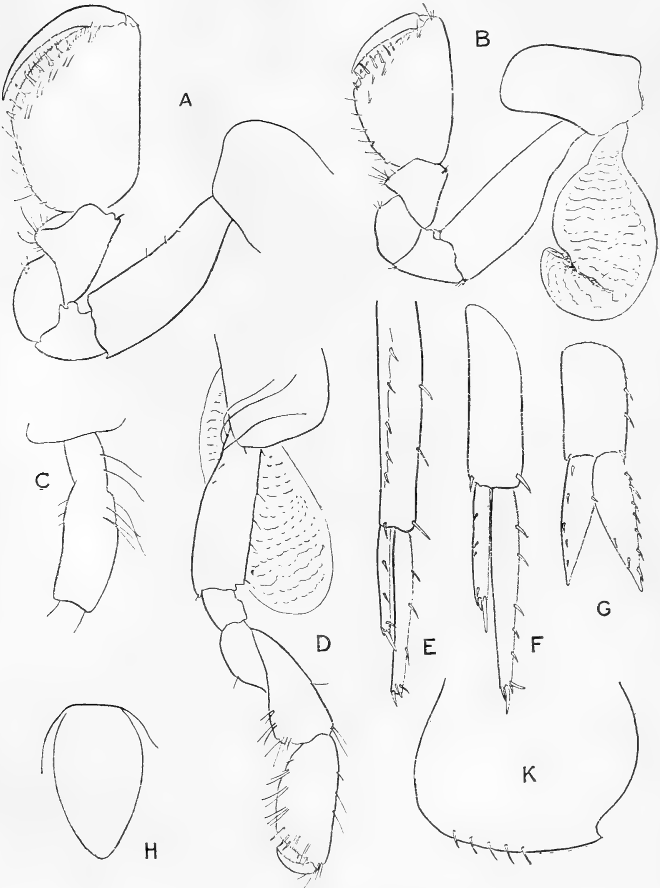

FIG. 1.—*Apherusa translucens.*

A. First gnathopod of male.
B. Second gnathopod of male.*
C. Basal joint of first gnathopod of female.
D. Second gnathopod of female.
E. First uropod.
F. Second uropod.
G. Third uropod.
H. Telson.
K. Third pleon segment.

* The branchia of this appendage has been drawn as it appeared in the preparation made. The irregularity is doubtless due to some abnormality.

Gnathopod 2 similar to the first in both sexes, but slightly smaller and with basal joint straight. Basal joint of peraeopoda 3–5 moderately expanded, oval, posterior margin with minute shallow crenations or serrations. Uropods 1 and 2 slender, similar, the outer ramus much shorter than the inner, inner margin of each ramus fringed with very minute spinules. Uropod 3 stouter and shorter, branches broadly lanceolate, about as long as peduncle. Telson oval, narrowing posteriorly, margin entire or with one or two minute setules on each side of the apex.

Length, about 9 mm.

Locality.—Lyttelton Harbour.

This species shows considerable resemblance both to *A. cirrus* (Bate) and to *A. jurinei* (M.-Edw.). If differs from the first in having no dorsal teeth, in this respect agreeing with *A. jurinei*, but the shape of the third pleon segment agrees closely with that of *A. cirrus*, thus differing from *A. jurinei*. The telson agrees closely with that of *A. jurinei*. In neither of these species does Stebbing speak of any sexual differences in the gnathopoda. Walker (1912, p. 600) has drawn attention to the variation in the shape of the third pleon segment in *A. jurinei*, and to sexual differences in the antennae in that species. Unfortunately the antennae are wanting in my specimens of *A. translucens*, and I am therefore unable to say whether similar differences are to be found in it.

Apherusa levis (G. M. Thomson). (Fig. 2, A to F.)

Amphithonotus levis G. M. Thomson, 1879, p. 330, pl. 16, figs. 1–4; 1881, p. 215, pl. vii, fig. 6: Thomson and Chilton, 1886, p. 148: Stebbing, 1906, p. 741.

This species was described by G. M. Thomson in 1879, and was referred to the genus *Amphithonotus* as agreeing well with the generic characters given by Spence Bate in the *Catalogue of the Amphipoda of the British Museum*. It appears, however, that the species at that time referred to *Amphithonotus* really belong to other genera, and the genus therefore lapsed. I have had some difficulty in deciding which is the proper genus to which Mr. Thomson's species should be referred, but its resemblance in nearly all points to the preceding species, *Apherusa translucens*, is so close that I am putting it down to the same genus. The only point in which it differs from Stebbing's description of the genus (1906, p. 304) is that the telson is distinctly cleft posteriorly, though not deeply so, while he describes the telson as being "entire." I presume, however, this means "simple"—that is, not divided—and the telson of the present species could quite well come under this description. Moreover, some of the species which he ascribes to *Apherusa* have the telson distinctly toothed or serrate posteriorly, and the margin therefore not entire.

Apherusa levis agrees with *A. translucens* in having the first and second gnathopods in each sex similar, the first being very slightly larger than the second, and both pairs in the male being considerably larger than corresponding pairs in the female. It differs, however, in the presence of a well-marked rostrum and in the shape of the telson; there are also slight differences in the gnathopods. It may be re-defined as follows:—

Body quite smooth, without dorsal teeth. Cephalon produced into a distinct rostrum. Eye large, oval with anterior margin straight or slightly

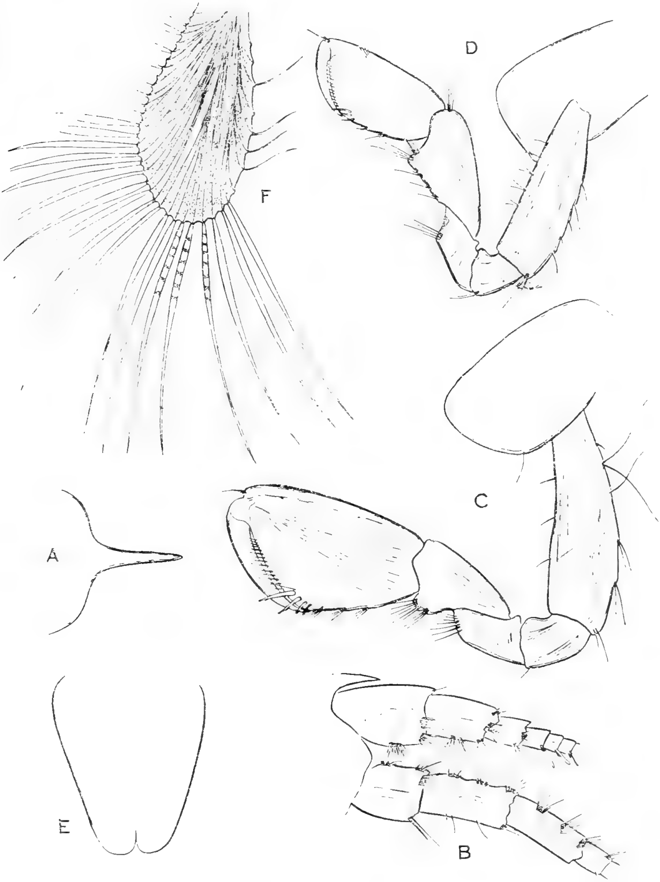

FIG. 2.—*Apherusa levis.*

A. Rostrum.
B. Peduncles of first and second antennae of male.
C. First gnathopod of male.
D. First gnathopod of female.
E. Telson.
F. Brood-plate.

concave. Superior antenna slightly longer than the inferior, both slender, with many-jointed flagella. In the male the peduncle of each antenna bears many tufts of very fine short hairs, as shown in fig. 2B. These are not present in the female. The gnathopods of the male considerably larger than those of the female, and the first gnathopod larger than the second in each sex; in the male the propod is large, widest at the commencement of the palm, which is defined by 3 or 4 stout setules; in the female the propod is smaller and narrower and not widened distally. Telson narrowing posteriorly, extremity with a shallow cleft dividing the posterior position into two rounded lobes, margins quite entire and without setae.

Length, about 8 mm.

Localities.—Otago Harbour; Blueskin Bay; Akaroa.

The brood-plates of the female in this species are characteristic and form an easy mark by which the species may be recognized. They are oval in shape, widening somewhat distally, and the margins towards the apex bear a number of very long setae, longer than the whole joint. These setae show, on the basal portion, alternate light and dark bands, as indicated in fig. 2F, in which only some of the setae are put in and only three of them filled in in detail.

Atyloides serraticauda Stebbing.

Atyloides serraticauda Stebbing, 1906, p. 362: Chilton, 1909, p. 627; 1912, p. 497. *A. calceolata* Chilton, 1912, p. 497, pl. ii, figs. 21–23.

Atyloides serraticauda is a species widely distributed in Antarctic and Subantarctic seas, and some specimens belonging to it were taken at Auckland Islands in 1907. Large specimens are well marked by the distinct serrations on the anterior side-plates, the side-plates of the segments of the pleon, and on the posterior margins of the lobes of the telson. In smaller specimens these serrations are much less distinct. The species described by me from the South Orkneys under the name of *A. calceolata* proves to be without doubt a male of *A. serraticauda.* As stated in the original description, it resembles that species in nearly all characters, but differs in the presence of calceoli on the lower surface of the peduncle of the first antenna and on the upper surface of the peduncle of the second antenna; the gnathopods are also slightly stouter, and differ a little in shape from those of the female. The arrangement of the calceoli on the antennae of the male is similar to that described by Walker (1912, p. 600) for *Apherusa jurinei* (M.-Edw.).

Lembos philacantha Stebbing.

Lembos philacantha Stebbing, 1906, p. 598; 1910, p. 605.

This species was taken by the "Challenger" Expedition in Bass Strait at a depth of 71 metres, and described by Stebbing in the report of that expedition. It has been taken since at different places on the Australian coast. It has not hitherto been recorded from New Zealand, but I have one specimen from the Chatham Islands that agrees well with Stebbing's description and must be referred to his species. The relation of this species to others of the genus found in the Southern Hemisphere requires investigation.

Photis brevicaudata Stebbing. (Fig. 3, A to E.)

Photis brevicaudata Stebbing, 1888, p. 1068, pl. 108; 1906, p. 606; 1910, p. 648.

Several specimens that certainly belong to this species were obtained near the Gannet Islands, off the west coast of Auckland, in January, 1915, at a depth of about 50 metres. The species were originally described from specimens obtained by the "Challenger" Expedition off Melbourne, Australia, at a depth of 60 metres, but only the female was then taken.

My specimens agree well with Stebbing's description and figures of the female; in the first gnathopod the palm is slightly concave, as shown in his detail figure. The male specimens differ from the female in the size and shape of the second gnathopod, but particularly in the great elongation of the fourth peraeopod. The second gnathopod of the male has the shape in general like that of the female described by Stebbing, but the propod is larger, the palm much more excavate, and the angle defining it much more marked. The fourth peraeopod in the older males is very greatly enlarged, being much larger and broader than the fifth, as will be seen by comparing figs. 3D and 3E. The basal joint is broad, narrowing distally, the meral joint is greatly elongated, being longer than the carpus and propod together; the details as to the proportions of the joints can be best learnt from fig. 3D. The other appendages agree well with the description given by Stebbing.

In the male specimen from which fig. 3B of the second gnathopod was taken the first gnathopods were unsymmetrical. One, shown in fig. 3A, is practically the same as that of the female. The one from the other side (fig. 3C) has the propod similar to that of the second gnathopod, though rather smaller, but the carpus is much longer than in the second gnathopod, and therefore more like that of a normal first gnathopod.

The great enlargement of the fourth propod in this species recalls the somewhat similar development of the same appendage in *Eurystheus crassipes* (Haswell).

Stebbing describes the telson as "very short, much broader than long, apex rounded," and figures it without setules. In the specimen I have examined the apex is less rounded, and bears setules on either side as in *P. macrocarpa* Stebbing and other species of the genus.

Jassa falcata Montagu.

Cancer (*Gammarus*) *falcatus* Montagu, 1808, *Trans. Linn. Soc.*, vol. 9, p. 100, pl. 5, fig. 2. *Podocerus validus* Thomson and Chilton, 1886, p. 143. *Jassa pulchella* and *Jassa falcata* Stebbing, 1906, pp. 654, 656. *J. falcata* Sexton, 1911, p. 212; Chilton, 1912, p. 511; Stebbing, 1914, p. 371.

This species had been collected in New Zealand by Thomson about the year 1885, and identified with Dana's *Podocerus validus* from Rio de Janeiro. About the same time I had obtained numerous specimens from a buoy in Lyttelton Harbour, and had figured both male and female forms. The species has proved to be specifically identical with *Jassa falcata*, originally described by Montagu from the south coast of England, and now known to be very widely distributed both in northern and southern seas. There are probably two forms of the male, both different from the female, and the immature stages in the development of the adult male characters have led to much confusion and multiplication of species. Fuller accounts will be found in Mrs. Sexton's paper quoted above and in my report of the Amphipoda of the "Scotia" Expedition (1912, p. 351).

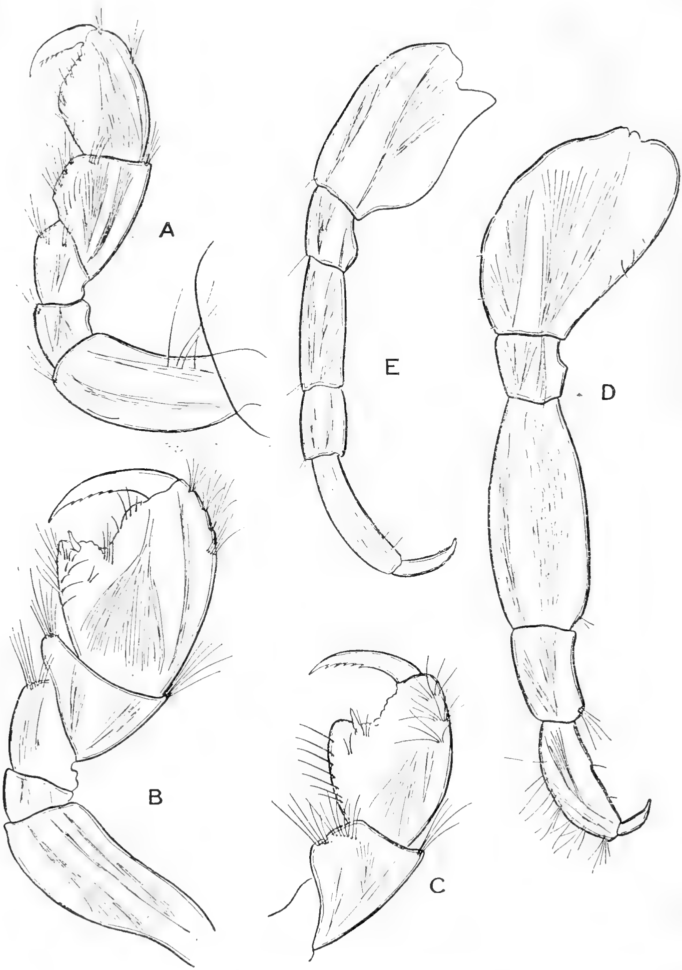

Fig. 3.—*Photis brevicaudata* Stebbing.

A. First gnathopod of male.
B. Second gnathopod of male.
C. First gnathopod (abnormal) of male.
D. Fourth peraeopod of male.
E. Fifth peraeopod of male.

Jassa frequens (Chilton). (Fig. 4, A to D.)

Podocerus frequens Chilton, 1883, p. 85, pl. 3, fig. 2. *P. latipes* Chilton, 1884, p. 258, pl. 19, fig. 2 *a–d*. *Jassa frequens* Stebbing, 1906, p. 656.

This species was described under the name *Podocerus frequens* in 1883 from a number of small specimens obtained in Lyttelton Harbour, and although male and female were described it is probable that none of them were quite fully developed. In the following year other specimens similar in general character but differing somewhat in the second gnathopods, and particularly in the greatly broadened character of the fourth peraeopod, were obtained from the same locality and were named *Podocerus latipes*, it being suggested, however, that they might prove to be only a variety of *P. frequens*. In 1906 Stebbing combined these two species under the name *Jassa frequens*, regarding the form described as *P. latipes* as the male.

The species is fairly common in Lyttelton Harbour at the roots of *Macrocystis* and other seaweeds above low-water level, and I have numerous specimens and can therefore add something to the descriptions previously given. I am not certain about the generic position of this species, but on the whole it seems to come within the characters of *Jassa*, the name now adopted for the genus *Podocerus*, except that I cannot find upturned teeth on the outer ramus of the third uropod, both rami being apparently free from these teeth. The broadened character of the fourth peraeopod proves, however, not to be confined to the male, but to be present also, sometimes apparently even to a greater degree, in the female. The differences between the two sexes in the second gnathopod are not greatly marked, but in the female the palm of the propod is slightly concave and the basal part of the propod is not produced into a distinct process as it is in the male; in the male this process is stout and truncate at the end, but the whole gnathopod is not greatly larger than in the female. One or two specimens, however, which, from the shape of the second gnathopod, would be considered males, bear brood-plates on some of the peraeopoda.

Ischyrocerus anguipes Kröyer.

Podocerus cylindricus Kirk, 1879, p. 402. *Wyvillea longimana* Haswell, 1879, p. 337, pl. 22, fig. 7; Stebbing, 1906, p. 648. *Podocerus longimanus* Chilton, 1884, p. 255, pl. 17, fig. 2 *a–e*. *Ischyrocerus anguipes* Sars, 1894, p. 588, pl. 209; Stebbing, 1906, p. 658.

This species was first recorded from New Zealand by T. W. Kirk in 1879 from specimens collected at Worser Bay, Wellington, which were by him identified as *Podocerus cylindricus* Say, the identification, however, being subsequently questioned by Miers (1880, p. 125). In the same year Haswell had described *Wyvillea longimana* from Port Jackson, establishing for it the new genus *Wyvillea*. In 1884 I identified specimens taken at Lyttelton as being the same as Haswell's *Wyvillea longimana*, and pointed out that his generic description had apparently been based on a misinterpretation of the terminal uropods, and that the animal in question was the same as the specimens referred by Kirk to *Podocerus cylindricus*, which I had been able to examine. Owing, however, to Miers's doubt as to the possibility of an Arctic species being found also in New Zealand, I adopted Haswell's specific name, and therefore named the species *Podocerus longimanus*. In 1888 Stebbing in his notice of Haswell's paper says, "The

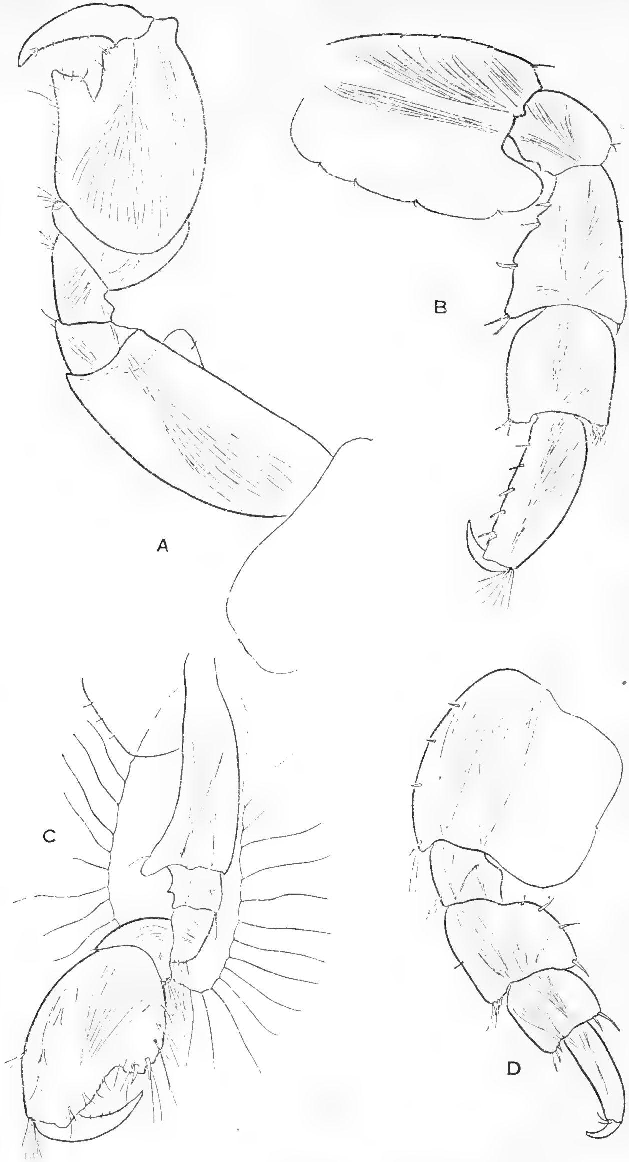

Fig. 4.—*Jassa frequens* (Chilton).

A. Second gnathopod of male.
B. Fourth peraeopod of the same.
C. Second gnathopod of female.
D. Fourth peraeopod of same.

figure which Mr. Haswell gives much resembles *Ischyrocerus* (*Podocerus*) *anguipes* Kröyer. Mr. Chilton supposes that the description given of the pleopoda [uropoda] is the result of an oversight, and that the genus must be cancelled in favour of *Podocerus*. It must, however, be observed that Mr. Haswell's description of the maxillipeds is quite inconsistent with this conclusion." In *Das Tierreich* Stebbing (1906, p. 648) retains the genus *Wyvillea* Haswell, describing the maxillipeds as "exunguiculate, inner and outer plates rudimentary, palp three-jointed," and to this genus he ascribes two species—viz., *W. longimana* Haswell and *W. haswelli* (G. M. Thomson). This description of the maxillipeds must, I think, be based on Haswell's original description, which was apparently incorrect. In the specimens from Lyttelton, which I feel sure are rightly referred to Haswell's species,* the maxillipeds are normal and closely resemble the figure given by Sars for *Ischyrocerus anguipes*. I have also been able to compare my specimens with an Arctic one from Davis Strait sent to me by Dr. W. T. Calman, and have no hesitation in identifying them both as belonging to the one species. I have already pointed out (1920, p. 6) that the other species, *Wyvillea haswelli* (G. M. Thomson), is a species of *Eurystheus*. In this the maxillipeds are also normal. Consequently the genus *Wyvillea* must be finally dropped.

The Lyttelton specimens are all rather small, the largest about 6 mm. long; but those examined by Kirk were very much larger, the second gnathopod (now in my collection) of one specimen being itself 5 mm. long. Stebbing gives the length as varying from 4 mm. to 15 mm. The Davis Strait specimen that I have examined is about 12 mm. in length.

The differences between the male and female, as pointed out by me in 1884 from New Zealand specimens, closely agree with those described and figured by Sars in 1894. The special characters of the second gnathopod of the male are only acquired when the animal is fully adult, the immature stages being at first similar to those of the female. I have one immature male specimen in which the gnathopod closely resembles the figure given by Sars of *Ischyrocerus minutus* Lilljeborg, a species which Stebbing considers a synonym of *I. anguipes* Kröyer.

Ischyrocerus anguipes has been recorded from South Africa by Barnard, and is another example of an amphipod first described from northern seas which proves to be also widely distributed in the Southern Hemisphere.

Corophium crassicorne Bruz.

Corophium contractum Stimpson, 1855, *P. Ac. Philad.*, vol. 7, p. 383. *C. contractum* G. M. Thomson, 1880, p. 6; 1881, p. 220, pl. 8, fig. 9: Thomson and Chilton, 1886, p. 142. *C. crassicorne* Thomson and Chilton, 1886, p. 142; Sars, 1894, p. 615, pl. 220; Stebbing, 1906, p. 690. ? *C. bonellii* Sars, 1894, p. 616, pl. 221, fig. 1; Stebbing, 1906, p. 691; Walker, 1914, p. 559.

In 1880 Mr. G. M. Thomson (1880, p. 6) obtained by the dredge in Dunedin Harbour two specimens of a species of *Corophium* which he identified as *C. contractum* Stimpson, a species described from Japan. Both Mr. Thomson's specimens were stated to be adult females. In a paper published in the following year (1881, p. 220) he repeated the observations and description which he had given of his specimens, and added a figure

* Since this was printed specimens quite similar to those from Lyttelton have been sent to me from Coogee, close to Port Jackson, New South Wales, the type locality for *Podocerus longimanus* Haswell.

of the whole animal. Shortly after this I collected in Lyttelton Harbour specimens that agreed with the description given by Mr. Thomson, and I therefore identified them as *C. contractum.* At the same time, and in association with these specimens, I collected others similar in most characters but differing in the form of the second antenna. These specimens appeared to be closely similar to the descriptions and figures given of *C. crassicorne* Bruz. in Spence Bate's *Catalogue of the Amphipoda in the British Museum* and in Bate and Westwood's *British Sessile-eyed Crustacea*, and were accordingly named *C. crassicorne.* Since the specimens identified as *C. crassicorne* were associated with those identified as *C. contractum* and apparently were males—at any rate, not bearing eggs—I concluded from the general resemblance between the two that they were male and female of the one species. As *C. crassicorne* was recorded from Europe, I looked up the works mentioned above to see if there was any mention of a form similar to *C. contractum* to represent the female of *C. crassicorne* in Europe, and found that *C. bonellii* Milne-Edwards appeared to be very similar to the New Zealand specimens I had identified as *C. contractum*, and I concluded therefore that it was probably the female of *C. crassicorne.* On writing to the Rev. T. R. R. Stebbing asking for information as to whether this conclusion was correct or not, he replied that some authorities considered *C. crassicorne* and *C. bonellii* to be male and female of the one species, while others, including Sars, considered them as distinct species.

In view of this difference of opinion, and in the absence of specimens from Europe, or sufficiently detailed descriptions to investigate the matter fully, the question was for the time left an open one, and in the list of the Crustacea Malacostraca of New Zealand, published in 1896 by Mr. G. M. Thomson and myself, the two species *C. contractum* Stimpson and *C. crassicorne* Bruz. were included with the following note after the last-named: " This species is taken along with *C. contractum*, and it is probable that they are only male and female of the same species. *C. bonellii* (Milne-Edwards) is probably the same as *C. contractum.*—C. C." (1886, p. 142).

For various reasons I was unable to give further attention to this particular question for many years, though on several occasions when specimens of *Corophium* were collected at different parts of the New Zealand coast both forms—*i.e.*, " *C. contractum* Stimpson " and " *C. crassicorne* Bruz."—were taken together, thus fully confirming my opinion that these were male and female of the same species, whatever might be the case with the *C. crassicorne* Bruz. and *C. bonellii* in Europe.

In the meantime many important works on the Amphipoda have been published which contain more or less direct evidence on the point at issue: *e.g.*, Sars in his great work on the Amphipoda of Norway in 1894 still keeps the two species separate, and describes forms which he considers to be male and female of *C. crassicorne*, the female form being different from the specimens which he refers to *C. bonellii.* Of this latter species he describes no male, saying, " It is very strange that I have never met with males of this form, though I have collected the species in several different places. Perhaps the sexual difference is so very slight as to escape attention " (1894, p. 617). In *Das Tierreich Amphipoda*, Stebbing (1906, p. 690), apparently following Sars, describes male and female forms of *C. crassicorne*, and considers *C. bonellii* a separate species, of which only the female is known.

I do not propose to go into the history of the various opinions that have been expressed as to the relation of *C. crassicorne* Bruz. and

C. bonellii M.-Edw. It is evidently a difficult question, and probably will not be thoroughly settled till we know more of the life-history and sexual differences of these animals. The latest discussion with which I am acquainted is given in a paper by Walker (1914, p. 559), where he points out that *C. acherusicum* Costa is a synonym of *C. bonellii*, and in which he regards this species as distinct from *C. crassicorne* Bruz. He had previously (1909, p. 343) recorded *C. bonellii* from the Indian Ocean, but at that time had evidently been in considerable doubt about the identification, for in the copy of his paper forwarded to me he had altered the printed name *C. bonellii* to *C. crassicorne*. In 1914 he says the name *C. bonellii* should be left as printed.

I shall content myself with a statement of the facts of the New Zealand species as they appear to me. The male specimens have the very large stout second antennae corresponding precisely with the figures given by Sars for *C. crassicorne* Bruz., and in other points the animals appear to agree closely with his description and figures except for the slight difference in the third uropod which is mentioned below. The female specimens also seem to agree closely with the description he gives for the female of *C. crassicorne*, though there appears to be some variation in the second antenna, the number of spines on which does not always agree precisely with the figure, and in some specimens these appendages agree more closely with his figure of *C. bonellii*. These two forms have been constantly found together in New Zealand, and I feel certain that they must be looked upon as male and female of the one species. Doubtless, as in other species, the adult characters of the second antenna in the male are only gradually attained, and the immature stages more or less closely resemble the female form. In an attempt to settle the question I got specimens some years ago, through the kindness of Mrs. Sexton, Plymouth, from the Dutch coast, sent by Dr. Hoek as "*C. crassicorne*," and others from the laboratory at Plymouth labelled "*C. bonellii*." The Plymouth specimens were apparently all females—at any rate, I have not found an adult male among them; but those from the Dutch coast contained both males and females, the males agreeing closely with Sars's description of *C. crassicorne*. After careful comparison of both sexes of these specimens with the New Zealand forms I have failed to distinguish any character that I consider of specific importance, and I am therefore labelling and recording the New Zealand specimens as *C. crassicorne* Bruz. I have also specimens from Port Jackson, New South Wales, agreeing minutely with the New Zealand forms.

Sars says that that *C. bonellii* is distinguished by (1) the absence of a rostrum, (2) the rounded lateral angle of the head (not sharply acute as in *C. crassicorne*), and (3) the character of the second antenna of the female. In all the specimens that I have examined for this particular point—viz., from New Zealand, "*C. crassicorne*" from the Dutch coast, and "*C. bonellii*" from Plymouth—the rostrum is present. The lateral angle of the head is, as Walker states, difficult to see, but as far as I can make out it varies, in some cases being somewhat rounded, as described by Sars for *C. bonellii*, and in others more acute. With regard to the third point, as already stated, I find considerable variation in the antennae of the females, and the New Zealand forms agree, some with the figure given by Sars for *C. crassicorne*, others with that for *C. bonellii*.

The only point in which the New Zealand specimens differ from the European ones that I have examined appears to be in the third uropods, which are slightly broader both in the peduncle and in the ramus, and have the two rami usually directed slightly towards the median line, instead of projecting directly backwards as shown by Sars for *C. crassicorne.* The difference is, however, not great, although it is easy to make considerable difference in the figure, and the general appearance of the end of the pleon is very near to that figured by Sars for *C. bonellii.**

Although the fully adult males and females in this species appear to be readily distinguished from one another by the characters of the second antenna, it is probable that the sexual relations are not always quite so simple. For example, I have a specimen, now mounted permanently as a micro-slide, in which the second antennae are stout and have on the under-surface a stout tooth which corresponds to the tooth found in the adult male, though not so pronounced; this specimen I should without hesitation consider as an immature male, but unfortunately on the appendages of the peraeon there are brood-pouches similar to those in the female. In the two species *C. spinicorne* Stimpson and *C. salmonis* Stimpson from the Pacific, which were redescribed in 1908 by Bradley, the adult females, as figured by him, have the characters of the second antennae of the adult male, though these are not developed to quite the same extent.

It is well known that *C. crassicorne,* like other species of the genus, is frequently found in brackish and sometimes even in perfectly fresh water. As far as I am aware, the New Zealand species has been taken in salt water only, though the allied form *Paracorophium excavatum* Thomson is found in brackish and fresh water. Stebbing has described from the brackish water of Lake Negombo, in Ceylon, a species, *C. triaeonyx,* which appears to me to be very close to the New Zealand forms, but differs in having the third uropods much less broadened. Similarly, in 1912, Wundsch described *C. devium* from fresh water near Berlin, a species which, from his figures, seems to agree very closely with Stebbing's species in the characters of the terminal uropods.

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* Stebbing (1914, p. 372) records *Corophium cylindricus* (Say) from the Falkland Islands, saying, "The figures and description of the female supplied by Dr. S. J. Holmes leave no doubt that Mr. Vallentin's specimens belong to this species." He quotes *C. cylindricus* Paulmier (1905, p. 167, fig. 37) as a synonym, and suggests that *C. quadriceps* Dana (2 mm. long) from Rio de Janeiro, and *C. contractum* Stimpson, 1855, from Japan, and the specimens from New Zealand recorded under this name by G. M. Thomson also belong to the same species. He gives no description of the Falkland Islands specimens except that they measure only 3 mm., as compared with 3–4 mm. given by Holmes, and 5 mm. by Paulmier, "probably with reference to a male specimen which he figures in full." I agree with Stebbing that the Falkland Island specimens are probably the same as those from New Zealand, but I do not know why he assigns them to *C. cylindricus* rather than to *C. crassicorne.* In *Das Tierreich Amphipoda* (1906, p. 692) he classes *C. cylindricus* among the "obscure" species, but in the appendix (p. 740) gives references to the description and figures given by Paulmier and Holmes.

I can find nothing in Holmes's description and figures inconsistent with the supposition that the species he describes is the same as the European *C. crassicorne,* and certainly the figures he gives of the second antenna both of male and female apply well to the New Zealand forms that I have referred to *C. crassicorne.* Similarly, the description and the figure of the male given by Paulmier apply equally well to the New Zealand forms. Neither Paulmier nor Holmes makes any reference to or comparison with other species.

Barnard (1916, p. 272) records *C. acherusicum* Costa from Durban Bay. Stebbing (1906, p. 692) give this species among the "obscure" species, with the remark, "perhaps identical with *C. bonellii.*" Walker (1914, p. 559), after comparing specimens of each, definitely united *C. acherusicum* with the older *C. bonellii*, to which he also referred *C. crassicorne* Hoeck (1879, p. 115).

It seems to me that these facts, which I had not paid special attention to when writing the remarks given above, show that all the forms to which these varied names have been given are so alike that they cannot be distinguished even by experts, and the conclusion I had already come to in the text receives additional confirmation.

It seems evident that a good deal more work must be devoted to the genus *Corophium* before the various problems indicated above can be solved. Probably we are dealing with a widely distributed form which is in the process of development but has not yet differentiated into distinct species, and some of the differences recorded may be associated with the character of the water in which it lives.

The telson appears to be practically the same in all the specimens—European, Australian, and New Zealand—that I have examined. It is broadly triangular, with the posterior margin truncate or slightly convex, and it bears on the dorsal surface, towards the posterior margin, two ridges diverging anteriorly and each bearing about four minute blunt spines projecting upwards. These ridges do not appear to be described or figured

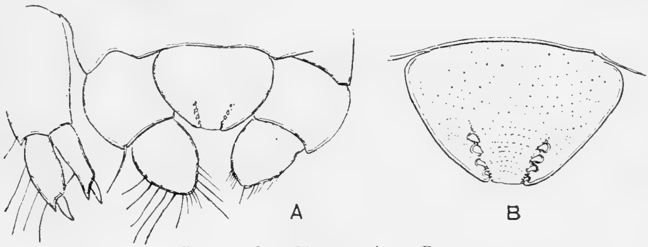

FIG. 5.—*Corophium crassicorne* Bruz.
A. Telson with second and third uropoda.
B. Telson (more highly magnified).

by Sars or Stebbing, though they are indicated in Sars's figure of the telson of *C. bonellii* (1895, pl. 22, fig. 1, *t*), and apparently in that of *C. affine* (*l.c.*, fig. 2, *t*). The telson shows different appearances according to its precise position when mounted. My specimens, which are all mounted permanently in Canada balsam, have become transparent enough to show the two ridges pretty clearly. In a specimen of *C. triaeonyx* Stebbing from Ceylon the terminal portion of the telson appears to have become doubled underneath, and consequently the two anterior spines extend clearly beyond the visible margin. In another specimen of the same species from Chilka Lake, however, the other spines could be clearly made out.

Phronima sedentaria Forskal.

Phronima sedentaria Bovallius, 1885, p. 354. *P. novae-zealandiae* Powell, 1875, p. 21, figs. 1, 2; Stebbing, 1888, p. 1356, pl. 161B; Chilton, 1912A, p. 131.

This species is frequently washed up on the coast of New Zealand, and I have specimens also from the Chatham Islands. It was described by Powell as a species peculiar to southern seas, but there is no doubt that Bovallius is right in referring it to the northern species *sedentaria*. A very full description and discussion of the synonyms is given by Bovallius in the reference quoted above. The animal is pelagic, and is invariably found in its "house," which is supposed to be the "test" of a salp or of some tunicate. The young in various stages of development are frequently found in the "house" with the female, but so far as I am aware nothing is known of the way in which they obtain a "house" for themselves. Males are very rare; I have not seen one among the New Zealand specimens.

Euprimno macropus Guérin Memeville.

Euprimno macropus Bovallius, 1885, p. 400, pl. xvii, figs. 23–40, and pl. xviii, figs. 1, 2. *Primno latreillei*, Stebbing, 1881, p. 1445.

This species was recorded from the neighbourhood of New Zealand by Stebbing in the "*Challenger*" *Reports* under the name of *Primno latreillei*. Bovallius unites *P. latreillei*, *P. menevillei* Stebbing, and *P. antarctica* Stebbing with *Euprimno macropus*. I have a specimen washed up on the Ocean Beach of Dunedin that agrees with the description given by Bovallius, and also with that given by Stebbing of *P. latreillei*, and from comparison of the two I feel convinced that Bovallius is correct in uniting the species.

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Art. XXVI.—*The Life-history of some New Zealand Insects: No. 1.*

By John G. Myers, F.E.S.

[*Read before the Wellington Philosophical Society, 27th October, 1920; received by Editor, 31st December, 1920; issued separately, 20th July, 1921.*]

Plate XLIV.

This paper is the first of a series which it is hoped to publish on the biology of New Zealand insects, chiefly those belonging to the Hemiptera. The life-history of not a single species of our endemic Heteroptera has been studied. This is to be regretted, if only because, as Kirkaldy (3) says, "from ovum to adult many of the Hemiptera undergo very remarkable changes of form, much more interesting in reality than the ecdyses of Lepidoptera or other Heteromorpha." *Ctenoneurus hochstetteri* Mayr., the subject of this study, is a very abundant member of the family of "flat bugs," or Aradidae, the species of which, like certain beetles (*Brontopriscus*) and spiders (*Hemicloea* spp.) are dorsoventrally flattened in a manner admirably adapted to a subcortical habitat.

I am indebted to Mr. E. B. Levy for the trouble he took in photographing the eggs and insects, and to Mr. David Miller for kindly reading the manuscript and making many valuable suggestions.

Ctenoneurus hochstetteri Mayr. (Hem.-Het.)

Neuroctenus hochstetteri Mayr., *Reise der "Novara,"* Zool. ii, pl. 4, fig. 47, Hem., p. 166. *Crimia attenuata* Walk., *Cat. Hem.-Het. Brit. Mus.*, pt. vii, p. 22. *Mezira maorica*, Walk., *loc. cit.*, p. 28. *Neuroctenus hochstetteri* Mayr., Hutton, *Trans. N.Z. Inst.*, vol. 30, p. 175, 1898. *Ctenoneurus hochstetteri* Mayr., Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 25, 1909.

Distribution.—Owing to the lack of collectors interested in Hemiptera, the range of most of the species is unknown. This insect is probably generally distributed throughout the country; it is certainly abundant at Wanganui, Wellington, and Auckland.

Habitat.—Although this bug is abundant beneath almost any loose bark, it shows a decided preference for tawa (*Beilschmiedia tawa*). This preference is perhaps more due to the looseness of large flakes of bark on dead tawa than to any superiority in the food-supply. Prostrate logs are as much affected as standing stumps, and the number of the insects harboured by them is amazing. Both on the under-surface of the bark and upon the trunk beneath, the massed bugs may form black patches 6 in. or more in diameter, and composed of individuals of various ages, all exuding, especially if crushed, that peculiar and characteristic "buggy" odour familiar to those who have met the bed-bug.

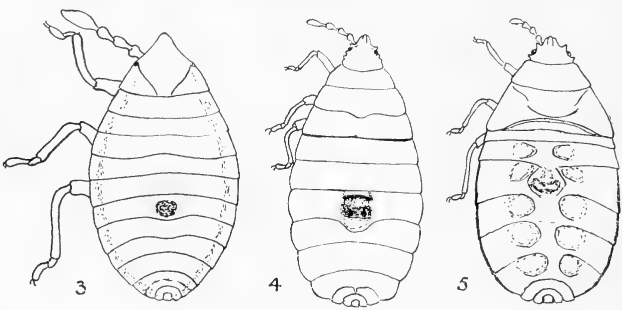
Life-history.—Owing to the difficulty experienced in artificially rearing any specimen through more than a few stadia, this account does not claim to be complete. The early instars live for weeks with very little attention, but the older nymphs and the imagines die with disappointing rapidity.

The Egg (Plate XLIV, fig. 1; text-figs. 1, 2).—Average length 1·5 mm. It is long, elliptical, and pure-white, the surface rendered beautifully punctate by the reticulation of numerous narrow ridges enclosing regular hexagonal pits. The position of the micropyle was not determined. The ova are deposited promiscuously or in patches on the bark or portions of the trunk, and are gummed lightly by the long axis of the egg. A patch of eggs may measure as much as 4 in. in diameter, and on removal of the bark be visible at 15 or 20 yards distance.

Ctenoneurus hochstetteri

Fig. 1.—Egg, showing sculpture. × 20.
Fig. 2.—Egg, showing dehiscence (sculpture omitted).

In the laboratory eggs hatched within one month, but that this is the normal period is uncertain. Individuals of most instars are found throughout the season, and the relative periods of the life-cycle probably vary with the time. Eggs hatch as late as April.



Ctenoneurus hochstetteri. Nymphs.

Fig. 3.—Second instar, just after first ecdysis. × 35.
Fig. 4.—An intermediate instar. × 11.
Fig. 5.—A late instar. × 8.

Dehiscence of the chorion occurs along approximately two-thirds of one side of the egg to one end, with one or two transverse fissures not extending more than half-way round the egg. Hatching is accompanied by some difficulty, the young nymph carrying the egg-shell for as long as three to six days. The edges of the shell fit round the first segments of the abdomen. The oolemm edges project as a delicate iridescent envelope.

[E. B. Levy, photo.

FIG. 1.—*Ctenoneurus hochstetteri.* Eggs (mostly hatched) *in situ* on under-surface of tawa-bark.

[E. B. Levy, photo.

FIG. 2.—*Ctenoneurus hochstetteri.* Imagines and nymph of advanced age.

Face p. 236.]

The first instar only is white or colourless, except for a bright yellow area surrounding the orifice of the scent-gland, and caused by the appearance of that gland showing through the transparent exoskeleton. The head is smooth and shining, while the rest of the dorsal surface appears dull.

In October and November the first ecdysis occurs after about six days. The cuticle splits along the mid-dorsal line of the thorax. The second instar shows little structural change; but colour appears as a dark grey on the head, two grey streaks separated by a narrow pale line along the whole dorsal surface, and dark spots on the lateral edges of each segment. The scent-gland opens on a raised area of a dark colour. The individuals of the first and second instars show a habit of standing remarkably high on their legs, a peculiarity noted by Kershaw and Kirkaldy in an Oriental species.

The subsequent nymphal history is marked by an enormous increase in the size of the body relatively to the length of the appendages; by the appearance of spines on the lateral margins of the head; by the growth of tubercles and spots on the posterior margins of the abdominal segments; by the increase of granulation over the whole dorsal surface; and, above all, by the gradual curving of the mesonotal and metanotal posterior margins with the formation of wing-pads, of which those of the mesothorax, forming the rudimentary tegmina, soon cover entirely those of the metathorax. The compound eyes of the second and subsequent instars are brilliant red.

Although Osborn considers five instars to be the normal number in the Hemiptera, Kershaw and Kirkaldy note eight in the case of *Dindymus sanguineus* Fabr., an Oriental Pyrrohocorid; and there is every indication that *Ctenoneurus hochstetteri* passes through an equally large number of stadia. The difficulty of ascertaining the exact number of instars may be increased by individual as well as seasonal variation. Such a variation, according to Tillyard, is well known to occur in certain dragon-flies, where the nymphal instars are extremely numerous.

Maternal Solicitude.—Although J. H. Fabre has cast the weight of his authority against the classic example of De Geer's "grey bugs" (*Elasmucha grisea*) and their display of parental affection, it may be of interest to note that imagines of *C. hochstetteri* are sometimes found carrying several first or second instar nymphs on their backs and sides in a manner comparable to that of Lycosid spiders. Considering the gregarious habit of the species, perhaps we should rule out maternal solicitude as an explanation; but it is significant that these young nymphs do not apparently cling to older nymphs which closely approach imagines in size.

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Art. XXVII.—*A Revision of the New Zealand Cicadidae (Homoptera), with Descriptions of New Species.*

By John G. Myers, F.E.S.

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Plates XLV, XLVI.

In 1908 Kirkaldy pointed out the urgent need for a revision of the New Zealand species of *Melampsalta*. This paper is an attempt to supply the want.

I must first acknowledge a deep debt of gratitude to Mr. G. V. Hudson. Without his encouragement the paper would not have been commenced; without his assistance it would not have been completed. He has also honoured me by furnishing the plates, which form a most valuable portion of the paper. My thanks are due also to Professor H. B. Kirk, who kindly read the text.

In the difficult work of establishing the synonymy much valuable help was received from manuscript notes of Mr. Howard Ashton, of Sydney, to whom Mr. Hudson sent a collection of Cicadidae in 1907. In some few instances my own researches have led me to conclusions at variance with those of Mr. Ashton, particularly with regard to the much-disputed synonymy of the multifarious forms of *M. cruentata* Fabr.

In field-work and collecting, Mr. T. C. Cockcroft's keen assistance has been invaluable.

In the order Hemiptera, or Rhynchota, the suborder Homoptera contains two very distinct divisions, based on the position of the rostrum. Of these, the Auchenorryncha comprise the cicadas and leaf-hoppers, while the Sternorrhyncha include the springing plant-lice, the true plant-lice (or aphides), and the scale insects.

The Auchenorrhynchous Homoptera form a much-neglected group, of which the importance, both economic and biological, is, however, extremely great. As the suctorial mouth-parts of these insects inflict only very minute wounds on plants, the damage they do to crops is apt to be largely underestimated. That their study is not only of purely scientific interest is demonstrated by the fact that, according to Osborn, at least one-fourth of all the grass in North America is annually destroyed by leaf-hoppers.

To show the affinities of the Cicadidae it will be necessary to indicate briefly the classification of the Auchenorrhyncha. Under the system proposed by Kirkaldy the group is divided into two main "superfamilies"—the Cicadoidea, containing the families Cicadidae, Jassidae, Membracidae, and Cercopidae (the frog-hoppers or cuckoo-spit insects so common in Europe, and occurring also in New Zealand); and the Fulgoroidea, containing the famous lantern-flies, of which the luminosity is now generally doubted if not absolutely disproved, and a multitude of smaller, often very beautiful forms, for which no one has yet found popular names. It is proposed to devote a later paper to the leaf-hoppers generally.

Of the families themselves, the Cicadidae, though attaining a very high degree of specialization in their stridulatory organs, are yet to be considered, as a whole, the most primitive. In general points of structure, particularly of the head and thorax, and in wing-venation, the cicadas are considered by Osborn to approach, more closely than do other Auchenorrhyncha, the Psyllidae, which Tillyard believes to be the oldest family of the Sternorrhyncha. Though this lends additional colour to the view that the Cicadidae are the most primitive of the Auchenorrhyncha, fossil cicadas, according to Tillyard, do not occur before the Cretaceous, long after typical Jassids and Fulgoroids had appeared.

So much for the present state of knowledge—or, rather, speculation—with regard to the phylogeny of the family. With respect to structure, the Cicadidae are characterized by—Ocelli three, on vertex. Head and antennae very short. Rostrum long, with three joints. Thorax large, with a narrow transverse pronotum and a large mesonotum carrying posteriorly a cruciform elevation. Tegmina and wings usually hyaline.

The subfamily Tibiceninae may be recognized by the entirely uncovered state of the sound-organs in the male; while the genus *Melampsalta* Amy. (= *Cicadetta* Kol.), to which all our species belong, is identified by the union or close contiguity of the bases of the ulnar veins of the tegmina at the end of the basal cell.

The genus *Melampsalta*, though occurring in Europe and Asia, has its headquarters in Australasia. Of the thirteen New Zealand species, the common and variable *M. cruentata* (*angusta*) occurs also in Adelaide and Victoria (Goding and Froggatt). All the others, with the possible but highly improbable exception of *M. quadricincta*, are endemic.

With regard to the biology of these beautiful insects, which are popularly but very inaccurately known as "locusts," very few details are known. During the summer months almost every type of country, be it bush, meadow, swamp, seashore, scrub, or alpine slope, is enlivened by the song of one or more peculiar species. I should like to emphasize the fact that practically every species described may be distinguished in the field by characters—such as song, habitat, and, may I say, psychology—other than those usually considered by the systematist. It has been noticed that, even in the most variable forms, the song is practically the same throughout the species. It is, however, rather difficult to describe and to utilize for a written description.

I have observed either oviposition or, much more frequently, the marks of the process in two species, *M. cingulata* and *M. cruentata*. In the latter, for example, a twig of *Macropiper excelsum* was gashed to the centre for about 2 in. In the former a female *M. cruentata* was operating on a fairly soft, green stalk of fennel (*Foeniculum*), with her body parallel to the stem and her ovipositor working with a vigorous, vertical, saw-like motion at right angles.

The nymphs on hatching are said to drop to the ground, beneath which the whole of the nymphal instars are passed. It is hoped to obtain next season more precise information regarding the events subsequent to hatching in the New Zealand species. The nymphs at a later stage, with their very powerful, fossorial first pair of legs, and their smooth, yellowish integument, are familiar objects to the gardener. The duration of the subterranean existence of the New Zealand species is not known; but that it may, at least occasionally, extend beyond a season is demonstrated by the occurrence of full-grown nymphs of *M. cingulata* at the end of May (Hudson, *Ent. Mo. Mag.*, vol. 55, p. 181, August, 1919). The famous periodical cicada (*Tibicen septemdecim*) of North America spends, of course, seventeen years beneath the surface.

When the time of emergence of the New Zealand species is at hand the full-grown nymph makes its way to the surface and climbs, often to a height of some feet, a tree or any other convenient support. The two sand-dune species are necessarily confined to short, unstable herbage. Dehiscence takes place along the mid-dorsal line of the thorax, and emergence occurs at night, or at least after sunset. The nymphal exuviae remain, abundant and familiar objects, hanging to the support.

Probably the most noticeable characteristic of the imago is its song, which is produced only by the male. For an account of the sound-producing apparatus of the New Zealand species the reader is referred to a paper by Powell in the *Transactions of the New Zealand Institute*, vol. 5, p. 286. Though our large species, *M. cingulata*, can produce a surprising volume of sound, it is excelled by many foreign species, notably by an Australian form, of which McCoy, quoted by Distant, gives the following account: "It produces almost a deafening sound from the numbers of the individuals in the hottest days, and the loudness of their noise, which, beginning with a prolonged, high-toned whirr like that of a knife-grinder, or the letter R loudly prolonged in a high pitch, continued for a minute or two, breaks into a series of diminuendo 'squawks,' like that of a frightened duck in a farmyard, loud enough to be heard some hundred yards off, and stunning our ears with the shrilling and squalling. This, kept up with 'damnable iteration,' as Falstaff says, by hundreds of individuals all day long, would tax the patience of a saint, if such existed in Australia."

Though the cicada is usually linked with the cricket in contrast to the conventional provident and industrious ant, and though the life of the *cigale* is considered an Arcadian existence by the Provençal peasant, its enemies are by no means few. First in importance probably are birds of various species, but especially house-sparrows (Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 51, 1891). Other insects, such as mantids, other carnivorous Orthoptera, dragon-flies, ichneumons, and hornets, have been recorded outside New Zealand as exploiters of the Cicadidae. In New Zealand I have seen the carnivorous Heteropteron, *Cermatulus nasalis* Westw., that butcher of noctuid caterpillars, attack a male *M. cruentata* much larger than itself. The bug had inserted its rostrum into the end of the cicada's abdomen. The "singer," attempting to fly, was actually swinging by its exserted extreme abdominal segments, while the bug, gripping with its claws the rough toetoe (*Arundo conspicua*) leaf, held back hard, though nearly pulled off its perch by the larger insect, which kept up a shrill, screaming stridulation, very different from its normal happy note.

Finally, the fungus *Cordyceps Sinclarii* attacks the nymph and (less frequently) the imago, occupying every part of the body with mycelial hyphae, in a manner similar to that of the well-known *C. Robertsii*, the "vegetable caterpillar."

Measurements.—All dimensions are given in millimetres, and are the averages of large series where such could be obtained. Instead of giving the expanse, I have measured the tegmen itself, thus allowing the important taxonomic ratio of body-length to tegmen-length to be more readily used.

1. **Melampsalta cingulata** Fabr. (Plate XLV: fig. 5, ♂; fig. 6, ♀.)

Tettigonia cingulata Fabr., *Syst. Ent.*, 680, 9, 1775. *Cicada cingulata* Hudson, *Man. N.Z. Ent.*, p. 118, 1892; *Trans. N.Z. Inst.*, vol. 23, p. 50, 1891. *C. zealandica* Boisduval, *Voy.* "*Astrolabe*," *Ent.*, pl. 10, fig. 6, 1832. *C. indivulsa* Walk., *Cat. Hom. B.M. Suppl.* 33, 1858. *Cicadetta cingulata* Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

Head black; *frons* with pale-brownish median area, continuing on vertex. *Notum* black. *Pronotum with median, longitudinal yellow or green streak. Mesonotum* with five more or less interrupted green or ochraceous longitudinal stripes, the median one very short. Cruciform elevation forms two diverging green crescents. *Abdomen black.* Segments edged with spots or broken lines of brown and more or less silvery pubescence. In female seventh abdominal segment cinctured more or less conspicuously with yellow. Ventral surface—abdomen usually uniform black; sometimes brown with black segmented margins. *Tegmina—costa strongly bowed at distal end of radial area,* brown or olivaceous. *Distal ends of first and second ulnar areas black. Bases of tegmina and wings green or olivaceous.*

Long. corp. 22–26 mm.; tegmen, 35–40 mm.

Distribution.—Auckland to Southland (Hutton). December to April.

This is probably, by reason of its size, abundance, and loud note, the most conspicuous species of the family. In habits it is essentially arboreal, delighting to perch on bare trunks and the larger branches, though posts and even buildings in the towns are not disdained. At Wanganui I have counted at many as thirty-nine on a single telegraph-post. The extreme wariness of this cicada, together with its habit of perching at a considerable height, renders it a difficult insect to catch. One of the "vegetable-caterpillar" fungi, *Coryceps Sinclairii,* attacks this species both in the final nymphal and in the imaginal instars. *M. cingulata* is nearest *M. strepitans,* from which it is distinguished by its larger size, longer tegmina with *greenish basal areas,* and *very varied song*

2. **Melampsalta strepitans** Kirkaldy. (Plate XLV, fig. 7, ♂.)

Cicada cingulata var. *obscura* Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 51, 1891. *Cicadetta strepitans* Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

In colour and markings resembles *M. cingulata;* but abdomen more often concolorous, and *pattern extremely indistinct. Silvery pubescence,* especially on abdomen, *much more pronounced than in* M. cingulata. *Bases of tegmina and wings clouded with orange.* Costa olivaceous, strongly bowed at distal end of radial area. *Proximal junctions of ulnar veins separated much farther than in* M. cingulata.

Body very short and stout; tegmina short and broad. Long. corp. 19–21 mm.; tegmen, 22–24 mm.

Distribution. — Kekerangu; Tasman River, Mount Cook (Hudson); Wellington; Christchurch. December to February.

This very distinct species was discovered by Mr. Hudson on boulders in a river-bed of the Kaikoura Mountains, Marlborough. Its song was described as loud and chattering. I have taken it in February on a rocky slope at the top of the cliff near Red Rocks, Wellington, where it was discovered by Mr. T. Cockcroft. The note is loud and distinct, differing from that of *M. cingulata* in its much more intermittent though monotonous character. The insects frequent rocks and stumps in the full sunshine, showing little liking for trees, thus differing from the tree-loving *M. cingulata.* They are extremely wary. It was proved that sight is their chief guide by approaching from the opposite side of the rock on which they were resting. A front approach was practically impossible.

3. Melampsalta cauta n. sp. (Plate XLV, fig. 8, ♂.)

Head green in male, cinereous in female, *with two black triangular spots posterior to ocelli,* which are red. *Pronotum black with maroon overmarkings; anterior and posterior borders pale green, connected by pale-green median line* Mesonotum deep reddish-black laterally; *anteriorly two large red obconical marks bordered with black,* followed by a pale-green area containing three black spots forming a triangle. Cruciform elevation conical, shining green. *Abdomen* ♂ almost uniform black, with faint reddish segmental margins; ventrally dull bluish-black; *genital segments long and narrow, shining black. Abdomen* ♀ black with segmental margins maroon-red. Indications of faint silvery median stripe. Ventral surface brownish. *Indications of yellowish cincture on seventh abdominal segment.* Costa reddish or reddish-olive, passing into black on post-costal area.

Body slender; tegmina long. Long. corp. 20–21 mm.; tegmen, 26–28 mm.

Distribution.—Ohakune; Karori; Day's Bay, Wellington. December to March.

This species is perhaps nearest *M. scutellaris* in markings, but is perfectly distinct. It frequents bush in hilly country, showing a preference for tree-trunks and logs, and exhibiting probably a greater wariness than any other member of the family. The nature of the country adds to the difficulty of its capture. The song is composed of two notes, much louder than that of *M. cruentata,* though much less varied and less loud than that of *M. cingulata,* which the insect strongly resembles in habits.

Miss Stella Hudson discovered this species at Ohakune.

4. Melampsalta scutellaris Walk. (Plate XLVI: fig. 3, ♂; fig. 4, ♀.)

Cicada scutellaris Walk., *Cat. Hom. B.M.*, 1850, 150. *C. arche, l.c.*, 195. *C. tristis* Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 52, 1891. *Cicadetta scutellaris* Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 27, 1909.

Goding and Froggatt (*Proc. Linn. Soc. N.S.W.*, vol. 29, p. 642), following Stal, consider *C. arche* a synonym of the Australian *M. telxiope* Walk. Kirkaldy (*l.c.*, p. 27) regards *C. arche* as a doubtful species and its synonymy with *M. telxiope* improbable. However this may be, our New Zealand *M. scutellaris,* which Kirby (*Trans. N.Z. Inst.*, vol. 28, p. 457, 1896), places in synonymy with *C. arche,* is certainly distinct from *M. telxiope.* Walker's type of *C. arche* is a "specimen bleached almost beyond recognition" (Kirby).

Head brassy to bronzy green. Vertex concolorous. *Pronotum greenish with slight blackish markings* and paler median streak widening posteriorly. Streak often dull-reddish. Mesonotum with *four obconical pinkish areas from anterior border, streaked with black, the two median areas half the length of the two laterals.* Cruciform elevation glabrous-green, conical.

Abdomen almost uniform bronze or greenish-bronze, sometimes segmental margins greener, or *reddish. Ventral surface*—♂ greenish ; abdomen dark ; opercula pale-greenish : ♀ pale yellowish-green ; abdomen with dark median stripe. *Tegmina—distal end of fifth ulnar area more acute than in any other species.* Costa olivaceous. *Eighth apical cell twice as long as broad.*

Long slender body, tapering antero-posteriorly ; *tegmina long.* Long. corp. 16–20 mm. ; tegmen, 21–25 mm.

Distribution.—Wellington ; Wanganui.

" Exceedingly sad and feeble song " (Hudson). Easily recognized by the *almost inaudible note, bronzy colour marked with green or reddish,* and *slender build.* Prefers low herbage and bushes, and is less wary than the other species, though extremely difficult to locate. The eighth apical cell of the tegmen is always easily twice as long as broad.

This species is very frequently caught in Epeirid-spider webs. January to middle of May.

5. **Melampsalta muta** Fabr. (Plate XLVI : fig. 5, ♂ ; fig. 6, ♀.)

> *Tettigonia muta* Fabr., *Syst. Ent.*, 681, 17, 1775. *Cicada cutora* Walk., *Cat. Hom. B.M.*, 172, 1850. *C. ochrina* Walk., *l.c.*, *Suppl.* 34, 1858. *C. aprilina* Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 53, 1891. *Melampsalta cuterae* Kirby, *Trans. N.Z. Inst.*, vol. 28, p. 456, 1896. *M. muta* Distant (part), *Ann. Mag. Nat. Hist.*, vol. 9, p. 326, 1892. *Cicadetta aprilina* Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

" A long series of this insect (*cuterae*) stood in the British Museum collection under the name of *Cicada muta* (our *M. cruentata*), among which were only two specimens really belonging to the latter species. This is probably the reason why Mr. Distant so positively maintains that *C. aprilina* is not distinct from *C. muta* " (*i.e.*, our *cruentata*). (Kirby, *l.c.*, p. 456. The parentheses are mine.)

General colour wholly and invariably vivid grass-green. Two short longitudinal black lines on anterior portion of mesonotum. Remainder green. *Cruciform elevation*—two brownish-green swellings with a grass-green projection between them. Golden longitudinal median stripe on *abdomen only.* Legs pale green with red tarsi. *Mesosternum* pale reddish (black in *cruentata*). *Tegmina*—veins green, olive-green, or reddish-brown.

Long. 19–21 mm. ; tegmen, 23–27 mm.

Sexes similar ; practically no variation.

Distribution. — Wellington ; Auckland ; Taupo. No authentic South Island records.

This is an extremely beautiful and very distinct species, differing from *M. cruentata,* its nearest relative, in markings, habits, note, habitat, time of greatest abundance, and sometimes in size. It is essentially the cicada of the bushes. As its colour might indicate, leaves are its habitual environment, whence its rather harsh note is frequently heard late in the season ; but it is amazingly difficult to detect its location. The note is *monotonous and insistent, with no variation.* It is much louder than that of *M. cruentata,* with a grating, harsh quality absent from the notes of the other cicadas.

February and March. One female of this species was taken at electric light in the evening.

6. **Melampsalta cruentata** Fabr. (Plate XLVI: fig. 9, ♂; fig. 10, ♀; fig. 11, red variety of ♂.)

Tettigonia cruentata Fabr., *Syst. Ent.*, 680, 10, 1775. *Cicada sericea* Walk., *Cat. Hom. B.M.*, 169, 1850. *C. rosea* Walk., *l.c.*, 220. *C. angusta* Walk., *l.c.*, 174. *C. bilinea* Walk., *l.c.*, *Suppl.* 34, 1858. *Melampsalta rosea* Stal, *Oefv. Vet. Ak. Fork.*, p. 484, 1862 (quoted by Distant). *M. muta* Distant (part), *Ann. Mag. Nat. Hist.*, vol. 9, p. 326, 1892; Kirby (vars. β–δ), *Trans. N.Z. Inst.*, vol. 28, p. 455, 1896. *M. sericea* Kirby, *l.c.*, p. 456. *M. angusta* Distant, *Ann. Mag. Nat. Hist.*, vol. 9, p. 326, 1892; Goding and Froggatt, *Proc. Linn. Soc. N.S.W.*, vol. 29, p. 643, 1904. *Cicada muta* Hudson (and vars. *flavescens, cinerascens, rufescens*), *Trans. N.Z. Inst.*, vol. 23, p. 51, 1891. *Cicadetta cruentata* and *angusta* Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909.

♂. *General colour dark red, brownish, or olivaceous, with a silvery or pale median stripe from frons to tip of abdomen.* Mesonotum with two heavy black obconical patches, variable in size. Cruciform elevation always paler. Abdomen—segmental margins red, brownish, or olivaceous, remainder dark. Costa olivaceous or reddish. *Tegmina and wings clear.*

Long. 14–17 mm.; tegmen, 18–21 mm.

♀. Resembles male except in *larger size* and the following: General colour *pale* greenish, olivaceous, yellowish, ochreous, or bright red.

Long. 18–23 mm.; tegmen, 20–24 mm.

Both sexes extremely variable in colour, size, and intensity of markings. *Pale median stripe always present*, sometimes edged with darker, especially on the anterior segments of abdomen. The eighth apical cell of the tegmen is nearly as broad as long.

Distribution.—Probably generally distributed throughout the country at low levels. It is interesting to note that this is the only species not endemic. Goding and Froggatt ("Monograph of Australian Cicadidae") record it from Adelaide and Victoria.

This is the common cicada of the open country from November to May. In contradistinction to the shrub-loving *M. muta*, it shows a decided preference for grass, herbage, and swamp-vegetation on or near the ground. The species is extremely variable; but the continuous median stripe is constant, and the note varies but little. In tone the song is intermediate between the shrill, weak chirping of *M. scutellaris* and *M. cincta* and the rather harsh, insistent stridulation of *M. muta*. Observations in the field emphatically confirm Distant's opinion that the two extreme forms (*angusta* and *cruentata*) are one and the same species.

Var. **subalpina.** (Plate XLVI: fig. 12, ♂; fig. 13, ♀.)

Cicada muta var. *subalpina* Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 51, 1891. *Melampsalta muta* Kirby, *Trans. N.Z. Inst.*, vol. 28, p. 455, 1896. *Cicadetta muta* Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 27, 1909.

General colour vivid green occasionally suffused with reddish. *Genital segment with two dark lateral lines.* Cruciform elevation tinged with red or yellow. The obconical spots of the mesonotum sometimes marked with red. Legs sometimes green with red tarsi. *Tegmina and wings suffused with green* (distinction from type). Veins green, costa reddish.

Size larger than type. Long. 18–23 mm.; tegmen, 23–28 mm.

This is a well-marked green variety which sometimes bears a great superficial resemblance to *M. muta*, from which it is readily distinguished by the pale median stripe of the pronotum. Its note also seems intermediate between that of *M. cruentata* (type) and that of *M. muta.*

"That this is no more than a variety is proved by the fact that specimens have been known to mate with the typical red variety of the species." (Hudson.)

This is such a distinct variety that further study may justify its elevation to specific rank.

Distribution.—Silverstream, Wellington (T. Cockcroft); Mount Arthur and Dun Mountain, Nelson; Arthur's Pass; Tapuaenuku, Kaikoura Mountains; Murchison.

7. **Melampsalta fuliginosa** n. sp. (Plate XLVI, fig. 2, ♀.)

♀. *Head black. Notum uniform dead-black with slight scattered indications of golden pubescence. Abdomen black with silver median dorsal stripe. Segmental margins laterally olivaceous.* Ventral surface fuscous brown. *Abdominal segments edged with paler.*

In size, shape, and ratio of body-length to tegmen-length resembles *M. cruentata.* Long. corp. 21 mm.; tegmen, 21 mm.

Distribution.—Wellington. One specimen. February.

This is described from a unique female specimen. It may possibly prove, when a series can be obtained, to be only an extreme variety of the highly variable *M. cruentata.* However, in the absence of any intermediate forms it seems at present sufficiently distinct.

8. **Melampsalta indistincta** n. sp. (Plate XLVI: fig. 7, ♂; fig. 8, ♀.)

Eyes brown. Head pubescent, brownish-grey. *Vertex with central pale area.* Pronotum dark-brownish with small lateral dark streaks obscured by white pubescence. *Median line of pronotum pale-yellowish, edged with darker and expanding to full width at edge of mesonotum, though interrupted by two black spots.* Mesonotum black with two olive-brown lateral streaks. *Abdomen black with indications of a pale median dorsal streak and with segmental margins pale brown at the sides.* Sides of abdomen with silvery pubescence. *Cruciform elevation pale with black apex.* Costa and veins pale-brownish. Ventral surface—♂ pale brown with black median area, ♀ uniform pale yellowish-brown.

Long. corp. 14–17 mm.; tegmen, 17–20 mm.

Distribution.—Pipiriki, Wanganui River, Auckland (Hudson); Paekakariki. "Amongst boulders in hot sunshine. Note very distinctive." January.

This little species was discovered by Mr. Hudson.

9. **Melampsalta cincta** Walk. (Plate XLV, fig. 11, ♂.)

Cicada cincta Walk., *Cat. Hom. B.M.*, 204, 1850. *C. muta* var. *minor* Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 52, 1891.

General colour tawny or reddish with black markings. Pronotum with pale median longitudinal band containing posteriorly two distinct black dots. Two diagonal black streaks laterally. *Mesonotum heavily marked with black;* a faint silvery median streak. *Approximately anterior third of abdomen black,* remaining segments edged posteriorly with red, especially laterally. *Silvery median longitudinal streak varying in intensity. Bases of tegmina and wings brilliant red.* Anal area of wing outlined more or less vividly with carmine. *Costa and veins green.* Post-costal area red. More or less silvery pubescence on whole surface. Sexes similar. *Mesosternum almost wholly pale.*

Long. corp. 15–18 mm.; tegmen, 16–21 mm.

Distribution.—Taupo; Wellington (Hutton). River-bed of the Manawatu at Palmerston North; Pipiriki, Wanganui River; Motueka, Maitai (Hudson).

This well-marked species is confined to the sand-dunes not far above high-water mark, among *Spinifex hirsutus, Coprosma acerosa,* and *Scirpus frondosus.* Its note is shrill and weak, somewhat resembling that of the small cricket. In common with the other littoral species (*M. leptomera* n. sp.) it exhibits considerable unwillingness to fly; and *the males are out of all comparison much more abundant than the females.*

10. **Melampsalta leptomera** n. sp. (Plate XLVI, fig. 1, ♀.)

Markings generally as in *M. cincta. General colour pale tawny with black markings much obscured by abundant short silvery pubescence.* Median pale longitudinal band throughout rather indistinct. Pronotum almost as in *M. cincta.* Mesonotum black with two pale-brown longitudinal marks containing posteriorly a black dot. *Mesosternum black.* Abdomen black with the *segmental margins faintly red; but the whole appearing grey, owing to white closely-appressed pubescence. Bases of tegmina and wings, costa, post-costal area, and veins orange-yellow. Body and wings very long and narrow.* Sexes similar.

Long. corp. 16–20 mm.; tegmen, 18–23 mm.

Distribution.—Lyall Bay, Wellington. January, February.

This striking species occurs nearer the actual beach than *M. cincta,* almost exclusively among pingao (*Scirpus frondosus*), the tawny leaves of which it resembles in colour. The favourite position is low down in the axil of a leaf, with the folded tegmina and convexity of the back fitted into the concavity of the base of the leaf. The insect is extremely difficult to detect. It is comparatively unwilling to take to flight, and sometimes falls to the ground with folded wings, rather than attempt to escape in the usual manner. Possibly this is due to the windy nature of its habitat. The note is extremely weak, though not so high-pitched as that of *M. scutellaris.*

11. **Melampsalta quadricincta** Walk. (Plate XLV: fig. 3, ♂; fig. 4, ♀.)

> *Cicada quadricincta* Walk., *Cat. Hom. B.M.*, 191, 1850. *C. nervosa* Walk., *l.c.*, 213. *C. cassiope* Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 54, 1891. *Melampsalta quadricincta* Goding and Froggatt, *Proc. Linn. Soc. N.S.W.*, vol. 29, p. 645, 1904. *M. cassiope* Kirby, *Trans. N.Z. Inst.*, vol. 28, p. 457, 1896. *M. mangu* White, *Ent. Mo. Mag.*, vol. 15, p. 21, 1879. *M. mangu* Kirby, *l.c.*, p. 457.

The type of *C. quadricincta* Walk. is labelled "New Holland," but no specimens came under the notice of Goding and Froggatt when they monographed the Australian Cicadidae. Considering, therefore, the generally vague character of foreign-locality labels in 1850, I think we are justified, in the absence of other evidence, in concluding that *M. quadricincta* syn. *cassiope,* the common alpine cicada of New Zealand, *is endemic.*

General colour black with long hairs (especially in the female) *and pale pubescence. Frons heavily hirsute; tawny spot on each side.* Vertex—some indication of pale median area. *Pronotum considerably wider than head.* Mesonotum almost uniform black. Cruciform elevation tawny. *Segmental margins of abdomen more or less tawny or reddish. Ventral surface pale ochreous. Wings perfectly transparent,* short. Costa and veins fulvous.

♀ considerably larger.

Long. corp. 19–23 mm. ; tegmen, 18–22 mm.

For specimens of this species and all information respecting it I am indebted to Mr. G. V. Hudson. It is the common alpine cicada of New Zealand ; elevation, 2,500–4,000 ft.

"Song extremely low—a short muffled rasp, followed by a very faint shrill hiss, about one and a half times as long as the rasp. Written while cicada was singing." (Hudson.)

Distribution.—Dun Mountain ; Mount Earnslaw ; Kelly's Creek, Otira (1,000 ft.) ; Tapuaenuku, Marlborough ; Mount Arthur ; Lake Harris, Wakatipu. Probably generally distributed on South Island mountains. January, February.

12. **Melampsalta nigra** n. sp (Plate XLV : fig. 1, ♂ ; fig. 2, ♀.)

Very stout and squat. Shining deep black except where obscured by dark pubescence and hairs. *No signs of markings.* Head with coarse forwardly-directed black hairs. Eyes very deep brown. Ocelli red, separated by a deep groove. Surface of head coarsely punctate, more or less pubescent. Pronotum with two rugose grooves diverging from the posterior median elevation. Pubescence pale and sparse, hairs long and dark. Pronotum considerably wider than head. Mesonotum more or less smooth. A little greyish short pubescence in ♀. *Cruciform elevation* prominent, uniformly black. Long dark hairs covering the thorax are visible in profile. Abdomen short and thick. Dark hairs and greyish pubescence, the latter prominent on the segmental margins of the female. Last body-segment (preceding genital segments) pale in ♀. Dorsal portion of genital segments shining black, sides and under flaps paler. Legs brownish, except anterior pair which are black. Tegmina and wings suffused with brown. *Veins very heavy and black.*

Sexes similar in size. Long. corp. 16 mm. ; tegmen, 16 mm.

For specimens of this insect and all information regarding it I am indebted to Mr. Hudson.

Distribution.—Arthur's Pass : rocks and shingle in hot afternoon sunshine ; 4,600–5,200 ft. 11th February, 1920.

"On eastern side of Arthur's Pass (4,500–5,200 ft.) there are shingle-patches and mountain-grass interspersed. Here a new species of cicada was abundant. Extremely wary and difficult to approach. Note of male very short, quick, faint, and low-pitched—quite different from that of *M. quadricincta.*" (Hudson.)

13. **Melampsalta iolanthe** Huds. (Plate XLV, fig. 9, ♀.)

Cicada iolanthe Hudson, *Trans. N.Z. Inst.*, vol. 23, p. 53, 1891 ; *Man. N.Z. Ent.*, p. 119, 1892. *Cicadetta iolanthe* Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 27, 1909.

Head very hairy, fuscous. *Notum dark olive-brown with indistinct black markings*, pubescent. *Anterior and posterior borders of mesonotum glabrous, reddish-brown.* Cruciform elevation reddish-brown, ridged. Abdomen black, segmental margins brown or reddish. Costa reddish-brown. Genital segments reddish. Ventral surface pubescent. *Body exceedingly short and stout. Wings short. Median markings absent.*

Long. corp. 15 mm. ; tegmen, 16 mm.

Distribution.— Taupo ; Nelson ; Canterbury (Hutton) ; Wellington (Hudson).

This is the smallest species. December to March. (Hudson.) It has become rather rare, and I have not yet taken a specimen myself.

Artificial Key to Species of Melampsalta.

1.	Tegmen with two adjacent black spots at ⅔	2
	Tegmen without black spots	3
2.	Tegmen 27 mm. or longer, base green or olivaceous	*M. cingulata.*
	Tegmen 24 mm. or less, base orange	*M. strepitans.*
3.	Apex of fifth ulnar area acute	*M. scutellaris.*
	Apex of fifth ulnar area obtuse	4
4.	Continuous median dorsal stripe	5
	Median stripe wholly or partially absent	6
5.	Bases of wings red, costa green	*M. cincta.*
	Bases of wings orange, costa yellow	*M. leptomera.*
	Tegmina and wings colourless	*M. cruentata.*
6.	Colour vivid grass-green	*M. muta.*
	Colour dark	7
7.	Two obconical red black-edged marks on mesonotum	*M. cauta.*
	No such marks on mesonotum	8
8.	Conspicuous median stripe on abdomen only	*M. fuliginosa.*
	Stripe faint or absent	9
9.	Veins black, heavily marked	*M. nigra.*
	Veins normal	10
10.	Distinct pale median stripe on pronotum	*M. indistincta.*
	Pronotum practically concolorous	11
11.	Size larger, colour black, much pubescence	*M. quadricincta.*
	Size smaller, colour dark tawny, less pubescence	*M. iolanthe.*

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Supplementary Notes.

Since writing the above I have been enabled to read Distant's *Synonymic Catalogue of Homoptera*, pt. 1, *Cicadidae* (B.M.N.H., 1906), from which most of my synonymy was obtained through Mr. H. Ashton, of Sydney. The list includes, however, several items which need incorporating in the revision. It appears that, in the main, all Distant's conclusions are corroborated by New Zealand experience of the insects and of their bionomics. It should be noticed that *M. arche* Walk. is not synonymous with the New Zealand *M. scutellaris* Walk., as Kirby maintained. This conclusion of Distant therefore proves the endemicity of *M. scutellaris*, which had been impugned by Kirby's contention.

Melampsalta strepitans Kirk.—Reasons for following Kirkaldy in elevating *M. cingulata* var. *obscura* Huds. to the rank of a species under this name I have given at considerable length.

Melampsalta muta Fabr.—With regard to this species it must be emphatically maintained that it forms no part of *H. muta* Huds. in *Trans. N.Z. Inst.*, vol. 23, p. 51, 1891. Hudson consistently kept this species, under his name, *M. aprilina*, distinct from all the varieties of *M. cruentata* Fabr. (Hudson's *M. muta* and *M. cincta* Walk.).

Melampsalta quadricincta Walk.—It should be noted that there are still no further grounds than Walker's authority for believing that this, our common alpine cicada, occurs in Australia.

The following are additional notes on distribution and time of occurrence :—

Melampsalta cruentata Fabr.—The Dominion Museum possesses twelve specimens (two females and ten males) of the variety *subalpina* Huds., collected by W. L. Wallace, of the W. R. B. Oliver expedition to the Kermadecs in 1908. They were common on Sunday Island amongst ngaio (*Myoporum laetum*) from the end of August to March. Unlike the common form of *M. cruentata*, the variety *subalpina* is remarkably constant—a character well exhibited by the twelve museum specimens. It should be noted that, whereas the *angusta* form occurs in Australia (Goding and Froggatt, *Proc. Linn. Soc. N.S.W.*, vol. 29, p. 643, 1904), apparently the only form in the Kermadecs is variety *subalpina*.

In New Zealand itself the time of appearance of *M. cruentata* is evidently much earlier than previous records indicated. Mr. T. Cockcroft found a small dark male with the typical *cruentata* song on a bank with a northerly aspect at Upper Hutt on the 17th October, 1920. I have no records from the North Auckland district, where, judging from its appearance in August in the Kermadecs, it is probably much earlier.

Melampsalta muta Fabr.—This species was heard frequently, and a male was taken by T. Cockcroft as late as the 3rd June last season in Wellington. In the Wellington district, therefore, there are only three months during which cicadas have not been taken.

General Notes on Occurrence.

There are indications that this season's work will materially extend the known range, both seasonal and geographical, of the New Zealand cicadas. Judging from material in hand, it appears extremely probable that at least two more alpine species exist. These will be described at the end of the season, when more specimens are available. Meanwhile cicadas from all parts of the Dominion will be received and acknowledged with gratitude by the writer at the Biology Laboratories, Wellington. Already I am indebted to Messrs. Hamilton, Cockcroft, Roberts, Grimmett, Harris, Campbell, Lindsay, Philpott, Clark, and other indefatigable collectors, not to mention Mr. G. V. Hudson, who has always allowed me access to his own representative collection.

This supplement does not claim to bring our knowledge of the family in New Zealand up to date, as it is being sent to press in the middle of the season.

On Taxonomic Characters in the Cicadidae.

It has been suggested that the male genitalia will prove of great value in determining some of the difficult species (Kirkaldy, *Trans. N.Z. Inst.*, vol. 41, p. 28, 1909). The work of investigating the differences in genitalia is now in hand, and progressing as well as the paucity of material in the rarer species will allow. So far, however, our hopes have not been abundantly realized. Genital differences are often of the greatest value in separating genera ; but our cicadas belong, unfortunately, all to the same genus.

A Revision of Hutton's Plesiotypes in the Cicadidae.

Future workers on the family will find it difficult to follow Hutton's observations on the cicadas in his "Synopsis of the Hemiptera of New Zealand" (*Trans. N.Z. Inst.*, vol. 30, p. 167, 1898) without some knowledge of his plesiotypes. These, it is gratifying to learn, are being kept in their original arrangement at the Canterbury Museum, where the Curator kindly allowed me to examine them. The following species are represented :—

1. *Melampsalta scutellaris* Walk.—Two females are labelled correctly, and two other specimens appear over the name *M. dejecta* Huds.

2. *M. cingulata* Fabr.—Two typical examples.

3. *M. strepitans* Kirkaldy.—One specimen labelled correctly as *M. cingulata* var. *obscura* Huds., and one other wrongly identified as *M. mangu* F. B. White.

4. *M. cruentata* Fabr.—A long series of this common and difficult species is divided under the names *M. muta*, *M. cutora*, *M. cruentata*, and *M. angusta*. The *M. muta* series consists of specimens of *M. cruentata* var. *subalpina* Huds. It is interesting and rather puzzling to note that there is not a single true specimen of *M. muta* (*cutora*, or *cuterae*) in the collection. The Chatham Islands seem to possess a constant and well-marked variety of *M. cruentata*, represented here by six specimens, and characterized by a dark-ochreous ground-colour, marked extremely heavily with black. I shall have occasion elsewhere to mention the tendency towards melanism in the Chatham Island Hemiptera.

5. *M. cincta* Walk.—This species is represented by a number of typical specimens labelled *M. iolanthe*, and by a series of rather dark forms lacking the green costa and standing above the name *M. cincta*.

6. *M. quadricincta* Walk.—This is correctly labelled *M. nervosa* Stal, which falls into synonymy. There is another specimen unlabelled.

7. *M. iolanthe* Huds.—There is one unlabelled specimen.

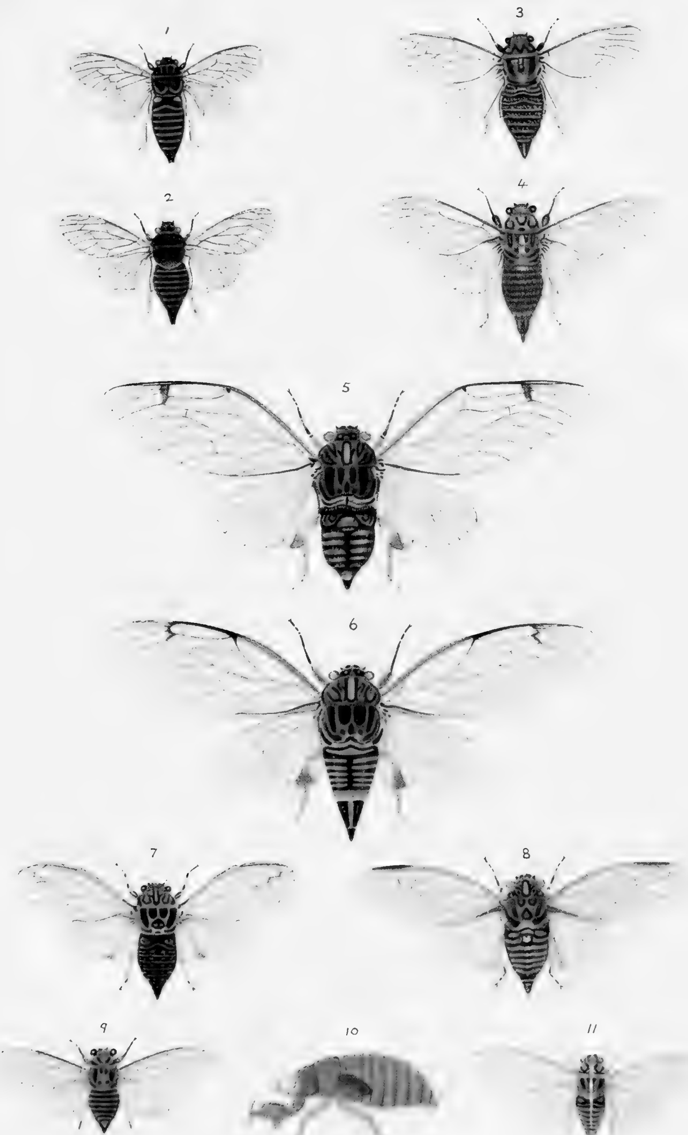
Explanation of Plate XLV.

Fig. 1.—*Melampsalta nigra* n. sp., male.
Fig. 2.—*Melampsalta nigra* n. sp., female.
Fig. 3.—*Melampsalta quadricincta* Walk., male.
Fig. 4.—*Melampsalta quadricincta* Walk., female.
Fig. 5.—*Melampsalta cingulata* Fabr., male.
Fig. 6.—*Melampsalta cingulata* Fabr., female.
Fig. 7.—*Melampsalta strepitans* Kirkaldy, male.
Fig. 8.—*Melampsalta cauta* n. sp., male.
Fig. 9.—*Melampsalta iolanthe* Huds., female.
Fig. 10.—Nymph of *Melampsalta cingulata.*
Fig. 11.—*Melampsalta cincta* Walk., male.

Explanation of Plate XLVI.

Fig. 1.—*Melampsalta leptomera* n. sp., female.
Fig. 2.—*Melampsalta fuliginosa* n. sp., female.
Fig. 3.—*Melampsalta scutellaris* Walk., male.
Fig. 4.—*Melampsalta scutellaris* Walk., female.
Fig. 5.—*Melampsalta muta* Fabr., male.
Fig. 6.—*Melampsalta muta* Fabr., female.
Fig. 7.—*Melampsalta indistincta* n. sp., male.
Fig. 8.—*Melampsalta indistincta* n. sp., female.
Fig. 9.—*Melampsalta cruentata* Fabr., male.
Fig. 10.—*Melampsalta cruentata* Fabr., female.
Fig. 11.—*Melampsalta cruentata* Fabr., red variety, male.
Fig. 12.—*Melampsalta cruentata* Fabr., var. *subalpina*, male.
Fig. 13.—*Melampsalta cruentata* Fabr., var. *subalpina*, female.

All figures natural size.



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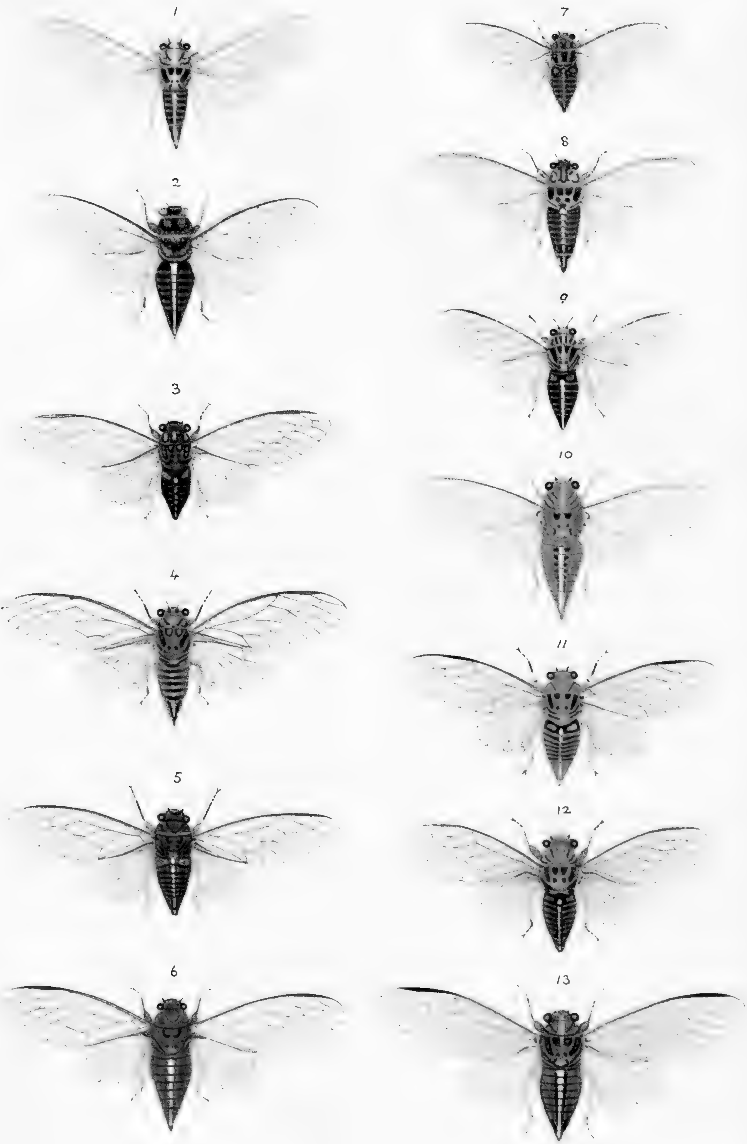

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Art. XXVIII.—*Bionomic Notes on some New Zealand Spiders, with a Plea for the Validity of the Species* Araneus orientalis *Urquhart.*

By John G. Myers, F.E.S.

[*Read before the Wellington Philosophical Society, 27th October, 1920 ; received by Editor. 31st December, 1920 ; issued separately, 20th July, 1921.*]

The following notes, representing some of the results of observations in the insectary and in the field, extending over a considerable period, are merely preliminary indications of the fact that our native spiders as well repay study as those more favoured French species immortalized by Fabre.

Hemicloea alacris de Dalmas.

Below the bark which fits closely on old logs and stumps are found the egg-cocoons of this species. In appearance each is a disc about 1 in. in diameter, adhering closely to the log, since it is not disturbed when the tight-covering bark is stripped off. An edging ot flocculent looser silk fastens it to the wood. On a closer examination the nest is found to be composed of two similar circular pieces of close-textured, smooth, white silk, fastened at the circumference and closely imprisoning the eggs, which are whitish in colour and, unlike those of many other species, non-adherent to one another. The young are white or colourless, with large swelling abdomina, dorsally convex, and thus offering a striking contrast to the thin bodies of the adults, which are dorsoventrally flattened to an extreme degree—an admirable adaptation to their life beneath the bark. It seems probable that the rounded abdomina of the young point to a descent from typical Drassids (Gnaphosids) with normal abdomina. When opened the nest is found to contain nothing in the nature of packing. Doubtless the soft bedding protecting the eggs of many other spiders is here rendered unnecessary by the sheltered position beneath the bark.

Other flat-bodied bark-spiders of the genus *Hemicloea* are frequently observed in the course of entomological field-work, but only this species, with its egg-cocoon, has been determined with certainty.

Argiope protensa L. Koch.

This striking and handsome species haunts low herbage and rushes, among which its egg-cocoon may be found in February and March. It is suspended by a loose envelope of white fluffy silk in which the cocoon is supported by stays in several directions. The cocoon itself, with a length of ½ in., is cylindrical, rounded at the bottom, with a flat and dilated top. Its material is very close-textured lustrous silk, bearing a considerable resemblance to the case-stuff of the bag-moth (*Oeceticus omnivorus*), but exhibiting a much smoother surface. Its attractive appearance is heightened by its colours of greenish-white below, merging into a dark greenish-brown above, where the flat top with its crenate edges resembles, and probably functions as, a lid. As is almost invariably the case, the nest, at least in captivity, is built in a single night.

Chiracanthium stratioticum L. Koch.

Until recently the study of spiders in New Zealand has been almost entirely neglected ; and, since I was unable to ascertain the scientific name of this species, I knew it as "the brown manuka-spider," a name still used when Latin polysyllables sound toc pedantic. The retreat is a den of transparent silk in a spray of leafy manuka. This retreat is fairly large, built of smooth, white silk, and has only one opening—a neat circular hole —near which sits the spider, her front legs on the edge of the orifice, ready for prey. I kept a specimen for several weeks. Once she caught a house-fly by chase, unaided by silk either to entangle the prey or to swathe it, as does the *Epeira* (*Araneus*). However, she had stretched entanglements of fine non-adhesive silk near the den, and flies were caught in these ; but in no case were the flies rolled up in silk, *Epeira*-fashion. The wings and head were disjointed or torn off.

The Nest.—I have found this in March. Several nearly parallel manuka-twigs are bound together to form a rough cylinder, by a sheet of stiff white silk of very close texture. Both the top and the bottom of the cylinder (length 1·2 in.) are flat and closely covered with the same material. However, this close, opaque sheeting is interrupted, both above and below, by a small window of jagged outline, covered with silk so thin as to be quite transparent and thus serve the purpose of a pane of glass. These are the loopholes of the fortress, at which, either at top or bottom, the self-immuned spider is usually to be seen watching. Disturb the window with a twig, and the wildly waving legs of the female spider are immediately perceived, just below the transparent covering. Thus might the ingress of an insect enemy easily be prevented. Thirteen approximately parallel twigs are incorporated in the structure of the cylinder-walls, and act as strengthening-pillars. Between two of these uprights I cut the fabric longitudinally, to expose the contents of the nest. No sooner was a slit made than the head of the spider, with extended chelicerae, appeared in the opening, ready to repel invasion. A pen offered to her was attacked with great fury, the spider attempting to seize the point with her very long and slender fangs. She had presumably been a considerable time in the nest without food, her abdomen being small and shrivelled, scarcely a third the size of a specimen of equal age but lacking a nest. The egg-ball was approximately spherical, and was bound tightly to the side of the nest by a silken envelope, which also kept together the very large yellow eggs. I had kept this nest for a week without opening it, and in that time the spider did not emerge from the nest. I consider it probable that the female of this species remains self-imprisoned with her eggs to guard them until they hatch, when she probably dies. However, I found a nest on the 22nd March which contained young, the mother being still shut in with them, and exhibiting great activity in their defence.

Philodromus rubrofrontus Urquhart.

Of this species the generic position is uncertain, but fairly abundant material is in hand for determining it. The spider itself is easily recognized by Urquhart's description. This crab-spider inhabits manuka-bushes, where its green colour renders it almost invisible. The nest, formed by joining leafy manuka-twigs with silk and covering the resulting oval with criss-crossed threads of fine, shining white silk, is about 1 in. long by $\frac{3}{4}$ in, wide. There is one fairly round opening on one side, clear of silk and leaves, but with these materials forming a network a short distance in front of it, so that an intruder would thread the maze and discover the entrance only with the greatest difficulty. With scissors I carefully cut away this labyrinth and widened the entrance; then cut down the side and spread out the nest book-wise. On one side, down the length of the nest was an irregular mass of white faintly green-tinged eggs, surrounded by a silk sheet which bound them tightly to the main fabric. Unlike those of some spiders, the eggs were not mutually adhesive, but fell apart when their enclosing silk was loosened. The female crouched near by. Another nest contained young spiders in company with their mother.

Genus Araneus (Epeira).

Of the common spiders with which I propose to deal here, we come now to this fascinating genus, the garden-spider. The following key will serve to distinguish the egg-cocoons of the commoner members of the genus:—

Covering, flocculent silk; shape hemispherical—
- Colour greenish .. .. *A. pustulosus* Walck.
- Colour orange .. .. *A. brouni* Urq.
- Colour white .. .. *A. saxitalis* Urq.

Covering, smooth, white, close-textured silk; shape irregular, varying with exigencies of position .. .. .. *A. crassus* Walck.

Araneus brouni Urquhart.

This species is the largest *Epeira* in the Wanganui district, and, as most specimens show a more or less distinct crescent on the surface of the abdomen, near the cephalothorax, I call it the "crescent *Epeira*." A nest was built in captivity in a single night in February. The ball of salmon-pink eggs was covered and securely fastened to the side of the jar and to a stick by a soft, thick layer of downy silk which was in parts white and in parts orange. This orange colour was not due to the tint of the eggs showing through the silk. The female was, naturally, much decreased in bulk, was very lethargic, taking no food, so that I thought her work was done and she was about to die. After three days' abstinence, however, she ate daily and well. In twenty-seven days from the time of laying the eggs hatched, and on the same morning I found the mother dead. It would be interesting to know whether she had performed some last office, such as opening the cocoon for the young. The young remained in the same position in the nest and displayed but little signs of life until disturbed, when the whole living ball pulsated in a queer manner, owing to the individual struggles of the minute spiders. In sixteen days from the time of hatching—that is, in the middle of March—the young left the nest. The details of this exodus resemble those so graphically described by Fabre in *The Life of the Spider* (English translation). In the early morning or previous night the young spiders had swarmed out of the perforated lid of their jar and were scattered over a film-like web fastened at several points to the wall above the nest The web was 3 ft. high, and extended irregularly laterally for nearly 4 ft. When touched the tiny spiders immediately dropped, but rapidly climbed to their former positions up the thread they had produced in their descent. Next day some still remained in the jar, but the nest itself was deserted. The web was widened considerably towards the open door of the shed in which the spider was kept, and the young spiders were gradually moving farther from the nest, toward the light. On the 19th March the spiders were, for the most part, about 6 in. farther from the nest than on the 17th, but still a few stragglers remained in the jar. On the 23rd, seven days after first leaving the nest, all had left the jar, and not a single spider was in sight. All their movements had taken place at night: during the day they had maintained the same positions in the web; and yet they all moved toward the light of the open doorway.

Summary of Life-history of Araneus brouni.—2nd February, nest built and eggs laid; 1st March, young hatched, mother died; 16th March, young left nest; 17th, some still in jar near nest; 18th, moving farther from nest; 19th some not yet left jar; 23rd, not a spider in sight.

Araneus pustulosus Walck.

This is throughout the country one of the commonest Epeirids, exhibiting a truly surprising variation in colouring and size, but always recognized by, among other characters, the black ventral quadrangular area on the abdomen, with the corners marked in white, and by the group of five posterior prominences.

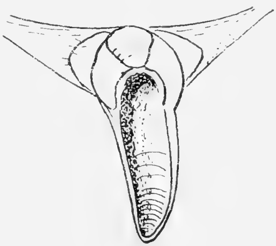
A captive female built, as usual, in one night a nest in the form of a hemispheric dome of soft, dark greyish-green silk, covering a ball of pink eggs, and itself confined by a transparent veil composed of loose but strong strands of fluffy reddish silk, serving to fasten the whole nest to a support. The outer veil is too thin to affect the general grey-green hue. In this case the flat base of the dome was attached to the lid of the jar. The spider had shrunk in size, but was as active and fed as well as before. In about seventeen days after laying, the eggs hatched; but two days before, to my intense surprise, the old spider built a second nest upon the first. The young of the first nest dispersed in the usual manner, and the second batch of eggs hatched in about twenty days. This, however, was not to be the end, for nine days after these had hatched the indefatigable spider constructed a third nest, joined to the other two, and containing the usual ball of pink eggs. I think this is an unusual procedure—the making of three separate nests containing fertile eggs, within a few weeks of one another, the female being enclosed the whole time, without any possibility of communication with a male; but there is nothing to show that it may not be a normal occurrence, since nests built in contiguity or even one on another are by no means rare.

Araneus orientalis Urquhart.

With regard to this very beautiful species, de Dalmas maintains, probably correctly, that the male described under this name by Urquhart is really that of *Araneus brouni;* but I wish to point out that the female of *A. orientalis* is indubitably a distinct species, however much the males may have been confused. This conclusion is based on the following bionomic and morphological characters:—

The nest, built in captivity in a single night, is almost exactly like that of *A. pustulosus*, but is slightly larger and rather more than a hemisphere. Its silk is dark grey-green in colour, quite different from the flaming orange fabric of *A. brouni.* The flat base is built on a foundation of strong white silk. The female spider which constructed this nest agreed in every detail with the description of *A. orientalis* (female) of Urquhart. In addition, after nest-building she regained her appetite and recovered completely, after the manner of *A. pustulosus*, but contrary to the ascertained habit of *A. brouni*. From the much commoner *A. pustulosus*, *A. orientalis* is readily distinguished by her heavily annulated legs and the two pronounced antero-dorsal prominences of the abdomen, in both of which characters she approaches *A. brouni*. She differs from both in the almost complete absence of a posterior prominence.

With regard to the epigyne, Urquhart (*Trans. N.Z. Inst.*, vol. 20, p. 121, 1888) gives the following description: "In mature examples a black, somewhat oval, rather pointed, deep-margined lip about half as broad as long, one-fourth longer than breadth of vulva, projects backwards from beneath the semi-pendulous process of the corpus vulvae." Three mature females have been carefully examined, and the external genitalia found to agree substantially with Urquhart's description. The long grooved lip is especially noticeable and very distinct from anything possessed by *A. brouni* or *A. pustulosus*. The parts are a deep, shining black. (See figure.)



Araneus orientalis: ♀ Epigyne. × 18.

While the pattern of the abdomen seems constant, the ground-colour may be a deep velvey reddish or an equally lustrous green, the whole effect rendering Urquhart's name singularly appropriate. Recent experience also has corroborated Urquhart's statements both with regard to the subglobose, dark-green cocoon, and the scanty irregularity of the web. The male has not yet been found. Mature females occurred at Wanganui in March and early April.

Araneus crassus Walck.

This exceedingly common species exhibits several well-marked varieties, all easily recognizable by the genital palp of the male and the epigyne of the female, both well figured by de Dalmas. A variety with tesselated abdomen and a transverse dorsal bar of china-white is exceptionally handsome.

The egg-cocoons may be found abundantly in late autumn. Dead twigs, branching finely, may be incorporated in an angular capsule of smooth, white, very tough silk, about ¾ in. in greatest length, containing the eggs surrounded by soft flocculent silk. Outside the cocoon is an entanglement of fine light lines, sometimes extending in every direction for 3 in. Unlike most Epeirids, the mother, extremely shrunk after laying, may often be seen crouching on the cocoon, in defence of which she will bestir herself with unexpected vigour. Whole leaves may be joined and covered with silk to form a portion of the nest, which owes its irregularity to these chance supports.

General Notes.

The drone-fly (*Evistalis tenax*) was eaten with the greatest willingness by *Araneus pustulosus* and by other species, in captivity and in the field. This experiment is not, however, important, as both the fly and the bee which it is supposed to mimic are introduced; and, in any case, bees are sometimes caught by spiders, though they are handled with great caution.

On the same subject of mimicry and warning coloration the following experiments offer more interest:—

Araneus brouni in captivity repeatedly refused *Nyctemera annulata*, the black-and-yellow day-flying Hypsid moth. The same moth was rejected time after time by the large hunting-spider, *Dolomedes imperiosus* (*minor*) L. Koch. It is suggestive that both these spiders ate readily many other moths, from Pyralids to Porinae. The following experiment was tried on a free specimen of *Araneus brouni* in its fully-formed web between two rose-bushes. By lamp-light, in the evening, I placed in its web the following live moths: first *Nyctemera annulata*, then *Declana floccosa*, and lastly *Rhapsa scotosialis*—all fair-sized moths. The spider sprang on each in turn and first applied its chelicerae, without discriminating between the moths. Then the victims were rotated and swathed in silk in the usual way, the three cylindrical parcels thus obtained being left hanging in the parts of the web where they had each been caught. The untimely destruction of the web prevented my ascertaining whether all these moths were finally eaten.

Spiders, owing to the ease with which they may be induced to build their nests in captivity, and the many unexpected peculiarities of habit which they display, should become favourite objects of study to those interested in the life-processes of the lower animals.

In conclusion, I should like to express my thanks to the Comte de Dalmas, of Paris, and to Mr. E. K. Lomas, for their invaluable assistance in the identification of specimens and in the procuring of spider literature. *Araignées de Nouvelle-Zélande* (*Ann. Soc. Ent. de France*), by Comte de Dalmas, is indispensable. To Professor H. B. Kirk and Mr Lomas I am indebted for reading the manuscript.

Art. XXIX.—*Notes on the Hemiptera of the Kermadec Islands, with an Addition to the Hemiptera Fauna of the New Zealand Subregion.*

By John G. Myers, F.E.S.

Read before the Wellington Philosophical Society, 27th October, 1920; received by Editor, 31st December, 1920; issued separately, 20th July, 1921.]

Though the kindness of the Dominion Museum authorities I have been enabled to examine a small collection of Hemiptera made in the Kermadecs during 1908 by W. L. Wallace, of the W. R. B. Oliver expedition. Of the eight species represented, one is not in a condition to be determined with accuracy; one is pelagic, with a wide distribution in the Pacific; one is common to Australia and New Zealand, though rare in the latter; one is probably new; while all the rest are New Zealand species.

Suborder HETEROPTERA

Family CIMICIDAE.

1. **Glaucias amyoti** White.

"Two specimens found on Denham Bay beach" (Sunday Island).

This handsome species is common in Australia, but rare in New Zealand.

Family NABIDAE.

2. **Reduviolus saundersi** F. B. White.

"Taken amongst weeds, Denham Bay. . . . Found preying on other insects."

This species has a fairly wide distribution in New Zealand.

Family GERRIDAE.

3. **Halobates sericeus** Esch.

Eighteen specimens—six females and twelve males—were found on Denham Bay beach after a heavy storm at sea. This is the first recorded occurrence of the extremely interesting pelagic genus *Halobates* Esch. in the waters of the New Zealand subregion. How far these specimens were brought from their usual habitat by the storm is, of course, uncertain, but this species is pre-emiently that of the North Pacific.

Family CAPSIDAE.

4. Two unidentifiable specimens, apparently of same species.

Suborder HOMOPTERA.

Family CICADIDAE.

5. **Melampsalta cruentata** Fabr. var. **subalpina** Huds.

This cicada was found commonly amongst ngaio (*Myoporum laetum*). The twelve specimens, of which ten are males and two females, are very typical of the variety, and exhibit surprisingly little variation among themselves. It is impossible to separate them from specimens caught in the neighbourhood of Wellington.

Family FULGORIDAE.

6. **Aka finitima** Walk.

This, or a closely allied species, was common on the under-surface of leaves of nikau-palm (*Rhopalostylis Baueri*). As it is represented in the collection by nymphs only, the specific identity cannot be determined with any degree of certainty.

In addition to the species in the above list, there are specimens of a green Jassid found also in New Zealand, and of a Delphacid, both of which are in the hands of Mr. F. Muir, of Honolulu, who has kindly consented to determine them.

Since writing the above I have been informed by Mr. Muir that the Delphacid possibly represents a new genus allied to *Micromasoria* Kirkaldy; but the unique specimen is scarcely perfect enough for description.

Art. XXX.—*Notes on the Blepharoceridae (Diptera) of New Zealand.*

By J. W. Campbell.

[*Read before the Philosophical Institute of Canterbury, 4th November, 1920; received by Editor, 31st December, 1920: issued separately, 20th July, 1921.*]

Attention was first drawn to the occurrence of Blepharoceridae in New Zealand by Dr. Charles Chilton (1906), who described a larva which he pointed out closely resembled that of *Curupira torrentium* F. Müll. Seven years later Mr. C. G. Lamb (1913), of Clare College, Cambridge, described, from material supplied by Mr. G. V. Hudson, two new genera and species of Blepharocerid flies. The first of these, of which only males were known, was called *Neocurupira hudsoni*, and the second, which was represented by both sexes (the females immature), was named *Peritheates turrifer*. In the following year Professor Mario Bezzi (1914) published descriptions of three larvae which he had received from Dr. Chilton. He designated them larva A, larva B, and larva C, the first of which was identical with Dr. Chilton's "larva ? *Curupira*," and "probably *Neocurupira hudsoni* Lamb." (Bezzi, 1914, p. 118.)

In November, 1919, Mr. W. G. Howes, of Dunedin, and the present writer took specimens of a third fly, intermediate in size between the two described by Lamb, while in December of this year Mr. T. R. Harris, of Ohakune, captured a fourth. These two flies are described in this article, some notes on larval forms being also given.

There seems to be some uncertainty as to which of the larvae A, B, and C belong to the two flies described by Lamb. Bezzi associated *Neocurupira hudsoni* Lamb with larva A, and *Peritheates turrifer* with larva C, leaving larva B unrepresented in the imago. He writes, "The first of the two genera described by Lamb, called *Neocurupira*, belongs to my second subfamily Paltostominae, and apparently differs only in the much longer proboscis from the Brazilian *Curupira*. But I have already shown how this character is an uncertain one, while both the characters of the *assumed larvae* [the italics are mine] show the dorsal covering to have a greater number of spines than in *Curupira*, where they are inserted on special tubercles. The new species *Neocurupira hudsoni* Lamb, on account of its colour, aspect, and dimensions, closely corresponds with *Curupira torrentium* and other allied forms in Brazil." (Bezzi, 1914, p. 116.) Referring to the larvae, he says (p. 117), "One of them I believe is certainly related to *Neocurupira*, while the other two belong to the Apistomyinae, and the smaller of these is *Peritheates*." He continues (p. 118), "I shall therefore call the first larva A, which apparently belongs to the group *Curupira* in possessing dorsal spines and tracheal gills not arranged in tufts"; and further (p. 119), "In proportion this larva is much larger than the others." Larvae B and C he describes as with "dorsum unarmed and bare" (p. 122–23).

My own observations on these larvae are that all three have a dorsal armature with special tubercles corresponding in number and position on their respective segments—*i.e.*, 12 cephalothoracic, 14 on each body-segment, and 18 on the double 6th segment. The primary spines on A are large, sharp, and black in colour; those on B and C are transparent and cone-shaped. The larva B is larger than the others, as it should be if it is, as I suspect, related to *N. hudsoni.*

Bezzi describes the gills of the larvae as follows: Larva A—"Tracheal gills in single series, those of the anal clump distinct" (1914, p. 118). Mr. D. Miller, who has translated Bezzi's useful paper,* after examining Dr. Chilton's specimens says, "Not distinct, apparently six in number." Larva B—"Tracheal gills forming a small indistinct tuft near the anterior margin of the segment, those of the anal tuft apparently distinct" (p. 118). Larva C—"Suckers large, while the tracheal gills placed on the anterior margin of the segment are small but distinctly visible" (p. 124).

Bezzi was not quite certain about the gills, and he makes no note of other important characters; but this can be understood, as his specimens appear to have dried up. His description of the tracheal gills of *Curupira* is: "Tracheal gills not arranged in tufts, but forming 2 rows running from the anterior to the posterior margin of the segment, one on the right, the other on the left of the sucker, consisting of from 6 to 8 gills in each row; anal tuft composed of 4 branches, antennae very short, 2-jointed, lateral processes simple but very short, dorsum bearing powerful spines." (Bezzi, 1913, p. 76.) In *C. torrentium* there are 8 tracheal gills in each row.

Excepting the number of dorsal spines, this arrangement agrees fairly closely with that found in larva A. Moreover, a comparison of figs. 1 to 27 will show that in the form of the dorsal spines and the arrangement of the

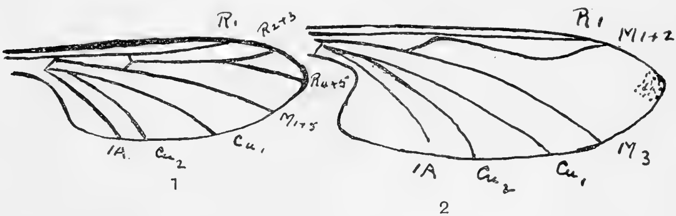


FIG. A.—1. Wing of *Curupira torrentium* (F. Müll.), (after Bezzi).
2. Wing of *Apistomyia elegans* (Big.), ♀.

tracheal gills larva A stands apart from larvae B and C, which resemble each other in dorsal armature, but differ in the form of the *lateral* processes (figs. 38–40) and in the number and arrangement of the gills. Larva A apparently belongs to the Paltostominae, and larvae B and C to the Apistomyinae.

To turn now to the imagines: Bezzi gives a diagram of the wing of *Curupira torrentium* F. Müll. (see fig. A, 1, of this article) which shows this

* Mr. Miller's manuscript translation is deposited in the Dominion Museum, Wellington.

wing to be very different from *N. hudsoni* Lamb in the form of the anal angle of the wing and the radial fork, while the form of the anal angle of the wing of *N. hudsoni* is similar to that of *Apistomyia elegans* (fig. A, 2), though the radial fork shows a different stage in reduction in these two forms. Bezzi has also pointed out (1913, p. 68) the close resemblance of *Apistomyia elegans* to *Apistomyia collini* from Australia. Further, the subcostal vein is evanescent in *P. turrifer* (figs. 48 and 53); it is small in *N. hudsoni* (figs. 44 and 50); and is still well developed in the first new species about to be described (figs. 47 and 52). All these characters in the venation, and the larval characters, require, in my opinion, that *N. hudsoni* and *P. turrifer* be placed in the Apistomyinae, while the new fly, herein described under the name *Curupira chiltoni*, should be placed in the Paltostominae. Moreover, the larva A of Bezzi is a Paltostomid, and is, I believe, that of *Curupira chiltoni*, while larvae B and C, being Apistomyids, belong respectively to *N. hudsoni* (or a similar fly) and *P. turrifer*. Support is given to these relationships by the distribution of the larvae and imagines—*e.g.*, in a stream at Purau *Peritheates* and larva C are found together with *Curupira chiltoni* and larva A, but I have never taken either larva B or *N. hudsoni*. I hope, however, to confirm or disprove the suggested relationships, at least of larvae A and C, during the coming season.

Referring, in a letter to the author, to the position as stated so far, Professor Bezzi points out that there may be other larvae more nearly approaching his description of B and C—*i.e.*, "dorsum unarmed and bare"—and that other Paltostomid flies may be found The discovery of the fourth fly from Ohakune has in at least one respect confirmed Professor Bezzi's opinion. This fly closely resembles *N. hudsoni* Lamb, but the vein R has lost its fork, and the wing is smaller. The assumed larva (from Ohakune) of this fly, which I propose to name *Apistomyia harrisi*, closely resembles the Otira larvae, which I take to be those of *N. hudsoni*. I have also from Queenstown a Blepharocerid larva (fig. 29) which has distinct characters, and is probably a closely related but undiscovered fly.

Returning again to Bezzi's figure of *Apistomyia elegans* (fig. A, 2), it should be noted that Bezzi's enumeration differs from that used in this paper. His M_{1+2} is R_3; R_2 has disappeared; the basal portion of his M_{1+2}, up to where it touches R_1, is really part of R_{4+5}; M_{1+2} is not represented, except that basal part marked M and *r–m* (fig. 46). The lost veins are dotted. This appears to be confirmed by the primitive wing-venation of *Edwardsina chilensis* Alexander; and, furthermore, fig. 49 shows the bases of insertion of the macrotrichia of R_{2+3} on the wing-membrane of *A. harrisi*. If *N. hudsoni* and *P. turrifer* be Apistomyids, we have, with *A. harrisi* n. sp., three distinct stages in wing-reduction in this ancient subfamily.

Curupira chiltoni n. sp. (Figs. 55 to 75.)

Head: Vertex small, finely pubescent, occupied by the large ocellar turret, around which is a number of stiff bristles. One ocellus anterior, the other two placed laterally. Space between the eyes projecting out to form the raised keel described by Lamb. This space is narrower in the ♂, and in both sexes appears broader as it approaches the base of the labrum Eyes hairy, dichoptic, bisected in both sexes, upper eye-facets larger.

A single hair arises from each angle of the hexagons (fig. 65). Labrum and hypopharynx as in fig. B. Internally the labrum bears strong single, double, and triple spines turned back from the point of the strong beak. This seems to suggest that our Blepharocerids may prey on other insects, otherwise this armature seems unnecessary (fig. 70). Mandibles present in ♀ (fig 69), absent in ♂. Maxillae present in ♂ (fig. 64), absent in ♀ (figs. 69 and 74). Labium (fig. 57) long, geniculate, divaricate. Antennae (figs. 62, 71, and 72) usually 14-jointed. Palpi (figs. 63 and 73) short, 2-jointed.

Thorax of normal form for the family, microscopically pubescent, with a definite chaetotaxy. Halteres long-stalked.

Legs (fig. 83): Relative dimensions and characters as in *P. turrifer*, two spurs on tibiae of hind legs, claws simple, empodium rudimentary. The colour-scheme is black, with a silvery-grey appearance, probably due to light-effects. Slight orange colour near the humeral knobs and wing-bases, legs lighter in colour on the trochanters and bases of the femora.

Wings (fig. 47) ground-glassy in appearance with dark veins, anal angle obtuse as in *Curupira*, membrane covered with fine microtrichia. Costa covered with strong macrotrichia, as many as 9 in the rows, corresponding to the primitive veinlets. From the margin of the wing just beyond R_3

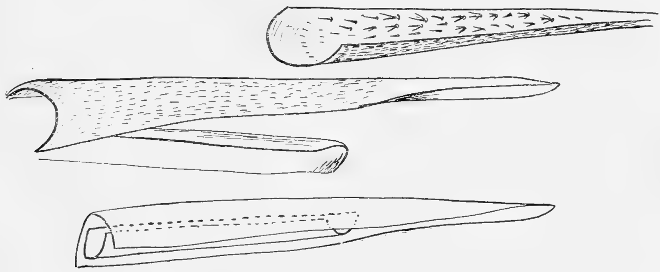


FIG. B.—Labrum and hypopharynx of *C. chiltoni*, ♂.

fine cilia continue round the wing to the base. The cilia increase in length as they approach the angle. Reduced Sc is more strongly marked than in the other three flies. Some of the bases of insertion of the macrotrichia still carry the spines. R_1 is a simple vein; R_{2+3} forms a fork; both R_2 and R_3 turn upward near the margin. M fuses with the angle of R_{4+5}, picking up the original *r–m* in the fusion. Cu_1 arises as a strong vein, fuses with the persistent fourth branch of M, forming a fork. The last vein is 1A or 2A. Here again I have taken the wing of *Edwardsina chilensis* (Alexander) as an indication of the lines of reduction. All four wings show the signs of reduction, making an interesting series, which may be clearly seen in the region of R_{4+5}, and to which I have referred previously in regard to the persistent bases of the macrotrichia.

Abdomen (figs. 86 and 87): ♂ with the characteristic laterally compressed and turned-up appearance; ♀ larger, round, and tapering. Body-segments with scattered bristles, more numerous near the margins of the segments. Ventrally on each segment are three groups of bristles (about 12–15 in each) forming a triangle with the apex anterior (figs. 88 and 89).

Hypopygium: ♂ as in fig. 93, ♀ as in fig. 94.

Loc.—Otira; Banks Peninsula, Purau.

Type in my collection.

Apistomyia harrisi n. sp. (Figs. 96 to 109.)

Head (figs. 97 and 98) with large and prominent turret. Eyes bisected and dichoptic in both sexes, upper eyes small, occupying about $\frac{1}{4}$ of the whole eye. Antennae 12-jointed. Labrum (figs. 99 and 101) sharply pointed, distinctly hairy, and terminating in a strong short spine. Internally the same type of barbs turned back from the point as in *C. chiltoni.* Hypopharynx (figs. 101 and 102) short, thick, and grooved. Maxillae (fig. 96) present in ♂, mandibles present in ♀. Labium (figs. 97, 108, and 109) long, geniculate, and divaricate, more strongly setose than in the other three flies, the labella show pronounced sensory organs at the tips. The labella of the ♀ are shorter and abruptly tapering at the tip (fig. 109).

Thorax (fig. 115) normal, finely pubescent, chaetotaxy definite. Halteres long-stalked and pear-shaped. Legs of the characteristic type, hind femora long, tibial spines large, rather longer and thinner than in *N. hudsoni.* Legs of ♀ proportionately shorter than in the ♂.

Wings (figs. 45 and 46): Wing of ♀ larger than that of ♂ (the dotted lines show the primitive position of the absent veins). Fig. 49 shows the bases of the macrotrichia near the cross-piece of R_{4+5}. No other wing in these flies has been noticed with the bases of the macrotrichia in this position.

Abdomen with scattered hairs on each segment, with the groups of hairs ventrally as in *C. chiltoni.* In the ♂ it is laterally compressed and turned up at the end; in ♀ it is cylindrical, tapering posteriorly. Hypopygium in the ♂ of the same type as *C. chiltoni*, claspers long and bristly. The ♀ hypopygium has broad laminae, and the area surrounding the ovipositor is covered with a number of large and long tubercles, from the centre of which projects a stiff blunt short spine. Laterally two short hairy processes project from the last segment, armed at the tips with the same type of tubercle and spine.

Colour: The general colour is grey to black. Thorax a deep black dorsally. The mesothoracic suture is interrupted; the middle third of the V of the tipulids is absent. Bezzi quotes Osten Sacken (1913, p. 89), "thoracic suture distinct, not interrupted in the middle," and refers to the importance of this character (1914, p. 89). In *C. chiltoni* and *A. harrisi* the lateral margins are yellow, and the yellow shows as a trident-shaped marking in fresh specimens between the lateral prominences of the scutellum of the mesothorax (fig. 115). Darker markings show round the junction of the femora and trochanters.

Loc.—Ohakune, North Island.

Type in my collection.

Larva of *A. harrisi.*—The Ohakune larvae, which I take to be those of *A. harrisi*, have similar characters to the Otira larvae (? *N. hudsoni*), but in all stages the latter is the larger. In colour dorsally there is little to choose between them, both being uniformly dark-coloured. Ventrally, however, the Ohakune larvae are lighter in colour. The gill-filaments increase in number with the age of the larvae, stages with 2, 4, and 7 filaments having been observed. Edwards (1915, p. 208) has noted a similar increase in *Elporia barnardi.*

NOTES ON EGGS, LARVAE, AND PUPAE.

Eggs. (Figs. 84 and 85.)

Slide specimens of the adult female *C. chiltoni* show the elliptical egg, contrasting with the egg of *Bibio johannis,* which is cylindrical with abruptly rounded ends. The egg-membrane and the granulated contents separate in slide preparations, and the membrane appears covered with round bosses, corresponding to the developing external layer of cells of the egg. Eggs that I have found adhering to the underside of stones in a creek are brown in colour. During the last stages they show distinctly darker on one side. With a good top lighting, low powers show that the dark side is the dorsum of the contained larva. Each segment has 4 spines, and the antennae and the central plate of the cephalon are clearly discerned. The light side shows the 6 circular dark rings of the suckers and the faint outline of the lateral processes. No evidence is available as to how the

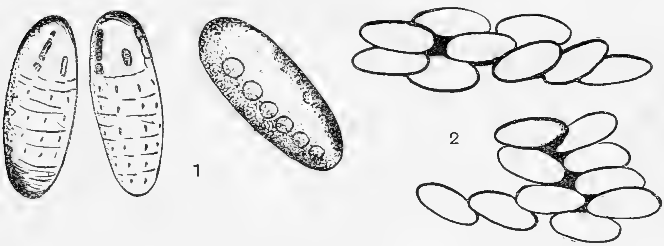


FIG. C.—Blepharocerid eggs. 1. Showing patches of eggs. 2. Magnified to show developing larva.

fly places the eggs on the stones beneath the water. Freshly emerged larvae appear to have only the anal set of gills ; the next stage includes the addition of one gill on each side for the other segments, and the total number of gills is reached before the last moult. Spines and gills increase during the moulting stages. Further search has confirmed my opinion in regard to Purau Creek. The Blepharocerid there is *C. chiltoni,* and after careful search I failed to get a single specimen of *turrifer.* The flies have a habit of sitting on the stones with the long hind legs touching the margin of the running water. With each increase of the flow of the water the fly will be pushed up about $\frac{1}{4}$ in. or more, but each time the fly merely backs down to the original position. It seems probable that the female dives under to lay; otherwise it seems difficult to account for the eggs adhering in patches, at depths far beyond the reach of the insect.

Larvae.

Head (fig. D): Bezzi (1914, pp. 119, 122, 123) describes the colour-scheme of the frontal spot on all three larvae. The frontal spot is a special plate forming the dorsal prominence of the cephalon. It is subquadrate, rounded posteriorly, the lateral portions separated from the remainder of the segment by well-defined connecting membrane. In the centre lies a definite separate elliptical plate, placed longitudinally, tapering sharply at the ends, and suggesting some relation to the process of pupation, or moulting stages of the larvae (fig. 125).

Dorsal armature (figs. 1 to 37): In addition to the primary spiny armature, all three larvae bear numerous spines, ranging from a minute single hair, or a group of single hairs (palmate), through the type of cone or double cone, up to the many varied types of fan-shaped spines. A study of these spines strongly suggests an evolutionary series. The largest fan spines range themselves in rows near the anterior margins of the segments and form groups near the base of the lateral processess. Each

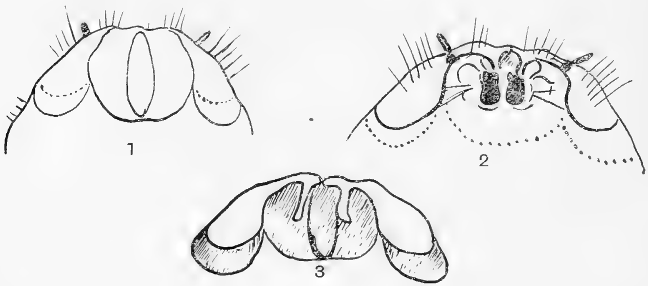


Fig. D.—Cephalon (diagrammatic) of larva. 1. (Dorsal) showing central plate. 2. (Ventral) showing mouth-parts. 3. (Ventral) showing relation of dorsal and ventral portions.

segment has also many special flat cells or groups of cells scattered over the dorsum (figs 117 to 121), and these also are arranged in rows near the outer portion of the anterior margins of the segments. Larva B has a thickly-scattered armature of transparent fan spines, and these approximate so closely to the main armature in size in many cases that it is difficult to pick out the cones from the fans (fig. 119). The integument on all three larvae shows a well-defined zigzag appearance. At the margins of the segments this resolves into the scale-like minute processes of the integument (fig. 120). A view along the margin shows them V-shaped or W-shaped like the teeth of a saw. In *B. johannis* the scale processes have a minute terminal spine. I can detect no terminal spine on these processes in the Blepharocerid larvae. The three types of lateral processes (figs. 38 to 40) are distinct in their form and in the type of the spines or hairs connected with each.

Posterior marginal spines (figs. 41 to 43): Larva A averages 40 spines in a double row laterally, merging to a single row towards the centre of the margin. Larva B has about 30 spines in a single row, as also has larva C.

In A and C there is a secondary ventral row of about 10 spines, and in B there is a secondary row of about 30 spines. In all three the secondary spines are short and stout.

Gills (figs. 10, 11, 12): Larva A has 7 gills in a series on each segment (2 double gills, 1 single proclinate, then a space followed by 2 single reclinate gills). The 4 anal gills are large. Larva B has 7 gills in a tuft on the anterior margin of each segment (2 double and 3 single), the anal gills large. Larva C has 4 gills in series on the anterior portion of the segments (1 double and 2 single), the anal gills large. In all three larvae the two posterior of the anal gills are only one-third the size of the anterior ones. The anal aperture is just in front of the point of attachment of the anal gills, which lie in a semicircular depression between the sucker and the posterior margin of the segment.

Suckers (figs. 122 to 129): The cup of the disc shows fine lines running to the margin of the suckers (fig. 122), where a specialized rim intervenes, the cilia from this point continuing from a rounded basis and tapering to a fine point. The rim shows an irregular pavement appearance, and viewed on cross-section (fig. 123) shows the vertical short pieces of the rim formation. The sucker has 6 tracheal (?) apertures (fig. 130), and the anterior margin has a specialized valve gateway (fig. 127). Underlying the disc appears a fine transparent pellicle showing very fine marginal cilia. Palmate hairs, similar to the type found on Culicid larvae, are found near the suckers.

Mouth-parts (figs. 131 to 137): The mandibles are large, black, and bidentate, the tips of the cusps transparent. The maxillae are complex and difficult to determine; they are densely hairy, with a biting-area bearing small cusps. The labrum bears 2 strong spines on its broad base, and tapers distally as a long brush lying between the mandibles. The labium is short, densely hairy, and subtriangular; the palpi appear as 2 small oval buttons marked with 2 large round black spots with 6 or 7 small dots between them. The palpi and maxillae, and perhaps the mandibles, have brushes or bunches of hairs, but the general crowding-together of hairs makes definition extremely difficult from whole (slide) specimens. The mouth-parts are set in a depression bounded anteriorly by a raised rim, behind which lies the base of the labrum. Darkly chitinized lateral boundaries show prominently, and carry the origins of the powerful muscles and ligaments. Strong bristles are inserted along the rim and the lateral portions of the segment. The developing pupa, contained within the larva, and with its breathing-tubes chitinized to about half their length, shows stages of development of the future adult mouth-parts (figs. 138 to 141), and at the base of the developing mandibles, &c., appear branched hairs similar to those found on larvae of *Culex* and *Anopheles* (fig. 139). These special hairs I have not found externally on the larvae or adult flies.

Alimentary and tracheal systems (figs. 142 to 145): The alimentary system, lying centrally, shows diverticula in the form of chitinized pouches (fig. 126) lying about half-way towards the lateral margin. The tracheal system shows strong vessels passing round the margins of segments, and the areas occupied by the dorsal marginal rows of spines. Branches appear to pass from the gills to the suckers terminating in the 6 apertures. The spiracles (closed) (fig. 124) of the larva lie at the base of the lateral processes. One seems forced to assume that the tracheal apertures of the disc have a perfectly transparent membrane over the aperture, or that the tubes (visible) (fig. 130) have no connection with the tracheal system proper. Bearing in mind the peculiar dorsal armature following the tracheal system, and the specialized cells of the dorsum, it seems possible that the gills and discs are connected by a system of air-tubes relating to suction alone, and that the opening and closing of the disc is aided by the use of the valve-gateway at the anterior margin of the disc. The mechanics of the disc action, however, need further research.

Pupae.

Bezzi (1913, p. 80) describes the pupae as "oval in shape, convex and strongly chitinized dorsally, where the colour is black, and flat and whitish ventrally. The prothoracic respiratory appendages project forward in the form of two horns, enclosing the delicate respiratory organs." The following notes can be added: When examined under a high power the black dots resolve into small brown raised bosses (fig. 150). Dark markings appear at the lateral margins, where they curl over to form the rim of the cradle for the enclosed occupant (figs. 147 and 149). A group of light-brown spots appears on each segment, half-way between the centre and the margin, but these are only visible on slide specimens (fig. 149). Each respiratory appendage consists of 4 plates.

The presence of Blepharocerid larvae in the vicinity of Dunedin and Queenstown brings the area of distribution considerably farther south than the 40° mentioned by Bezzi (1913, p. 71). Dunedin is nearly 46° S latitude. Altitudes: Dunedin, about 600 ft.; Queenstown, 2,000 ft.; Arthur's Pass, Otira, from 1,260 ft.; Ohakune, 2,018 ft.; Purau, about sea-level.

I have to express my keen appreciation of the kindly interest taken in my work by Dr. Chilton, Mr. Gilbert Archey, and many other friends, and of the valuable help they have given me in my attempt to increase, however slightly, our knowledge of the New Zealand representatives of this family.

Literature cited.

Bezzi, M., 1913. *Bull. Soc. Ent. Ital.*, vol. 44, pp. 1–113.
—— 1914. *Ibid.*, vol. 45, pp. 115–29.
Chilton, C., 1906. *Trans. N.Z. Inst.*, vol. 38, pp. 277–78, pl. 46.
Edwards, F. W., 1915. *Ann. Mag. Nat. Hist.*, ser. 8, vol. 16, pp. 203–15, figs. 1–22.
Lamb, C. G., 1913. *Trans. N.Z. Inst.*, vol. 45, pp. 70–75, figs. 1–9.

Note.

In regard to my enumeration of the wing-veins, Dr. Tillyard has kindly pointed out the improbability of any fusion of R and M in the Blepharoceridae. The error is mine, and bears no relation to the evidence for wing-reduction in New Zealand forms.

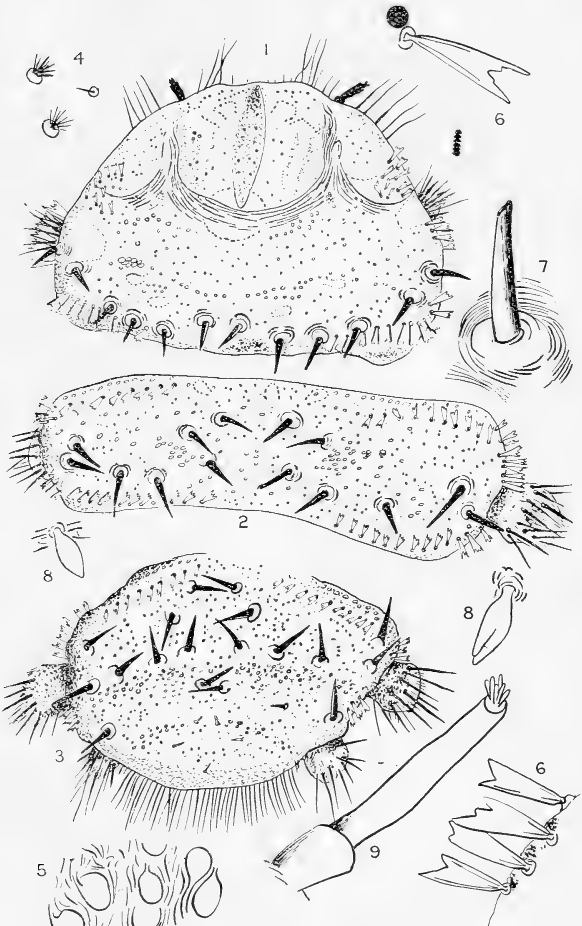
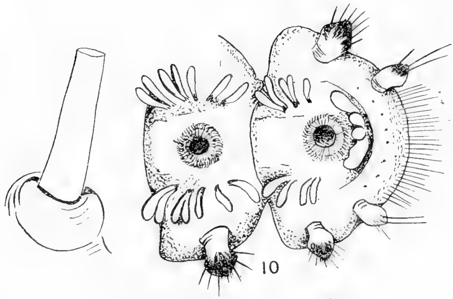


FIG. 1.—Larva A: 1st segment.
FIG. 2.—Larva A: body segment.
FIG. 3.—Larva A: 6th segment.
FIG. 4.—Larva A: palmate spines.
FIG. 5.—Larva A: group of cells.
FIG. 6.—Larva A: fan spine.
FIG. 7.—Larva A: primary spine.
FIG. 8.—Larva A: cone spine.
FIG. 9.—Larva A: antenna.



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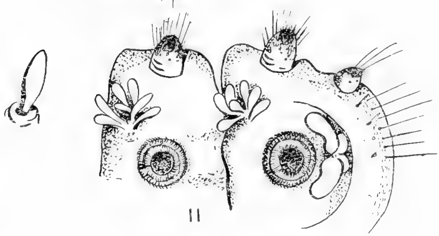

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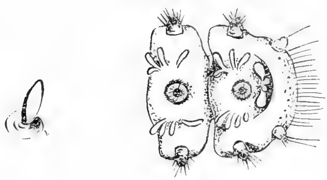

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Fig. 10.—Larva A: ventral surface.
Fig. 11.—Larva B: ventral surface.
Fig. 12.—Larva C: ventral surface.

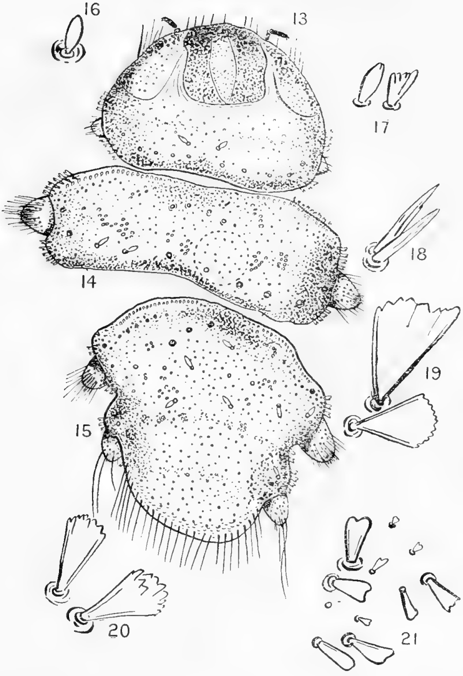


FIG. 13.—Larva B: 1st segment.
FIG. 14.—Larva B: body segment.
FIG. 15.—Larva B: 6th segment.
FIG. 16.—Larva B: primary spine.
FIGS. 17–21.—Larva B: types of spines of dorsum.

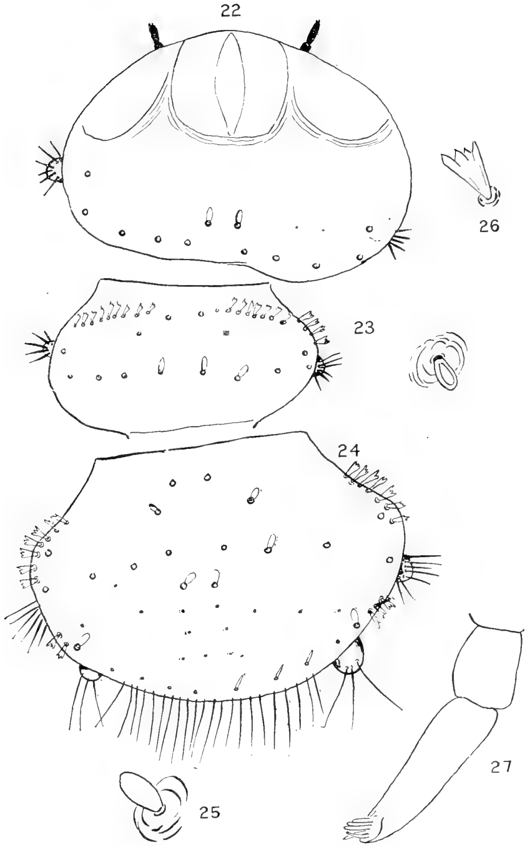


FIG. 22.—Larva C: 1st segment.
FIG. 23.—Larva C: body segment.
FIG. 24.—Larva C: 6th segment.
FIG. 25.—Larva C: primary spine.
FIG. 26.—Larva C: fan spine.
FIG. 27.—Larva C: antenna.

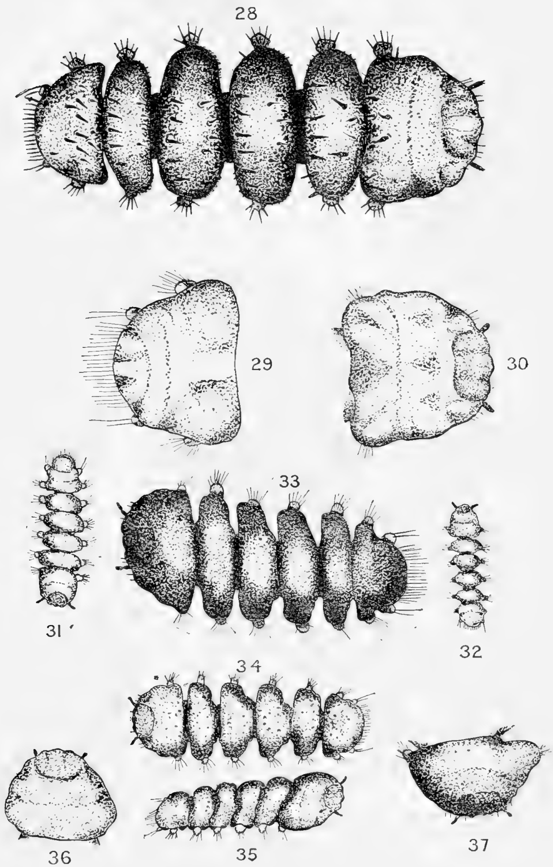
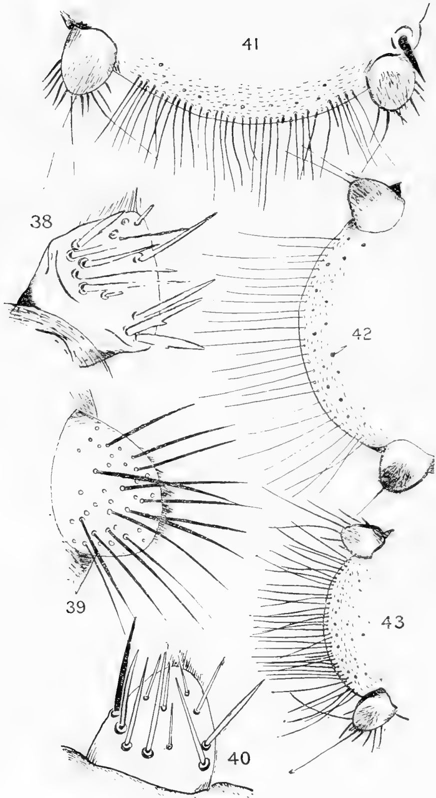


Fig. 28.—Larva A, from Purau.
Figs. 29, 30.—Larva, from Queenstown.
Figs. 31, 32.—Young larva B, from Ohakune.
Fig. 33.—Adult larva B, from Ohakune.
Figs. 34, 35.—Larva C, from Purau.
Figs. 36 37.—Heads of larva B.



Lateral processes and marginal spines, 6th segment.

Fig. 38.—Larva A.
Fig. 39.—Larva B.
Fig. 40.—Larva C.
Fig. 41.—Larva A.
Fig. 42.—Larva B.
Fig. 43.—Larva C.

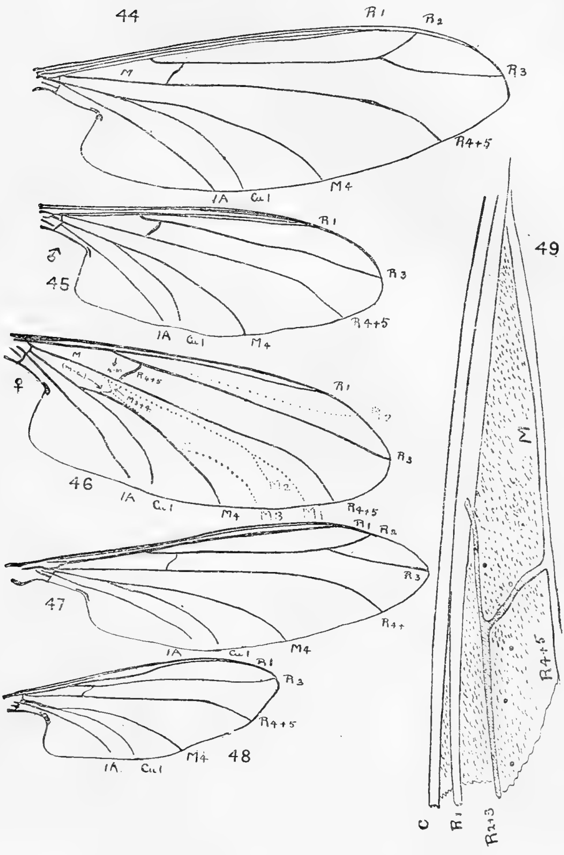
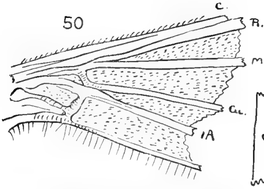
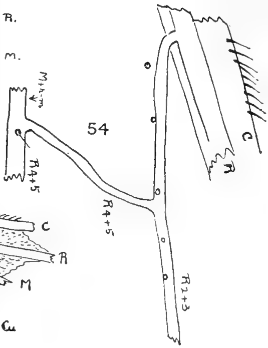
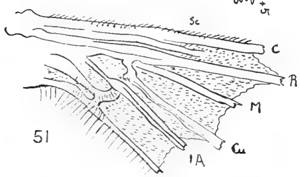


FIG. 44.—Wing of *N. hudsoni.*
FIG. 45.—Wing of *A. harrisi,* ♂.
FIG. 46.—Wing of *A. harrisi,* ♀.
FIG. 47.—Wing of *C. chiltoni.*
FIG. 48.—Wing of *P. turrifer.*
FIG. 49.—Wing of *A. harrisi* showing macrotrichia round R_{4+5}.







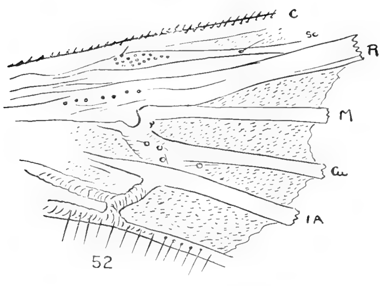
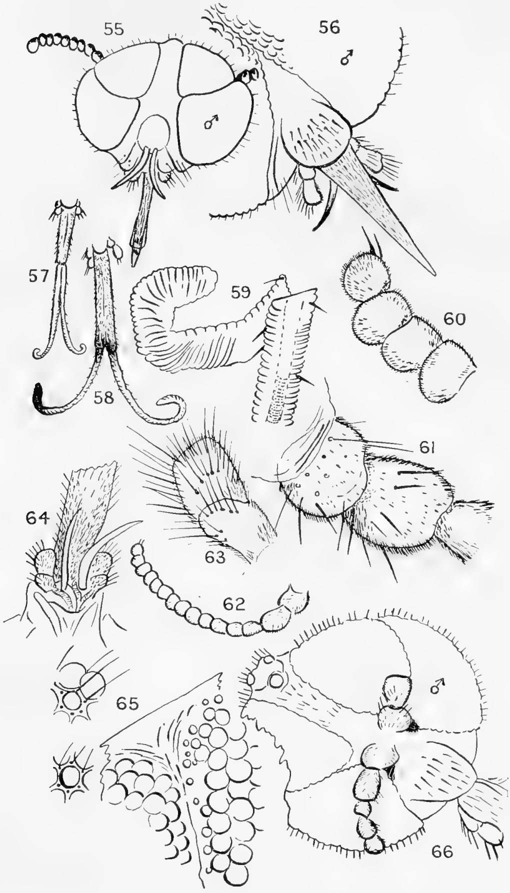
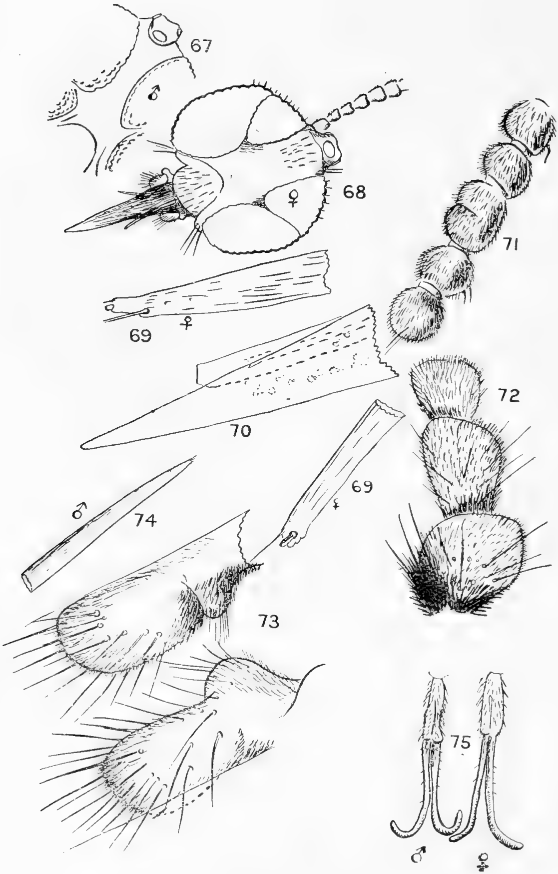


Fig. 50.—Wing-base of *N. hudsoni.*
Fig. 51.—Wing-base of *A. harrisi.*
Fig. 52.—Wing-base of *C. chiltoni.*
Fig. 53.—Wing-base of *P. turrifer.*
Fig. 54.—Macrotrichia round R_{4+5} on wing of *C. chiltoni*



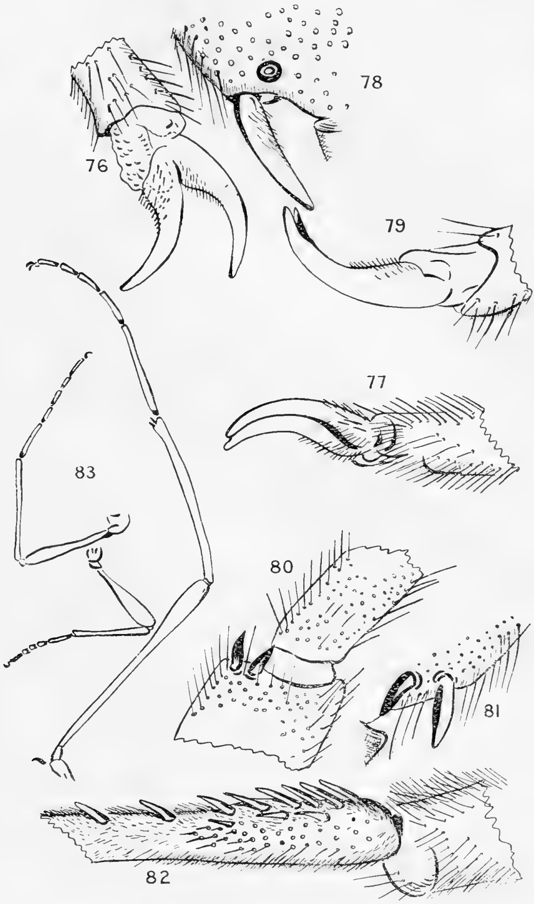
Curupira chiltoni, ♂, excepting figs. 56, 58.

FIG. 55.—Head (view from behind), showing maxillae.
FIG. 56.—Head of *N. hudsoni*, showing *holoptic eyes*.
FIG. 57.—Labium.
FIG. 58.—Labium of *N. hudsoni*, ♂.
FIG. 59.—Tip of labella and portion of same.
FIG. 60.—Four terminal joints of antenna.
FIG. 61.—Two basal joints of antenna.
FIG. 62.—Antenna (complete), 14 joints.
FIG. 63.—Maxillary palp.
FIG. 64.—Part of labium, maxillary palps, and maxillae.
FIG. 65.—Upper and lower eye-facets, showing bisection.
FIG. 66.—Ocellar turret and insertion of antennae.

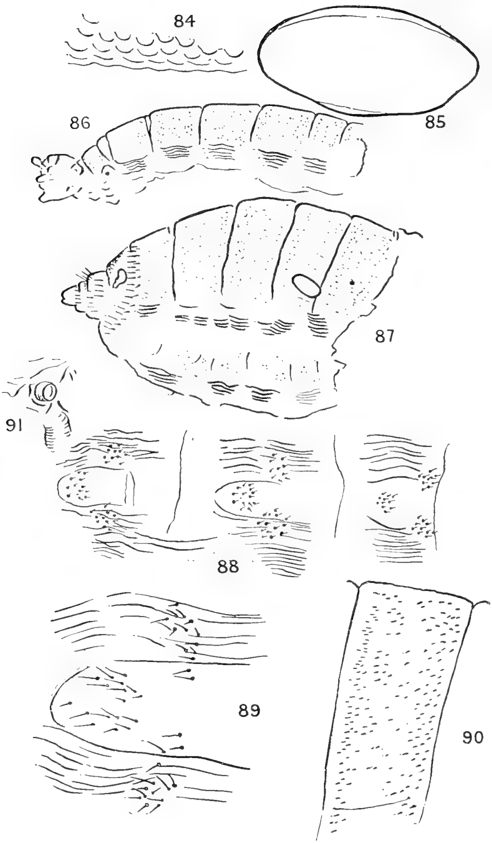


Curupira chiltoni.

Fig. 67.—Head of ♂.
Fig. 68.—Head of ♀, contrasting space between eyes.
Fig. 69.—Mandibles, ♀.
Fig. 70.—Labrum and hypopharynx.
Fig. 71.—Antenna.
Fig. 72.—Antenna, basal joints.
Fig. 73.—Maxillary palps.
Fig. 74.—Maxilla, ♂.
Fig. 75.—Labium, ♂ and ♀.



FIGS. 76, 77.—Claws, hind legs of *C. chiltoni*, ♂.
Fig. 78.—Tibial spur of *N. hudsoni*, ♂.
FIG. 79.—Claw, hind leg of *N. hudsoni*, ♂.
FIGS. 80, 81.—Tibial spurs of *C. chiltoni*, ♂.
FIG. 82.—1st tarsal joint, front leg of *C. chiltoni*, ♂.
FIG. 83.—Legs of *C. chiltoni*, showing relative size of the joints.



Curupira chiltoni.

Fig. 84.—Margin of ovum.
Fig. 85.—Ovum.
Fig. 86.—Body, ♂.
Fig. 87.—Body, ♀, showing ovum.
Fig. 88.—Ventral surface of body, showing groups of hairs.
Fig. 89.—Central group (enlarged).
Fig. 90.—Body segment, showing microtrichia.
Fig. 91.—A spiracle.

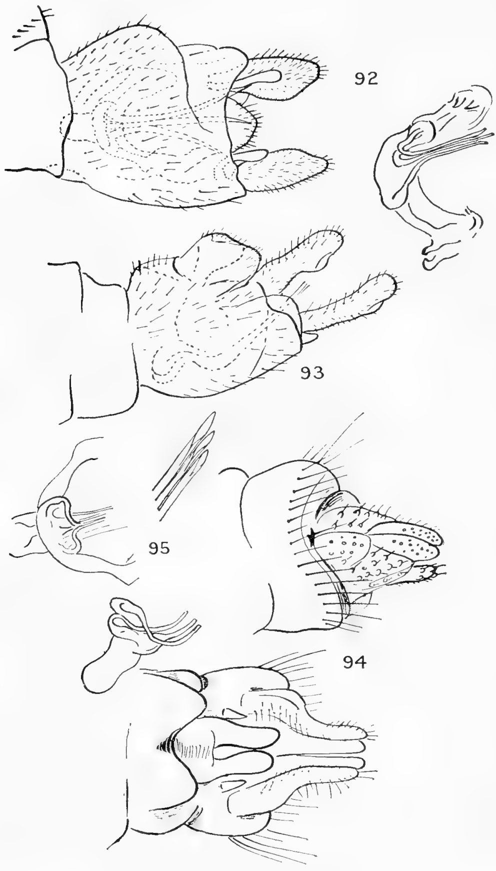
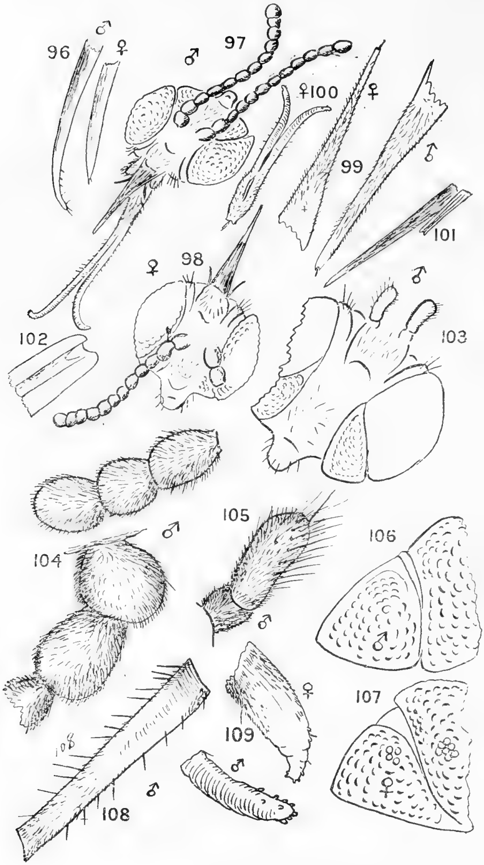
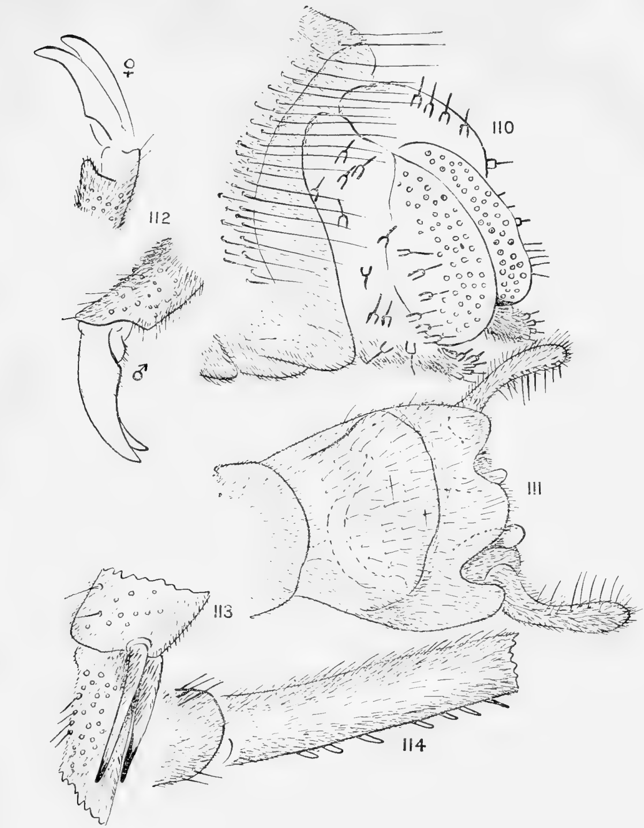


FIG. 92.—Hypopygium of *N. hudsoni*, ♂.
FIG. 93.—Hypopygium of *C. chiltoni*, ♂
FIG. 94.—Hypopygium of *C. chiltoni*, ♀.
FIG. 95.—Penis and bulb of *C. chiltoni*, ♂.



Apistomyia harrisi.

FIG. 96.—Maxilla of ♂; mandible of ♀.
FIG. 97.—Head of ♂.
FIG. 98.—Head of ♀.
FIG. 99.—Labrum, ♂ and ♀.
FIG. 100.—Labium, ♀ (short labella).
FIG. 101.—Labrum and hypopharynx, ♂.
FIG. 102.—Tip of hypopharynx, ♂.
FIG. 103.—Head, ♀ (antennae removed).
FIG. 104.—Antennae, basal joints and tip.
FIG. 105.—Maxillary palp, ♂.
FIG. 106.—Upper eye, ♂.
FIG. 107.—Upper eye, ♀.
FIG. 108.—Portion of labium, ♂.
FIG. 109.—Tips of labella, ♂ and ♀.



Apistomya harrisi.

FIG. 110.—Hypopygium, ♀.
FIG. 111.—Hypopygium, ♂.
FIG. 112.—Claw, hind leg, ♀; claw, hind leg, ♂.
FIG. 113.—Tibial spur, hind leg, ♂.
FIG. 114.—1st tarsal joint (front leg), ♂.

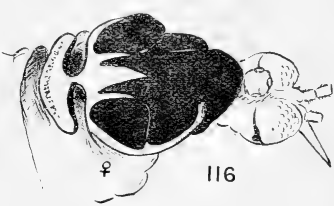


FIG. 115.—*Apistomyia harrisi*, ♀.
FIG. 116.—*Curupira chiltoni*, ♀.

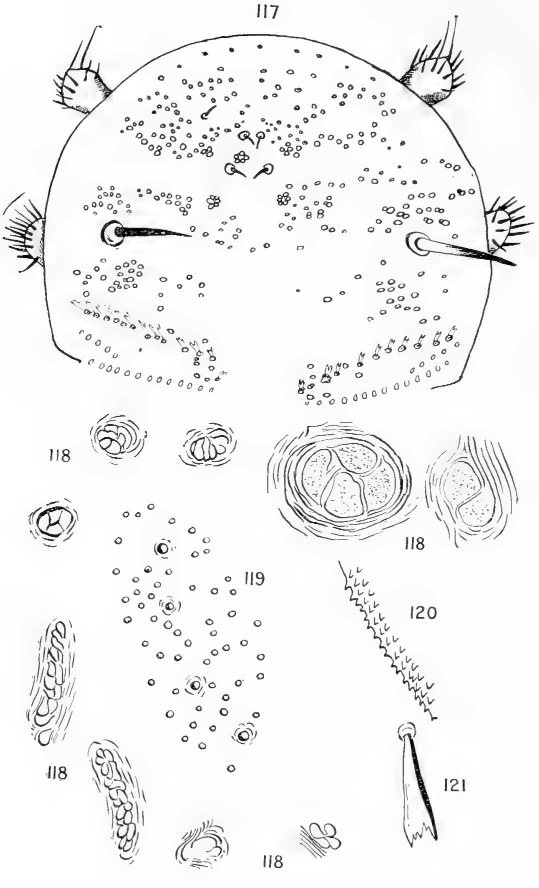


Fig. 117.—Larva A: 6th segment (dorsal), showing special cells.
Fig. 118.—Larva A: special cells, enlarged.
Fig. 119.—Larva B: portion of dorsum, showing four spines of primary armature and secondary spines surrounding them.
Fig. 120.—Margin of integument, showing the scale processes.
Fig 121.—Fan spine, showing thickness.

Note.—The posterior half of the segment shows the reduced remains of the primary spines of the original 7th segment.

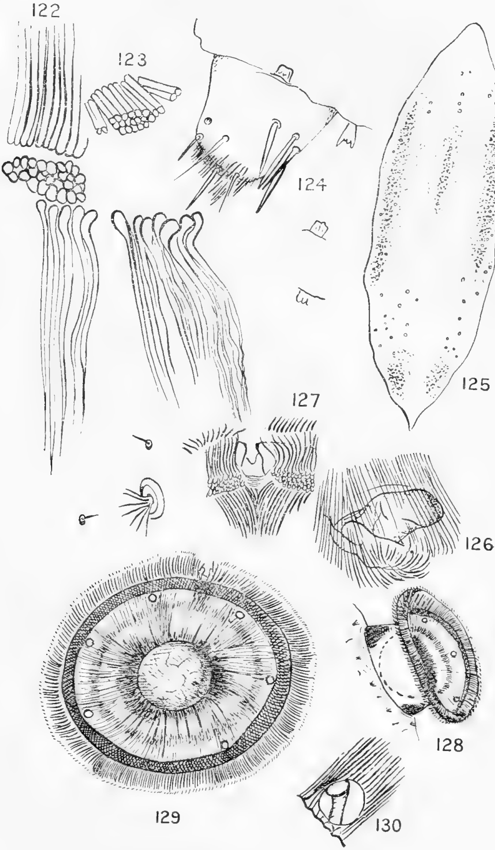
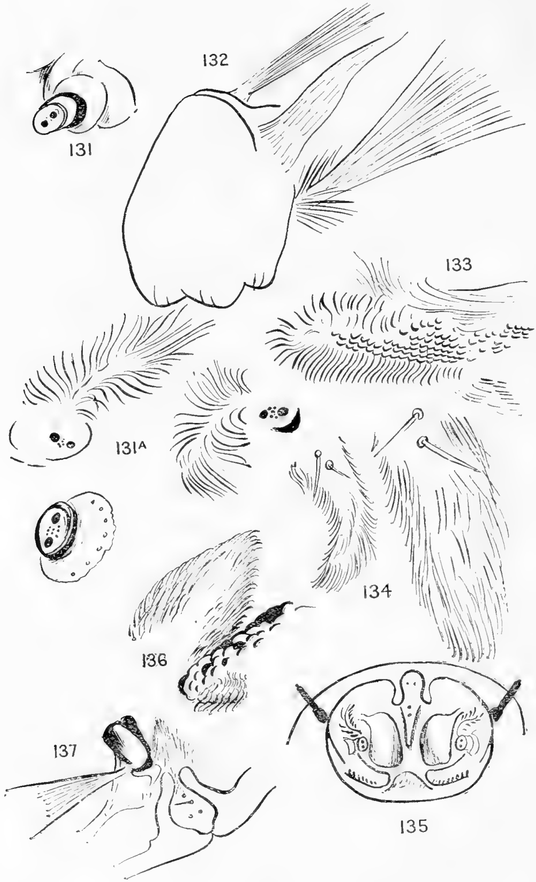


FIG. 122.—Cilia and portion of rim and cup.
FIG. 123.—Section of rim.
FIG. 124.—Lateral process, showing spiracles.
FIG. 125.—Central dorsal plate of larva cephalon (pointed end anterior).
FIG. 126.—Internal diverticula (subdermal) of larva.
FIG. 127.—Valve gateway of sucker.
FIG. 128.—Side view of sucker.
FIG. 129.—Sucker, showing six apertures (palmate and minute hairs).
FIG. 130.—An aperture enlarged to show the tube.



FIGS. 131, 131A.—Maxillary palps.
FIG. 132.—Mandible.
FIG. 133.—Maxilla.
FIG. 134.—Labrum.
FIG. 135.—Diagram of arrangement of parts.
FIG. 136.—Labium and part of maxilla.
FIG. 137.—Labrum and mandible.

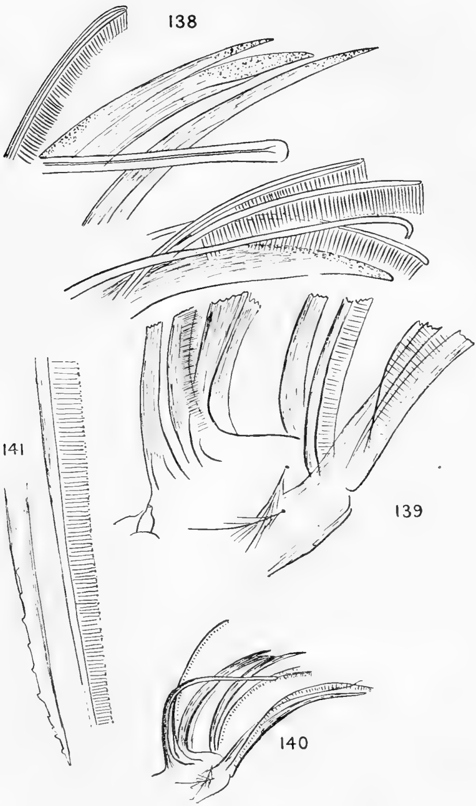


FIG. 138.—Tips magnified.
FIG. 139.—Base magnified.
FIG. 140.—Mouth-parts of future image.
FIG. 141.—Mandible of *Culex* ? sp.

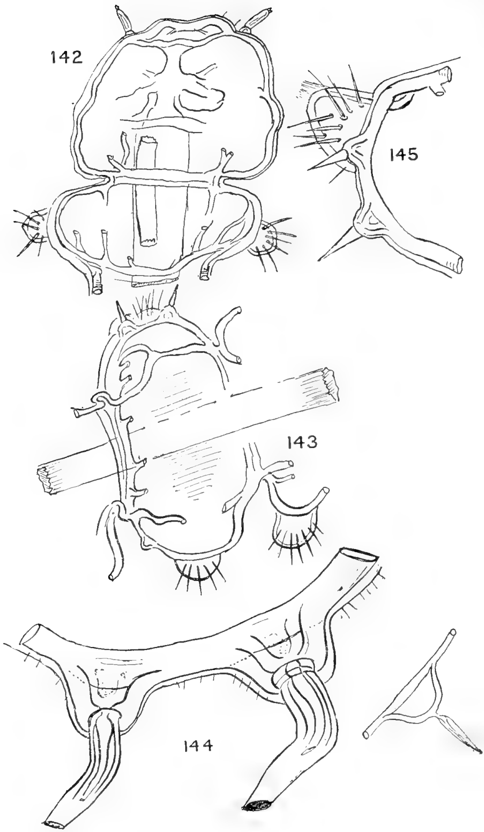
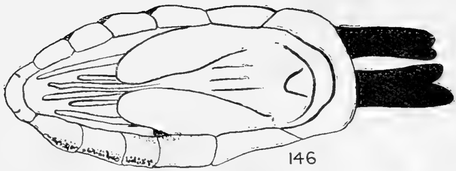


Fig. 142.—Larva A: 1st and 2nd segments.
Fig. 143.—Larva A: 4th segment.
Fig. 144.—Lateral portion of a segment.
Fig. 145.—Two spines and a lateral process.



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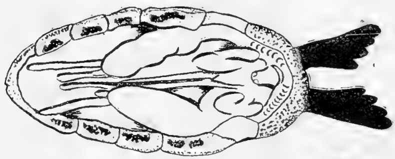

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FIG. 146.—Pupa, probably *N. hudsoni.*
FIG. 147.—Pupa of *P. turrifer*, showing antennae, turret proboscis, &c.
FIG. 148.—Empty case of *C. chiltoni.*

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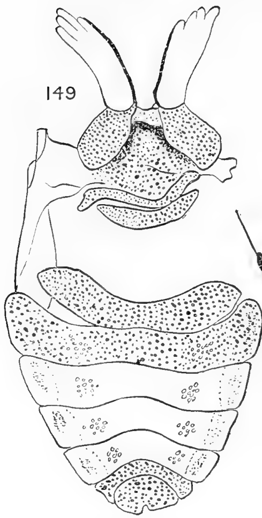

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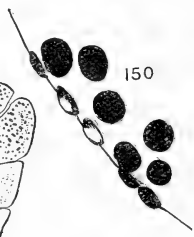

Fig. 149.—Pupa: dorsal view of posterior segments; ventral view of anterior segments and wing-case: showing how pupa splits for emergence of adult. Central dorsal markings (on slides). Lateral markings are ventral.

Fig. 150.—Black appearance consists of dots. The dots enlarged to show as circular bosses

ART. XXXI.—*Material for a Monograph on the Diptera Fauna of New Zealand: Part II, Family Syrphidae.**

By DAVID MILLER, F.E.S., Government Entomologist.

[*Read before the Wellington Philosophical Society, 27th October, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

Plates XLVII–LII.

OWING to the fact that some four years ago the greater part of my collection of New Zealand Diptera was accidentally destroyed, I have not until recently had sufficient material at my disposal upon which to publish a regular series. It has in four years been possible, however, to get together a collection very nearly as complete as the original one, which represented the work of ten years, such rapid reconstruction being for the most part due to those able entomologists Mr. G. V. Hudson, of Wellington, Mr. E. Clarke, of Dunedin, Mr. J. R. Harris, of Ohakune, and Mr. J. W. Campbell, of Christchurch, who have generously presented extensive collections from various parts of the Dominion, not only replacing many of the species destroyed, but also bringing to light many new forms. The preparation of this paper was also simplified by the kindness of Mr. R. Speight and Mr. G. Archey, of the Canterbury Museum, in placing at my disposal the late Captain Hutton's types of New Zealand Diptera. The invaluable photographic illustrations are the excellent work of Mr. E. B. Levy, of the Government Biological Laboratories.

Since the publication of Part I, which dealt in part with the Stratiomyidae, further representatives of that family have been obtained and will eventually appear as a supplement to Part I.

The Syrphidae may be characterized as follows: Eyes moderately or densely pilose, sparsely haired or bare, those of the male holoptic at a point or more completely, or dichoptic, in which case they may be very much approximated or more widely separated; when dichoptic the frontal orbits may be parallel on upper half but divergent on lower, being thus angulated (fig. 68); in many cases there is a transverse furrow on the front connecting the orbital angulation. In profile the eyes may descend almost to the oral margin, thus practically eliminating the cheeks, or be much shorter, while in some cases they are comparatively small. The ocellar triangle is of varying shapes and sizes, sometimes, for example, being more or less round and reaching from eye to eye, or long and triangular reaching well on to the front; the ocelli well developed. Front varying in width according to sex, clothed with pile, with longer or shorter dense or scattered hairs, or altogether bare; it may be smooth, transversely wrinkled, or grooved medio-longitudinally. Antennae shorter or longer, the 3rd joint oval or orbicular (fig. 14); more or less rectangular, or elongate (fig. 6); arista dorsal in the known New Zealand species, bare

* Part I in *Trans. N.Z. Inst.*, vol. 49, p. 172 (1917).

or pubescent (hairy in some exotic species). Face of varying shape; concave (fig. 48), convex, arched (fig. 5), or vertical (fig. 7) below antennae, with (fig. 15) or without (fig. 52) a central tubercle or swelling; sometimes produced at oral margin (fig. 52); clothed with hairs or bare, and sometimes transversely wrinkled; oral margin horizontal, descending (fig. 63) or ascending (fig. 5); cheeks more or less well developed and usually clothed with hairs. The proboscis well developed, the labella larger or smaller; the palpi slender or stouter.

Thorax usually robust, sparsely or densely clothed with long or short hairs or with pile, or altogether bare; scutellum crescentic or quadrangular, sometimes tuberculate, clothed or bare. Legs well developed, slender or stout, the posterior femora sometimes thickened and with a swelling or a tooth-like process below toward apex or base; the tibiae and tarsi sometimes broadened and peculiarly developed; the legs sometimes clothed with longer or shorter hairs and less commonly with bristles which are most frequent on underside of the posterior femora, on the tarsi, and abdomen, particularly on the genital segments of the male; claws and pulvilli small or well developed, the empodium bristle-like or styliform.

The wings usually longer than the abdomen, in some cases shorter; incumbent when at rest or held slightly divergent just exposing the abdomen. The wings vary somewhat in outline, being apically pointed

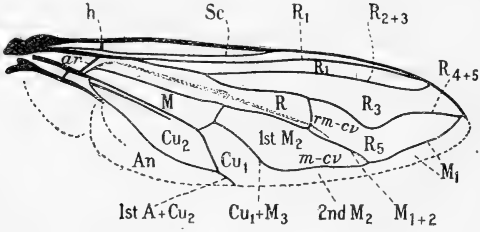

Fig. 1.—Diagram of a syrphid wing, showing venation.

or blunt, while the anal angle is evenly rounded or strongly developed; the alula is usually short, but may be long and narrow, reaching almost to the posterior margin of the wing (fig. 2); the squamae and anti-squamae are well developed and fringed with hairs, those on the former being long and frequently branched, and on the latter short. In colour the wings are either clear or tinged over the whole or part of the membrane, the base and cell Sc being more deeply coloured. The venation (fig. 1), which is distinct and readily characterizes the family, presents some interesting peculiarities. The costa ends at its junction with vein R_{4+5} either at or before the apex of the wing; sometimes there is a supernumerary humeral vein present; in some cases Sc_2 is developed, uniting as a cross-vein, Sc_1 with R_1 near the apex of the former; vein R_{2+3} runs more or less straight, or is strongly curved upward and sometimes slightly backward at its apex to meet the costa or to unite with vein R_1, thus closing cell R_1; vein R_{4+5} is straight, slightly curved downward, or deeply looped into cell R_5, which is always closed apically either on, near, or considerably before the costa by the confluence of

R_{4+5} and M_1, the latter running almost parallel with the wing-margin; basally cell R_5 is closed by the cross-vein *r–m*, which is more or less oblique, longer or shorter, and situated before, near, at, or beyond the middle of cell 1st M_2. Intersecting the lower part of the cross-vein *r–m* and running through cell R to end in cell R_5 close to the vein M_{1+2} is a more or less developed—though sometimes absent—spurious vein characteristic of the family: this is the *vena spuria*. Basally the vena spuria may be evanescent, but otherwise arises from the origin of vein R_{2+3} usually in those forms where the cross-vein *r–m* lies before the middle of cell 1st M_2, or, where this cross-vein is beyond the middle of cell 1st M_2, the spurious vein originates from the vein M where the latter curves downward to meet vein Cu at the base of the wing. A little before *r–m* in cell R the vena spuria is swollen knob-like, from whence a vein-like stump may descend either to evanesce or unite with vein M, or a spurious cross-vein may connect the vena spuria above with the vein R_{4+5} near the origin of the latter, which is then somewhat angulated at this point. The vein M, just beneath the swelling of the vena spuria and behind the cell 1st M_2, is frequently sinuated; from the origin of this sinuation in some species (fig. 27) an indistinct vein arises perpendicularly into cell M and turns abruptly forward, crossing into cell 1st M_2. The veins M_1 and M_2 are united for the greater part of their length, branching near the wing-margin, the anterior branch, M_1, closing the cell R_5 as already noted; M_2 may either continue beyond the fork or be confluent with M_1, which in some cases is angulated, giving rise to a short stump into cell R_5 (fig. 22). Connecting the veins M and Cu_1+M_3 is the cross-vein *m* running more or less parallel with the wing-margin and meeting vein M either before the branching of M_1 in such forms where M_2 is continued toward the margin, or at the fork of M_1 where M_2 is confluent with M_1. As with vein M_2, the vein Cu_1+M_3 is either confluent with the cross-vein *m* or is continued beyond toward the margin; owing to the fusion of the veins Cu_1 and M_3, the cross-vein *m–cu* is eliminated. After the confluence of Cu_2 and 1st A, Cu_2 + 1st A either runs straight to the margin or is more or less prolonged and curved. In cell Cu_2 of most species is a distinctly developed vein arising at the origin of 1st A and, running close to vein Cu, ending beyond the middle of the cell. The basal "vein" of the alula is connected with the origin of Cu by a distinct cross-vein and the arculus between Cu and R, or M and R, is well developed.

According to the venation, the species discussed below form three groups. In the first (Plate XLVII, fig. 6) the costa ends with vein R_{4+5} at the apex of the wing, which is more or less blunt; the vein R_{4+5} is practically straight above cell R_5, and the veins Cu_1+M_3 and M_2 are more or less developed beyond the cross-vein *m* and the vein M_1 respectively; also the cross-vein *r–m* is before the middle of cell 1st M_2 (Syrphinae). In the second group (figs. 3 and 4), the costa ends before the apex of the wing, which is more or less pointed; the vein R_{4+5} is gently curved into cell R_5, the veins Cu_1+M_3 and M_2 are confluent with the cross-vein *m* and the vein M_1 respectively, and the cross-vein *r–m* is near or beyond the middle of cell 1st M_2 (Milesiinae). In the third group (fig. 1) the costa ends distinctly before the apex of the wing, which is pointed; the vein R_{4+5} is deeply curved into cell R_5; the veins Cu_1+M_3 and M_2 as the second group; the cross-vein *r–m* beyond the middle of cell 1st M_2. A further reduction occurs in this group (Plate LI, fig. 3) in the closing of the cell R_1 of some species by the confluence of veins R_1 and R_{2+3} (Eristalinae).

The abdomen is ovate (particularly in some females), elongate and narrow with parallel sides, or sides converging basally or along the middle, or rectangular; bare, or sparsely or densely clothed with hair, or sometimes with bristles to a certain extent. In the New Zealand species there are 4 visible segments in the male and 5 in the female; in the male segments 5–9 are curved to one side beneath the apex of the abdomen; in the female the apical segments are usually retracted within the 5th, but may be extruded to some considerable length.

The colours of the Syrphidae are frequently more intense in warmer parts of the Dominion and are usually conspicuous. Although a few are melanoid, many are brilliantly metallic, or black with yellow or white spots and stripes; there are also reflections of various hues caused by tomentum or the arrangement of the vestiture. On account of the structure, the flower-frequenting habit, and the mode of flight, many syrphids closely resemble certain Hymenoptera: the European narcissus-fly (*Merodon equestris* Fabr.), sometimes found in New Zealand, bears a strong resemblance to a bumble-bee, while the European drone-fly (*Eristalis tenax* Linn.), now well established in this country, is frequently mistaken for the honey-bee. The absence of indigenous Apidae may account for the absence among New Zealand syrphids of those densely-haired and bee-like species. It is also noteworthy that the native bees are all of the short-tongued group, and that there is an amount of resemblance between these insects and certain native syrphids: for example, *Lepidomyia decessum* Hutton is superficially similar to the native *Halictus huttoni* Cam.*

In the following pages some thirty-three species are recorded, three of which are of European origin, one is found also in Australia, and the remainder are indigenous; of these, fourteen are new species. As in Part I, the terms *pro-*, *epi-*, *meso-*, *meta-*, and *onycho-tarsus* are used for the 1st to 5th tarsal joints respectively, as suggested by Williston. Unless otherwise stated, the term "front" refers to the front and vertex.

TABLE OF GENERA.†

1	Cross-vein *r–m* before middle of cell 1st M_2	2
	Cross-vein *r–m* at or beyond middle of cell 1st M_2	9

Subfam. SYRPHINAE.

2	Species with yellow markings on face or abdomen, or both ..	3
	Species without yellow markings, but with greyish tomentose areas or white spots on abdomen	6
3	Face distinctly convex and produced at knob and mouth (fig. 5)	*Paragus.*
	Face not produced, but vertical or slightly concave	4

* An account of the economic aspect of this family, "Economic Bearing of Hover-flies," is given by the author in *N.Z. Jour. Agric.*, vol. 17, No. 3, pp. 129–35 (1918).

† SPECIES LIKELY TO BE CONFUSED.

{ *Paragus pseudo-ropalus* n. sp. (Plate LII, fig. 1; and text-figs. 5, 12.)
{ *Syrphus ropalus* Walk. (Text-fig. 37.)

{ *Myiatropa campbelli* n. sp. (Plate LI, fig. 1; and text-figs. 80, 84, 86.)
{ *Helophilus cargilli* Miller. (Text-figs. 75, 82.)

{ *Heliophilus antipodus* Schiner. (Plate L, figs. 1, 4; and text-figs. 63, 66, 70–73.)
{ *Helophilus trilineatus* Fabr. (Text-figs. 74, 76, 77, 79.)

{ *Helophilus campbellicus* Hutton.
{ *Helophilus chathamensis* Hutton.

{ *Cheilosia cunninghami* n. sp.
{ *Xylota montana* n. sp.
{ *Lepidomyia decessum* Hutton.

4	Pleurae altogether yellow; apex of wing clouded; abdomen of ♂ somewhat spatulate, being narrowed towards base (fig. 13)	*Sphaerophoria.*
	Pleurae partially yellow or without markings; apex of wing not clouded; abdomen of ♂ not spatulate, the sides parallel or restricted in middle	5
5	Face yellow or grey with black markings; abdominal spots linear if present	*Syrphus.*
	Face black; abdominal spots broad or clavate	*Melanostoma.*
6	Abdomen broad and ovate; face vertical, produced only at oral margin (fig. 7); 3rd antennal joint elongate (fig. 6); posterior femora broad and bristly beneath; eyes haired..	*Lepidomyia.*
	Abdomen narrow or rectangular; face not vertical to oral margin but with a distinct knob in middle; eyes bare ..	7
7	Legs normal	*Melanostoma.*
	Legs peculiarly haired (fig. 16); posterior tibiae and protarsi enlarged, or anterior tibiae and tarsi broadened (fig. 45) ..	8
8	Rather robust flies; head more or less distinctly rectangular; face vertical or produced slightly forward; antennae lying flat on face (figs. 15, 18, 19, and 20)	*Cheilosia.*
	Rather slender flies; head not distinctly rectangular; face concave if anything; antennae not flat on face	*Platycheirus.*
9	Vein R_{4+5} deeply looped into cell R_5	10
	Vein R_{4+5} moderately or slightly looped	14

Subfam. ERISTALINAE.

10	Cell R_1 closed	*Eristalis.*
	Cell R_1 open	11
11	Posterior femora with an extraordinarily large triangular tooth near apex below; vein M_1 strongly curved to meet R_{4+5} a considerable distance from costa	*Merodon.*
	Posterior femora without triangular process, at most with bristly swelling; vein M_1 meeting R_{4+5} on or near costa	12
12	Eyes hairy	*Myiatropa.*
	Eyes bare	13
13	Eyes dichoptic in both sexes; thorax moderately or indistinctly haired; scutellum normal	*Helophilus.*
	Eyes of ♂ holoptic; thorax densely haired; scutellum with a pair of tubercles	*Mallota.*

Subfam. MILESIINAE.

14	Cross-vein *r–m* beyond middle of cell 1st M_2; thorax striped; abdomen with hoary spots; posterior femora moderately thickened	*Tropidia.*
	Cross-vein *r–m* at middle of cell 1st M_2; posterior femora strongly thickened	15
15	Abdomen with yellow spots	*Syritta.*
	Abdomen immaculate	*Xylota.*

Subfamily SYRPHINAE.

Cross-vein *r–m* distinctly before middle of cell 1st M_2; vein R_{4+5} not curved into cell R_5 but more or less straight; cell R_1 open.

Genus PARAGUS Latreille (1805).

The outstanding character of this genus is the arched face; the eyes of the male are holoptic, those of the female dichoptic.

P. pseudo-ropalus n. sp. (Plate LII, fig. 1.)

A medium-sized fly with yellow face and scutellum, a pair of yellow spots on the 2nd and 5th, and a broad yellow band on the 3rd and 4th abdominal segments (fig. 12). This species is named *pesudo-ropalus* owing to its superficial resemblance to *Syrphus ropalus* Walk.; the two species may be distinguished by the shape of the face, which is arched in the former (fig. 5) and vertical in the latter (compare also figs. 12 and 37).

♂. Eyes bare, holoptic for a short distance in front of ocellar triangle, which is black with black hairs; ocelli brick-red. Front ochreous with scattered black hairs which extend on to face on each side; lunular area brownish; orbital margins narrowly blackish-brown. In profile the head is rather flat above to where the front descends to the antennae, which are somewhat elongated and sometimes surrounded with orange-yellow at the base; 1st and 2nd joints brownish and short; 3rd joint reddish-brown or yellow and elongate oval; arista brown and pubescent. Face thinly clothed with erect short black hairs; face pale yellow with a greenish tinge and a median blackish-brown stripe on lower half to oral margin, which is margined with blackish-brown; in profile the face is arched and produced at the knob (fig. 5); occiput black; proboscis and palpi brownish-black.

Thorax shiny black, clothed with short pale hairs; a tawny spot clothed with tawny hairs on each side of dorsum anterior to wing-articulation; scutellum testaceous and clothed with testaceous hairs; halteres testaceous. Wings faintly tinged; the veins and stigma blackish-brown. Legs testaceous but paler at the knees and basal half of tibiae; tarsi, particularly the posterior, fuscous.

Abdomen elongate, comparatively broad at the base, and somewhat narrowing between the 3rd and 4th segments; black, but to a great extent occupied by a pair of testaceous spots on the 2nd segment, a smaller pair on the 5th, and by two broad testaceous bands, one across the 3rd segment and the other across the 4th (fig. 12); genital segments blackish-brown except the 9th, which is tawny; 6th, 7th, and 8th clothed with scattered delicate hairs.

♂. Length, 8 mm.

Holotype: ♂, No. 1231, D. M

Habitat.—Dunedin.

Genus Lepidomyia Loew (1864).

The following species was originally described by Hutton as a *Melanostoma*, but it clearly does not belong to that genus, from which it is distinguished by the following features: Body robust, immaculate and hairy; antennae elongate; eyes densely haired; face tuberculate at oral margin; posterior femora thickened and bristly below; posterior tibiae broadened apically and their protarsi somewhat thickened.

L. decessum. (Plate XLVII, figs. 1, 2.)

Melanostoma decessum Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 43 (1901).

A shiny blue-black robust fly with the abdomen ovate and no colour-pattern.

♀. Eyes clothed with short whitish hairs; front angulated at a transverse central depression, shiny blue-black and densely clothed with short brownish hairs; lower frontal orbits silvery in certain lights. Antennae (fig. 6) black, with a lighter reflection; 3rd joint elongate, reaching well down the face, which is vertical in profile and tuberculate at oral margin (fig. 7). Face shiny blue-black, covered with a silvery tomentum; a silvery pubescence along facial orbits; cheeks black and clothed with silvery hairs; proboscis and palpi brownish-black.

Thorax and scutellum shiny blue-black with a greenish tinge, and clothed with a scattered white pubescence which becomes longer on the pleurae and is replaced by long hairs around the coxae; 2 areas of short white hairs on anterior margin of dorsum just posterior to the head; scutellum with a marginal fringe of scattered black hairs ; spiracles silvery ; halteres orange-yellow or orange-red. Wings clear, stigma brownish, veins blackish-brown ; R_{4+5} running straight between cells R_3 and R_5 ; cross-vein *r–m* a little shorter than its distance from base of cell 1st M_2. Legs hairy, the femora somewhat thickened, the posterior particularly so ; femora blue-black with greyish hairs, the posterior pair with numerous short bristles on lower side near apex ; knees brownish-yellow ; tibiae brownish-yellow darkening apically, the posterior pair darker and broader distally, all clothed with stiff greyish hairs longer on the posterior pair, which have a stiff golden pile below toward the apex ; tarsi brownish becoming black apically, and clothed with stiff silvery hairs ; posterior protarsi rather swollen and with a short golden brush beneath.

Abdomen shiny blue-black, immaculate, ovate, being broader than the thorax, and usually carried with the apical half turned downwards ; clothed with short and scattered greyish hairs, but 1st segment with longer ones on each side.

♂. Eyes densely hairy, and holoptic over the greater part of the front ; thorax and scutellum more densely and longer haired than the female ; posterior tibiae silvery below toward apex, in some lights ; posterior femora clothed with long erect bristle-like black hairs distally ; abdomen black, slightly brown in recently emerged specimens, more hairy than female, the hairs black. Genitalia black ; the genital segments, except the 9th, clothed with delicate hair-like bristles ; claspers long and bifid (fig. 8).

This species, when on the wing, closely resembles the native bee (*Halictus huttoni* Cam.).

Larva.—The larva is of the rat-tailed type, but the siphon is short (Plate XLVII, fig. 3) ; the body, which is creamy-white, may attain a length of 20 mm. including the siphon ; the transparent integument is transversely corrugated, and clothed with short bristles very minute on ventral surface, which otherwise is clothed with delicate hairs ; along each side the integument is further broken up by longitudinal folds upon which the bristles are longer and more hair-like ; from the lateral margin of each segment arises a tuft of 2 or 3 divergent bristle-like hairs which are distinctly longer than the surrounding vestiture and most conspicuous on the terminal segments, though absent on the ultimate segment, which is frequently withdrawn. The "prolegs," which are armed with strongly recurved spines, vary in shape according to the contraction or expansion of the segments, being prominent knob-like swellings or merely transverse ridges of the integument. A characteristic feature is the form of the anterior segment, which is longitudinally fluted on the dorsal surface (fig. 9) when the anterior margin is contracted by being drawn around the oral cavity, much in the same way as the mouth of a pouch is drawn together by strings ; if fully expanded this segment is truncated and the flutings indistinct. The anterior respiratory processes are trumpet-shaped and short ; posteriorly the body tapers and the posterior angles of the penultimate segment are produced and carry the tuft of 3 bristle-like hairs characteristic of the body segments. The siphon is short, the tracheal opening being fringed by tufts of long and recurrent setose hairs (fig. 11).

Pupa (Plate XLVII, figs. 4, 5).—The pupa is brown in colour, the hard cuticle being transversely rugose and bearing the lateral hair-tufts of the larva ; in outline it is club-shaped, being strongly arched dorsally and tapering posteriorly to the respiratory siphon ; the ventral surface is flat. Length, 10 mm. ; greatest breadth, 4 mm.

Habitat.—*L. decessum* is found throughout New Zealand, and occurs on the wing from September to May; it is most prevalent in the vicinity of flax-bushes (*Phormium tenax*) and cabbage-trees (*Cordyline australis*), which are the breeding-grounds of the larvae. All larval stages are to be found at the one time inhabiting the gum-fluid retained in the leaf-sheaths of *P. tenax;* the larval period, particularly during the colder months, is of considerable duration. Pupation occurs upon the dead flax-leaves, to which the pupae adhere; they are partially or completely covered by a white precipitate from the gum-fluid. Mr. G. V. Hudson* has found the larvae of this fly breeding in decaying matter under the bark of cabbage-trees.

♂ and ♀. Length, 7 mm.

Holotypes: ♀, Hutton's collection, Canterbury Museum; ♂, No. 1232, D. M.

Genus Sphaerophoria St. Far. et Serv. (1828).

Species of slender body; eyes bare; 3rd antennal joint circular; abdomen elongate, rather narrow and restricted at base in the male; wings somewhat elongate.

S. ventralis n. sp.

A small slender black fly with 4 tawny spots on the abdomen; legs, pleurae, and face yellow; apex of wing clouded.

♂. Eyes bare, approximated on vertex, which, together with the ocellar triangle, is shiny blue-black; ocelli vermilion; upper part of front shiny blue-black, the anterior margin of this colour being trifid, the central fork largest, the lateral ones short and extending to orbits; lower front pale yellow, somewhat greenish and widening to lunule, which is dark yellow; front and vertex clothed with short and erect brownish hairs. Antennae short and tawny; 3rd joint circular with a black upper edge; arista black. Face vertical below antennae but produced above oral margin (fig. 10); bare and shiny pale yellow with a dark-brown central spot on protuberance; cheeks pale yellow and clothed with short pale hairs; occiput black; proboscis and palpi dark yellow.

Dorsum of thorax shiny black-brown, tawny on alar calli and on each side posterior to transverse suture; humeri, pleurae, and halteres tawny; scutellum brown; legs tawny, the posterior tarsi somewhat darker. Wings more or less blunt at apex; a brown cloud at apex between veins R_1 and R_{4+5}; articulation tawny; wings otherwise clear and iridescent; squamae tawny. (Plate XLVII, fig. 6.)

Abdomen (fig. 13) shiny blackish-brown, elongate and narrow, somewhat narrowed basally; 1st segment with a tawny tuberculate swelling on each side of scutellum; 3rd and 4th segments each with a pair of elongate dark-yellow spots directed upward from the sides toward the centre; genitalia brownish-yellow.

♂. Length, 6·5 mm.

Holotype: No. 273, D. M.

Habitat.—Purakanui.

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* *Trans. N.Z. Inst.*, vol. 52, p. 34 (1920)

Genus CHEILOSIA Panz. (1809).

Rather robust flies, more or less rectangular in outline ; wings sometimes not extending beyond abdomen ; eyes bare or hairy, holoptic or dichoptic in the male, broadly dichoptic in the female ; head more or less rectangular in profile ; face with a prominent central knob ; antennae of species described below lying flat on face, the 3rd joint orbicular ; legs at times peculiarly haired, the anterior and posterior tibiae and tarsi sometimes broadened.

Two of the four new species described below—*C. howesii* and *C. leptospermi*—are represented one by a female and the other by a male ; they are singularly similar in many respects—so much so that they might readily be taken for the one species. However, I think there is sufficient reason to separate them, mainly on the character of the anal angle and alula of the wing, which are so markedly different in the two. The other two species are quite distinct.

TABLE OF SPECIES.

1	Anal angle of wing nearly right-angled ; alula long and narrow, reaching almost to anal angle ; abdomen dull bronzy blue, the apical segment brilliant cupreous	*leptospermi* n. sp.
	Anal angle and alula normal	2
2	Thorax and abdomen blue-black, the latter broadest across the middle ; length, 9 mm.	*cunninghami* n. sp.
	Thorax bronzy or cupreous ; abdomen rectangular	3
3	Thorax shiny bronze ; abdomen violet-blue and comparatively short ; length, 6 mm.	*howesii* n. sp.
	Thorax brilliant cupreous ; abdomen dull blackish-brown and rather elongate ; length, 10 mm.	*ronana* n. sp.

C. leptospermi n. sp.

A rather small, short-bodied, immaculate fly with the anal angle and alula of the wing well developed.

♂. Eyes bare, holoptic, somewhat coppery ; long black erect hairs on vertex ; front and ocellar triangle bronzy, the former clothed with silvery or greyish hairs ; lunular area shiny dark-blue, unusually large and semicircular. Antennae short, broadly separated at insertion, and lying flat on face (fig. 14) ; 1st and 2nd joints bare, bronzy, together a little longer than the 3rd, which is short, orbicular, and reddish-brown ; arista reddish-brown, short and thick but abruptly tapering apically. Face bronzy-black with a dense greyish pubescence and scattered silvery hairs, the protuberances bare ; face (fig. 15) descending slightly forward beneath antennae and thence abruptly outward to the prominent knob, below which at the oral aperture is a truncated protuberance which, in front view, is cup-shaped and divided by a perpendicular median ridge ; below this, on each side, the lower angles of the face are rounded, swollen, and somewhat descending ; oral margin shiny blue-black ; a shiny blue-black stripe running diagonally forward from the cheeks at oral margin on to the face between the orbits and anterior oral margin ; cheeks blue-black clothed with a greyish tomentum and scattered silvery hairs ; occiput shiny deep blue ; proboscis and palpi blackish-brown.

Thorax and scutellum shiny cupreous, the sternopleurae rather blackish blue ; dorsum clothed with short white hairs, becoming longer on the meso- and ptero-pleurae ; pleurae with a greyish reflection. Legs purplish-black and coppery, somewhat shiny ; the tibiae, which are rather swollen apically, are brown at extremities ; knees brown ; on the underside of the anterior tibiae apically, and the pro- and meso-tarsi is a brush of long brown hairs, the protarsi being elongated (fig. 16); on the middle legs this brush is represented by short stiff hairs ; posterior tibiae yellowish-brown on basal part, strongly bent and swollen apically (fig. 17) ; posterior tarsi with a short golden brush beneath, the protarsus not quite half the length of the whole joint and somewhat swollen ; anterior and middle femora with scattered greyish hairs ; all the tibiae and tarsi clothed with short hair-like bristles ; the onychotarsi bristly, a few of the bristles being long and delicate ; claws large ; pulvilli with numerous papillae ; posterior coxae with silvery hairs. Wings (fig. 2) slightly tinged with brown ; veins and stigma brown ; cross-veins slightly clouded ; alula long and narrow, reaching almost to

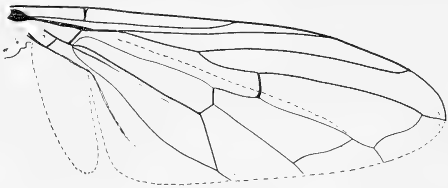

FIG. 2.—*Cheilosia leptospermi* n. sp. : wing.

anal angle which is strongly developed and in line with posterior margin of the wing, squamae and anti-squamae opal-white, the former fringed with long rigid white hairs and the latter with short ones ; halteres brown.

Abdomen rectangular in outline, clothed with scattered short white hairs lengthening along the sides of 1st and 2nd segments ; each segment transversely rugose ; apical segment brilliant cupreous, the remainder dull bronzy-blue ; genitalia brownish.

♂. Length, 6·5 mm.

Holotype : No. 524, D. M.

Habitat.—Wallacetown (A. Philpott).

C. howesii n. sp.*

A rather small robust shiny bronze fly with no colour-pattern.

♀. Eyes bare, comparatively small, broadly dichoptic ; ocellar triangle black clothed with a few hairs ; front broad, shiny bronze, clothed with conspicuous dark-brown hairs which are longer and more erect across vertex; lunular area large and deep blue. Antennae short, lying flat on face, well separated basally ; 1st and 2nd joints black, somewhat longer than the 3rd, and destitute of hairs or bristles; 3rd joint orbicular though rather quadrangular, dark reddish-brown with a lighter reflection caused by a minute pubescence ; arista short, stout, dark reddish-brown, and minutely pubescent. Face shiny, deep blue, clothed with a silvery pubescence and scattered short silvery hairs except on protuberances ; in profile (fig. 18) straight but running forward to tubercle, below which the oral margin projects as a pointed protuberance ; lower facial angles rounded at oral cavity ; cheeks shiny bronzy-black but greyish in some lights and clothed with silvery hairs ; occiput black with erect greyish hairs above ; proboscis blackish-brown, palpi brown.

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* Named after Mr. W. G. Howes, of Dunedin.

Thorax and scutellum clothed with short greyish hairs; shiny bronze, the pleurae with a greyish reflection and the scutellum at times somewhat bluish. Legs robust; blue-black, the knees brownish; the tibiae rather thickened apically and clothed with short and scattered silvery hairs; anterior tibiae with minute, erect, bristle-like hairs along lower side; anterior and middle protarsi with a brush of short bristles beneath, the former joint rather short; posterior protarsi somewhat elongate and with a short golden brush beneath; all the femora sparsely haired and the tarsi minutely bristly, a bristle at the angle of each joint being rather conspicuous; anterior and middle tarsi flattened. Wings comparatively short, very slightly tinged, the veins and stigma brown; anal angle and alula normal; squamae and anti-squamae brown, the former fringed with long brown hairs and the latter with short ones; halteres pale brown.

Abdomen elongate-quadrangular, not transversely rugose, dull violet-blue, and clothed with minute and scattered silvery hairs which form a longer fringe on each side of the basal segment.

♀. Length, 6 mm.

Holotype: No. 879, D. M.

Habitat.—Kevis (W. G. Howes).

C. cunninghami n. sp.*

A moderate-sized blue-black fly with no colour-pattern and superficially resembling *Xylota montana* and *Lepidomyia decessum.*

♀. Eyes bare, widely dichoptic, comparatively small; front clothed with strong black hairs, broad, widening anteriorly, shiny blue-black, a transverse furrow across the middle; ocellar triangle black clothed with a few delicate hairs; lunular area black, produced slightly between the base of the well-separated antennae, which lie on the face; 1st and 2nd antennal joints black, the former fringed with greyish hairs, the latter clothed with very short and scattered ones; 3rd joint orbicular though rather elongate, brownish but black in some lights; arista black, minutely pubescent, short and stout but tapering apically. Face broad, shiny blue-black with a greyish reflection, and clothed with strong black hairs; face, in profile, somewhat convex below antennae but running forward to the abrupt knob just beneath the 3rd antennal joint (fig. 19); anterior oral margin produced below facial knob and surrounded by a three-sided right-angled furrow; a small swelling on each side of oral process; lower angles of face swollen and produced downward, the oral margin thus descending anteriorly (fig. 19); cheeks clothed with strong brown and black hairs; occiput swollen along orbits, blue-black but brownish in some lights, and clothed with greyish hairs, which become long and erect at vertex; proboscis shiny blue-black to brown; palpi long and styliform, black at base but brownish apically.

Thorax and scutellum shiny blue-black, clothed with grey or silvery hairs, which become longer on the pleurae. Wings tinged with brown, veins brown, stigma pale brown; the arculus arising from medius; squamae and anti-squamae blackish-brown, pale beneath; the former with a long and the latter with a short fringe of pale-brown hairs; halteres brown. Legs blue-black, the apex of femora and base of apex of tibiae brownish;

* Named after Mr. G. H Cunningham, of the Government Biological Laboratories.

femora clothed with long brownish to black hairs; tibiae with a short and stiff greyish vestiture, the anterior and posterior—particularly the former—swollen apically; tarsi golden-brown beneath, caused by a brush of short rigid hairs; anterior tarsi (fig. 21) very much broadened and shortened, the protarsus being very little longer than the following joint; posterior protarsi elongate and slightly thickened; claws apically black, otherwise reddish-brown.

Abdomen blue-black, rather shiny; elongate but broader across the middle; clothed with delicate grey hairs, longer on the sides, and with indistinct rigid black ones towards the sides of each segment; surface indistinctly transversely rugose.

♀. Length, 9 mm.

Holotype: No. 1233, D. M.

Habitat.—Day's Bay.

C. ronana n. sp.

A medium-sized somewhat hairy elongate fly with a brilliant coppery thorax and brownish-black abdomen.

♂. Eyes bare, dichoptic; ocellar triangle black, clothed with short brownish-yellow hairs; front somewhat swollen, dull blue-black but with a greyish reflection, densely clothed with blackish hairs; lunular area semicircular and black; 1st antennal joint blue-black; 2nd joint brownish; 3rd ovate, brick-red, darker in some lights, and with pale-grey reflections; arista black. Face more or less vertical (fig. 20); shiny greenish-black; clothed with a dense greenish-grey tomentum except on the protuberances—one below end of antennae and the other above oral margin; cheeks greenish-black, clothed with short silvery hairs, which extend over the blue-black occiput particularly along the orbits.

Thorax and scutellum brilliant cupreous, with blacker reflections; clothed with short yellowish hairs, longer on the scutellum and pleurae and forming a distinct fringe on the dorsum across the scutellar suture. Wings slightly tinged with brown, stigma pale brown, veins brown; vein M_1 angulated and with a stump from this point into cell R_5 (fig. 22)*; squamae and anti-squamae tinged with pale brown; halteres golden-yellow. Legs brownish-yellow with an indistinct fuscous spot in the centre of femora and tibiae; posterior tibiae and protarsi somewhat swollen; tarsi, except the anterior and middle protarsi, blackish-brown; posterior tarsi with a golden reflection beneath caused by the vestitute.

Abdomen elongate, the sides parallel; clothed with short silvery hairs, longer at the sides; dull blackish-brown (though somewhat reddish), except the shiny greenish-black basal segment; the sides of each segment narrowly cupreous; a pair of indistinct greyish spots, caused by the vestiture, and seen best with the unaided eye, across the anterior margin of 3rd and 4th segments.

♂. Length, 10 mm.

Holotype: No. 1239, D. M.

Habitat.—Rona Bay (E. H. Atkinson).

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* Frequently too much importance has been placed upon the presence or absence of stump veins; I have frequently found that a stump, though present on the wings of some specimens of the same species, may be absent in others; the wings of the one specimen may even vary in this respect.

Genus SYRPHUS Fabr. (1775).

In this genus the face, which is vertical, though slightly concave, and gently produced to the knob, is yellow, with or without a darker median stripe, or altogether melanoid; the antennae are short, the 3rd joint being circular or somewhat oval; the dorsum of the thorax may be immaculate or margined with yellow; the scutellum is completely or partially yellow, altogether blackish or at times diaphanous; the pleurae may have yellow markings; the legs are rather slender, the femora not being thickened; in the wings the *r–m* cross-vein is considerably before the middle of cell 1st M_2, and the vein R_{4+5} is straight, or practically so, above cell R_5; the abdomen is elongate, somewhat ovate, narrow with parallel sides or restricted along the middle segments; it is usually spotted or banded with yellow or, as in two of the new species, immaculate.

Of the seven species recorded below, three are new. The resemblance of *S. ropalus* Walk. to *Paragus pseudo-ropalus* n. sp. has already been noted, while in a former work* the writer has pointed out that *S. obesus* Hutton = *S. viridiceps* Wied., an Australian species.

TABLE OF SPECIES.

1	Abdomen immaculate, either blue-black or orange-brown ..	2
	Abdomen spotted or banded with yellow	3
2	Face blue-black, golden-pruinose; abdomen orange-brown; length of ♀, 11 mm.	*harrisi* n. sp.
	Face tawny, with a median blue-black stripe extending broadly along oral margin (fig. 24); abdomen deep shiny blue; length of ♀, 6 mm.	*flavofaciens* n. sp.
3	Abdomen spotted and with 2 transverse bands, one on the 3rd and the other on the 4th segment	4
	Abdomen not banded but with pairs of spots on segments ..	5
4	Robust species; abdomen broad, bands occupying most of 3rd and 4th segments; antennae ochreous; pleurae with a tawny transverse band	*viridiceps*, ♂.
	Slender species; abdomen narrow, bands confined to anterior half of 3rd and 4th segments; antennae brownish-black; no band on pleurae	*ropalus.*
5	Front without yellow markings	*novae-zealandiae.*
	Anterior half of front partly or completely ochreous	6
6	Robust species; abdominal spots large, occupying greater part of segments; pleurae with a tawny band	*viridiceps*, ♀.
	Slender species, particularly the males; abdominal spots not large; no band on pleurae, at most mesopleurae partially yellow	7
7	Face with a blackish central stripe; abdomen of ♂ with 4 pairs of oblique spots but not especially narrowed along middle; length, 6–9 mm.	*ortas.*
	Face without a blackish central stripe; at most with a darker yellow marking; abdomen of ♂ very narrow, with 3 pairs of oblique spots, and restricted along the middle; length, 10–10·5 mm.	*hudsoni* n. sp.

S. harrisi n. sp.† (Plate LII, fig. 2.)

♀. A rather large fly, with a brilliant cupreous thorax, orange-brown abdomen, and wings tinged with tawny.

Eyes bare; ocelli pale yellow; front blue-black, clothed with scattered yellow hairs which are confined more toward the upper orbits; lower frontal

* Diptera of the Kermadec Islands, *Trans. N.Z. Inst.*, vol. 46, p. 126 (1914).

† Named after Mr. J. R. Harris, of Ohakune.

orbits broadly yellow, due to a pubescence which extends over the facial orbits; antennae orange-red, 3rd joint oval with a black upper edge; arista reddish-black; a tawny spot above the root of each antenna. Face slightly concave between antennae and knob; blue-black, but golden-pruinose on each side of knob and upwards beneath antennae; clothed also with short and scattered golden hairs; mouth-parts brownish-yellow; occiput depressed, black but yellow-pruinose and shortly haired along orbits.

Thorax brilliant cupreous; humeri tawny but whitish in some lights; alar angles to wings tawny; a narrow pale-yellow stripe from humeri to wings; halteres tawny. Wings large, with a tawny tinge except basally; stigma orange-red, veins brown; nodule of vena spuria connected by a cross-vein with vein R_{4+5} (fig. 23). Legs tawny, the anterior tibiae and posterior protarsi very slightly thickened.

Abdomen elongate-quadrangular, the sides almost parallel; brownish-yellow with indistinct and irregular blackish markings.

♀. Length, 11 mm.

Holotype: No. 1201, D. M.

Habitat.—Okakune (J. R. Harris); Karori (G. V. Hudson).

S. flavofaciens n. sp.

♂. A medium-sized dark-blue elongate fly with no abdominal markings but with a yellow spot on each side of thorax.

Eyes bare, somewhat approximated on vertex; front shiny dark-blue, clothed with short brownish hairs; two crescentic incisions on lunular area behind roots of antennae, which are brown in colour but darker basally; 3rd joint ovate; arista black. Face (fig. 24) tawny with a greyish-yellow tomentum and a median shiny blue-black stripe which is continued broadly along oral margin over the cheeks and produced upward at a point to facial orbits anterior to cheeks; posterior angle of oral cavity tawny on each side and beneath; occiput blue-black, posterior orbits with short silvery hairs; proboscis and palpi blue-black, the labella tawny.

Thorax shiny blue-black, clothed with short black hairs; a tawny area on the meso- and ptero-pleurae; scutellum blue-black with a bronzy tinge and tawny apex. Legs brownish-black, the femora testaceous basally; anterior legs somewhat lighter in colour. Wings clear or slightly tinged with brown; stigma brown, veins brownish-yellow; squamae and anti-squamae white; halteres brownish-yellow.

Abdomen elongate, shiny deep-blue, slightly narrowing at base, and clothed along sides with short and delicate whitish hairs; genital segments brownish.

♂. Length, 7 mm.

Holotype: No. 525, D. M.

Habitat.—Wallacetown (A. Philpott); Dunedin (W. G. Howes).

S. hudsoni n. sp.*

A medium-sized fly with yellow spots on the abdomen.

♂. Eyes bare, narrowly dichoptic, angulated half-way down the front, where there is a transverse groove, posterior to which the front is narrow and bronzy but anteriorly widens and is tawny on each side of a narrow

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* Named after Mr. G. V. Hudson, of Karori.

median greenish-blue stripe restricted in the middle (fig. 25); front clothed with brownish hairs; ocellar triangle elongate and situated forward from vertex. Antennae orange-yellow, with a broad dark-brown upper edge; 3rd joint oval; arista blackish-brown. Face minutely hairy, abruptly receding to oral margin below knob (fig. 26); general colour pale yellowish-green, with a darker, somewhat yellowish median stripe and a blackish reflection along orbits to lower eye-angle; cheeks yellow; mouth-parts brown; occiput black, posterior orbits silvery.

Dorsum of thorax shiny greenish-black, clothed with short pale hairs; a short yellow stripe on each side between humerus and wing; pleurae greenish-black, the metaplurae somewhat pale yellowish; scutellum ochreous but darker basally and clothed with tawny hairs. Wings clear though faintly tinged distally; stigma and veins brown; vena spuria, which arises at origin of R_{2+3}, has a stump from lower side of the nodule; just behind cell 1st M_2, vein M is slightly sinuated, and arising from proximal end of this sinuation is an indistinct vein-like structure which, arising vertically, turns abruptly forward parallel to vein M and crosses into cell 1st M_2 (fig. 27); halteres tawny. Anterior and middle legs ochreous, the posterior pair brown except for the ochreous basal half of the femora.

Abdomen black, clothed with delicate brownish marginal hairs; elongate and narrow, slightly restricted along each side; 2nd, 3rd, and 4th segments each with a pair of oblique ochreous spots (figs. 28); genital segments brownish.

The female differs from the male in the elongate ovate abdomen, which has a pair of more transverse and pointed spots on the 2nd, 3rd, 4th, and 5th segments.

♂. Length, 10 mm. ♀. Length, 10·5 mm.

Holotype: No. 1234, D. M.

Habitat.—Karori (G. V. Hudson).

S. novae-zealandiae Macq. (Plate XLVII, fig. 7.)

S. novae-zealandiae Macquart, *Dipt. Exot., Suppl.* 5, p. 115 (1885); Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 40 (1901); *Cat. Dipt. N.Z.*, p. 44 (1881); Miller, *Trans. N.Z. Inst.*, vol. 42, p. 230 (1910); *l.c.*, vol. 46, p. 126 (1914). *S. ortas*, Hudson, *Man. N.Z. Ento.*, p. 56 (1892).

A medium-sized fly with bronzy-black thorax and black abdomen spotted with orange-red, ochreous, cream, or white.

♂ Eyes holoptic and bare; front bronzy-green, vertex black, both clothed with erect black hairs, those on the front appearing as a tuft in profile; lunular area shiny black, the anterior margin brownish; frontal orbits narrowly silvery in some lights. Antennae with the first 2 joints black, the 3rd brownish and oval; arista black with a very minute and scattered pubescence (fig. 29). Face shiny, rather bronzy, but covered with a dense greyish-brown pubescence and scattered black hairs; knob shiny blue-black, below which the oral margin is shiny brownish-black, this colour extending across the face to the orbits as an oblique band (fig. 30); remainder of oral margin greyish-brown, except posteriorly, where it is tawny or orange-red, which in some specimens may extend on to the occiput as a broad area; cheeks pale greyish-brown, silvery along the orbits, and clothed with white hairs; proboscis black with a brown labella;

palpi tawny, the apical joint with a long yellow bristle below and one apically ; occiput black with a greyish reflection.

Dorsum of thorax shiny blackish-green to bronzy, with a vestitute of pale hairs ; scutellum shiny bronzy but yellowish apically and clothed with long pale hairs ; pleurae dull cupreous with darker and greyish reflections, and clothed with greyish to brown hairs. Anterior coxae elongate and black ; anterior and middle legs brownish, the base of the femora brownish-black, the apex of the tarsi fuscous ; posterior legs brownish-black, particularly the tarsi, the knees lighter ; all the femora with pale hairs beneath on basal half. Wings clear, veins and stigma brown ; a supernumerary humeral cross-vein sometimes present ; the supernumerary vein arising from vein M and already noticed in *S. hudsoni* (fig. 27) is quite distinct and vein-like in some specimens of *S. novae-zealandiae ;* halteres pale brown.

Abdomen (fig. 34) somewhat rectangular, the sides more or less parallel ; dull velvet-black, with a pair of ochreous, cream, orange-red, or white elongate and transverse spots on the 2nd, 3rd, and 4th segments. The variation in the colour of these spots is dependent to a great extent upon the age of the fly ; it is frequently found that some of the spots on the one individual may be of one tint and others lighter or darker ; newly-hatched specimens are semitransparent, the darker colours developing with age. The abdomen is clothed with short and stiff black hairs, with a fringe of silvery ones on each side of basal segment. The genital segments and genitalia are black, and their form is shown in fig. 32.

♀. Eyes dichoptic ; front and vertex shiny blue-black ; antennae black, 3rd joint with a reddish area on lower side at base ; a yellowish-brown area at articulation of antennae. Face with a central shiny blue-black stripe ; an oblique band running from anterior oral margin to orbits as in male ; otherwise face, cheeks and oral margin are brick-red, ochreous, or grey (fig. 31).

Thorax clothed with pale hairs ; dorsum brilliant cupreous-green ; pleurae and scutellum as dorsum, but the former with dull-black and greyish reflections and the latter diaphanous greenish-yellow apically ; the colour of the scutellum may be lighter or almost totally black.

Abdomen (fig. 35) rather ovate, with a pair of spots, which vary in colour as in the male, on 2nd, 3rd, 4th, and 5th segments.

♂ and ♀. Length, 9–11 mm.

Plesiotype : No. 1235, D. M.

Habitat.—Abundant throughout New Zealand, the Kermadec and Chatham Islands ; Hutton states that it has been recorded from Polynesia. The adults are on the wing from spring to autumn in the southern parts of the South Island, but in Nelson, Marlborough, and the warmer parts of the North Island they are to be found in varying numbers throughout the year. The eggs are usually laid singly upon plants, and the larvae (Plate XLVIII, fig. 1) feed upon caterpillars and aphids.

S. ortas Walker.

S. ortas Walker, *Cat. Dipt. Brit. Mus.*, p. 585 (1849) ; Hutton, *Cat. Dipt. N.Z.*, p. 43 (1881) ; *Trans. N.Z. Inst.*, vol. 33, p. 41 (1901).
S. rectus Nowicki, *Mem. Krakauer Akad. Wissen.*, 2, p. 24 (1875) ; Hutton, *Cat. Dipt. N.Z.*, p. 44 (1881).

A medium-sized fly with a brilliant bronze-green or blue-green thorax, yellow scutellum, and yellow-spotted brown abdomen.

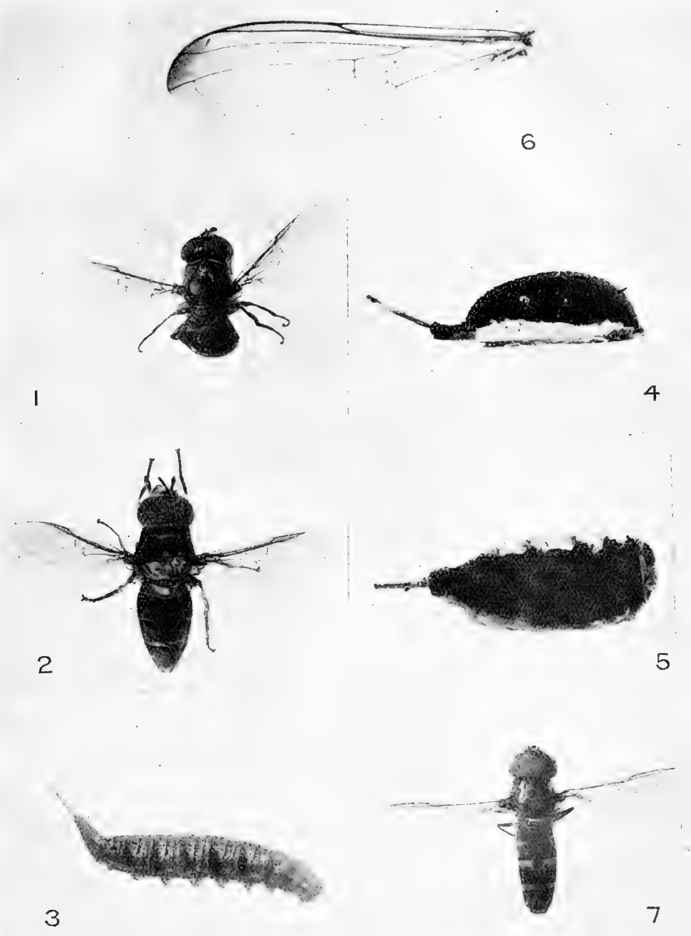
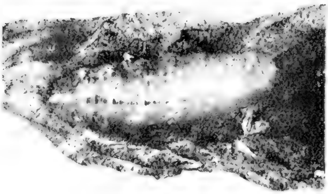


Fig. 1.—*Lepidomyia decessum*: adult female, showing abdomen in natural position. × 2½.
Fig. 2.—*L. decessum*: adult male, showing abdomen straightened. × 3.
Fig. 3.—*L. decessum*: larva. × 4.
Fig. 4.—*L. decessum*: pupa, side view. × 4.
Fig. 5.—*L. decessum*: pupa, dorsal view. × 4.
Fig. 6.—*Sphaerophoria ventralis* n. sp.: wing. × 8.
Fig. 7.—*Syrphus novae-zealandiae*: adult male. × 2½.



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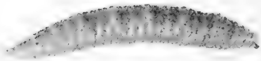

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Fig. 1.—*Syrphus novae-zealandiae:* larva on leaf. × 6.
Fig. 2.—*S. ropalus:* larva, side view. × 4.
Fig. 3.—*S. ropalus:* empty pupa, from above. × 5.
Fig. 4.—*S. viridiceps:* adult male. × 3.
Fig. 5.—*Platycheirus lignudus* n. sp.: adult female. × 4.
Fig. 6.—*Melanostoma fasciatum* eggs on a grass-head. Magnified.

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Fig. 1.—*Melanostoma fasciatum* larva on a leaf. × 8.
Fig. 2.—*Xylota montana* n. sp.: adult female. × 4.
Fig. 3.—*Tropidia bilineata*: adult female. × 3.

Fig. 1.—*Helophilus antipodus*: adult male. × 4.
Fig. 3. *H. hochstetteri*: adult female. × $2\frac{1}{3}$.

Fig. 2.—*Mallota cingulata*: adult female. × 3.
Fig. 4.—*Helophilus antipodus*: adult female. × $3\frac{1}{3}$.

♀. Eyes bare; front brilliant cupreous, with a brilliant pink transverse reflection in front of ocellar triangle, and clothed with a sparse brown pile causing a pale-brown reflection. Face greenish-yellow, this colour extending upward on each side to a point along frontal orbits; face clothed on each side with a short yellow pile; a median blue-black stripe extending from lunular area to mouth (fig. 33); cheeks and oral margin ochreous, the former clothed with a short yellow pile which extends over the occiput. Antennae short, brownish-yellow with darker markings particularly along the upper and front edges of the short rather truncated 3rd joint; arista dark brown; mouth-parts brown; occiput greyish-black, but in some cases tawny below, this colour extending from oral margin.

Thorax brilliant bronzy-green with a vestiture of short delicate hairs; a pale-yellow area on each side between the wing and humerus, and extending in certain lights as pale brownish-yellow over the mesopleurae; scutellum amber-yellow, clothed with delicate pale hairs. Wings clear and iridescent, the stigma brownish-yellow, veins tawny; halteres amber-yellow. Femora ochreous, but brownish distally, the posterior pair distinctly so; tibiae pale-brownish, the posterior darker centrally; tarsi brown.

Abdomen linear but somewhat broader anterior to centre (fig. 36); shiny dark-brown; delicate pale hairs on sides of 1st and 2nd segments; a pair of distinct transverse linear ochreous spots on 2nd, 3rd, and 4th segments, and a pair of indistinct brownish spots on 5th segment.

♂. Smaller and more slender than ♀; thorax shiny bronzy-black and scutellum clothed with short and scattered black hairs; the abdomen is more hairy, elongate and narrow, and the spots are broader and somewhat oblique; genitalia tawny.

♂. Length, 6 mm. ♀. Length, 9 mm.

Plesiotype: No. 1236, D. M.

Habitat.—Throughout New Zealand from August to May. The colour-markings of this species may be darker or lighter.

S. ropalus Walker.

S. ropalus Walker, *Cat. Dipt. Brit. Mus.*, p. 593 (1849); Hutton, *Cat. Dipt. N.Z.*, p. 44 (1881); *Trans. N.Z. Inst.*, vol. 33, p. 41 (1901); Miller, *N.Z. Jour. Agric.*, vol. 21, p. 335 (1920); Miller and Watt, *Trans. N.Z. Inst.*, vol. 47, p. 278 (1915).

A medium-sized fly with the face and sides of thorax yellow, 2 pairs of abdominal spots and 2 transverse bands, one on the 3rd and the other on the 4th segment. This species bears a superficial resemblance to *Paragus pseudo-ropalus* n. sp.

♀. Eyes bare; vertex and upper part of front bronzy-black to purple, lower half greenish-yellow, with a narrow median tawny stripe seen in some lights; the whole thinly clothed with short black hairs; 1st and 2nd joints of antennae tawny and with black bristles, the 2nd joint somewhat darker apically; 3rd joint ovate but rather blunt at apex, brownish-yellow but blackish-brown over upper edge, and clothed with minute greyish pubescence, which also covers the blackish-brown arista; lunular area tawny. Face greenish-yellow, gently produced to brown knob, above which is an indistinct median blackish-brown stripe; anterior oral margin brownish, the lower angles of face rather tawny; oral margin and cheeks yellowish-green, the latter and the face clothed with short pale hairs; occiput tawny in ground-colour but with blackish and greyish reflections and clothed with delicate pale hairs; proboscis and palpi brownish-yellow.

Dorsum of thorax clothed with short brownish hairs; shiny bronzy and broadly margined with yellowish-green on each side anterior to wings; humeri yellowish-green; alar regions rather brownish; scutellum yellowish-green to tawny, thinly clothed with short black hairs; pleurae clothed with pale hairs, greenish-yellow except for anterior margin of mesopleurae and upper and lower parts of sternopleurae (that is, sternopleurae with a longitudinal band of greenish-yellow). Femora tawny, brownish to black apically, particularly the posterior pair; clothed with short black bristle-like hairs apically, but with delicate pale hairs below basally; anterior and middle tibiae tawny with minute black apical bristles and clothed with short tawny hairs; posterior tibiae brownish-yellow and apically brownish to black; clothed with short, bristle-like black hairs; tarsi with a short golden brush and minute black bristles beneath, otherwise clothed as posterior tibiae; anterior and middle tarsi tawny, with darker reflections, the posterior brownish to black. Wings clear, the stigma slightly clouded, veins pale-brown; squamae tawny; halteres tawny to greenish-yellow.

Abdomen (fig. 37) shiny brownish-black, clothed with short blackish hairs, longer and tawny along sides of 1st and 2nd segments; 1st segment tawny; 2nd and 5th with a pair of broad tawny or orange spots; 3rd and 4th each with a tawny or orange transverse band, the posterior margin of each band being deeply notched and the anterior somewhat sinuated; posterior angles of 5th segment indistinctly tawny; 6th segment rather brownish on each side.

The male is smaller and more slender than the female, the markings are darker, and the abdominal spots more oblique; the genitalia are tawny.

Pre-adult Stages.—The full-grown larva (Plate XLVIII, fig. 2) measures 12·5 mm. in length; it is greenish-yellow in colour, and the soft corrugated skin is semitransparent, showing the organs within the body; on the sides of each segment is a short leg-like projection, while on the terminal segment a pair of approximated, testaceous respiratory organs project upward. The larvae are to be found in considerable numbers living in company with the larvae of *L. decessum* in the gum-fluid which collects in the leaf-bases of the Maori flax (*Phormium tenax*), where they feed upon the larvae of a Chironomid, and to a less extent upon those of *L. decessum.* After nightfall they frequently leave the gum-fluid and crawl about the leaves of the *Phormium* in search of flax-grubs (larvae of *Xanthorhoe praefectata*). They are also to be found upon the leaves of the cabbage-tree (*Cordyline australis*), where they attack the larvae of *Venusia verriculata.* Pupation takes place on the dead flax and cabbage-tree leaves; the pupa (Plate XLVIII, fig. 3), which measures 8·5 mm. in length, is club-shaped and elongated, being strongly arched anteriorly but more or less flattened and tapering posteriorly; it is of a light-brown colour, with a series of longitudinal dark-brown stripes running the full length of the body; a pair of respiratory organs project from the posterior end.

♂. Length, 6 mm. ♀. Length, 8 mm.

Plesiotype: No. 1237, D. M.

Habitat.—Throughout New Zealand. The adults are very abundant from August to April in the vicinity of flax-bushes and cabbage-trees.

S. viridiceps Wied.* (Plate XLVIII, fig. 4.)

S. viridiceps Wied., Miller, *Trans. N.Z. Inst.*, vol. 46, p. 126 (1914).
S. obesus Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 41 (1901).

This species is very abundant in Australia, and is fairly common in the North Auckland Peninsula as far north as Parengarenga ; it is also common on the Kermadec Islands.

Both sexes are robust ; eyes bare, holoptic in male ; face orange or greyish-yellow with a darker median stripe ; upper part of front in female shiny black, this colour forming a median stripe along the orange-yellow lower front. Antennae orange-brown. Dorsum of thorax shiny purplish-black, margined with tawny on each side ; pleurae with a tawny transverse band ; thorax of male thickly haired, but sparsely so in the female ; scutellum tawny, orange- or brownish-yellow ; legs tawny ; femora blackish-brown proximally ; tarsi fuscous. Wings clear ; halteres tawny.

Abdomen ovate and broad ; shiny black between the tawny markings ; basal segment somewhat bluish ; 2nd, 3rd, 4th, and 5th segments mostly occupied by tawny or orange-red markings, forming a pair of large spots on the 2nd and 5th segments and a broad band on the 3rd and 4th segments in the male ; in the female the markings consist of a pair of large spots narrowly interrupted in the middle of the 2nd to 5th segments.

♂. Length, 8 mm. ♀. Length, 8·5 mm.

Genus Melanostoma Schiner.

Eyes bare, holoptic in male ; antennae short, 3rd joint oval ; arista pubescent or bare. Face slightly produced to knob, black or metallic in ground-colour and frequently pruinose. Thorax black or metallic, usually brilliant ; legs normal, yellow or fuscous. Abdomen with or without yellow markings, ovate in female but more or less rectangular in male.

Table of Species.

Abdomen with yellow markings	*fasciatum.*
Abdomen immaculate	*apertum.*

M. fasciatum Macq.

Plesia fasciata Macquart, *Dipt. Exot., Suppl.* 4, p. 461, pl. 14, fig. 15 (1880). *Melanostoma fasciatum* Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 42 (1901) ; *Cat. Dipt. N.Z.*, p. 45 (1881).

A very common, rather small fly, readily recognized by the bright-yellow markings of the abdomen.

♂. Eyes bare, holoptic ; vertex black, clothed with very short black hairs ; ocelli orange ; front shiny brownish-black clothed with short black hairs. Antennae (fig. 41) somewhat elongate ; 1st joint black ; 2nd black basally, reddish-yellow apically ; 3rd tawny, sometimes rather reddish, oval, pubescent, and with a black area at apex extending over upper edge to base of arista, which is reddish-brown and pubescent ; lunular area with a reddish-yellow spot on each side at base of antennae. Face shiny bronzy-black, greyish-pruinose, sparsely clothed with silvery hairs ; its

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* I am indebted to Mr. W. W. Froggatt, Government Entomologist, New South Wales, for checking the identification of this species.

outline shown in fig. 38 ; cheeks black with a greyish reflection ; proboscis and palpi black, the latter sometimes brownish ; occiput black with greyish reflections.

Thorax brilliant bronze, with a tawny pubescence on dorsum ; scutellum brilliant blue-black. Legs tawny, sometimes fuscous, with tawny knees. Wings clear, iridescent ; veins and stigma brown ; halteres pale yellow.

Abdomen elongate, rectangular, the sides almost parallel ; shiny blackish-brown, but mostly occupied by the tawny or orange-red spots on the 2nd, 3rd, and 4th segments (fig. 39) ; the spots on the 2nd segment are the smallest, those on the 3rd and 4th occupy the whole of each segment except for a narrow median stripe and a band across the posterior margin which widens at the sides. The genitalia are tawny, the structure of the genital segments being shown in fig. 43.

♀. Eyes dichoptic ; front and vertex shiny black and clothed with short black hairs ; a narrow silvery reflection along frontal orbits ; a narrow transverse brownish band constricted in the middle and followed by a suture to be seen in some lights across the middle of front. Antennae altogether tawny except for a blackish apical area.

Thorax shiny bronzy-black ; scutellum shiny black ; the whole clothed with a tawny pubescence. Legs ochreous, the posterior tibiae distally and the tarsi fuscous.

Abdomen (fig. 40) ovate, shiny blue-black with a pair of ochreous spots on the 2nd, 3rd, 4th, and 5th segments, the last pair transverse, the remainder rather dome-shaped, those of the 2nd and 3rd segments narrowing to the sides ; apex of retracted segments tawny.

The intensity of the abdominal spots varies according to location and age : in the milder parts of the country they are more tawny, but in warmer localities they are of a rich orange-red.

The female deposits her yellowish eggs (Plate XLVIII, fig. 6) in pairs or sometimes singly upon plants infested with aphides and lepidopterous larvae. The larvae of *M. fasciatum* are yellowish and semitransparent with a darker medio-longitudinal stripe ; at the anterior end is a smooth shiny area. Plate XLIX, fig. 1, shows one of the larvae at rest on the underside of a rape-leaf. Large numbers of aphides and the larvae of the diamond-back moth (*Plutella maculipenis*) are destroyed by this syrphid. The pupae are short, club-shaped, and brownish, and may be found attached to the underside of leaves frequented by larvae.

♂ and ♀. Length, 6 mm.

Plesiotype : No. 1238, D. M.

Habitat.—Throughout New Zealand, from spring to autumn.

M. apertum Hutton.

M. apertum Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 42 (1901).

Hutton's type, the only specimen as yet known, has lost the 2nd and 3rd joints of one antenna and the 3rd of the other. Owing to the length of the existing 2nd joint, it is doubtful if this species belongs to *Melanostoma ;* however, it is retained here for the present until complete specimens are procured.

A small shiny blue-and-black fly with tawny legs and no colour-pattern.

♀. Eyes bare, dichoptic ; front and face shiny bronzy-black with a greyish tomentum ; ocelli yellowish, the ocellar triangle with delicate erect hairs; 1st and 2nd antennal joints black with a brownish or greyish tomentum; the 2nd joint elongate, reaching toward the facial prominence; outline of face as in *fasciatum;* mouth-parts withdrawn, black but tawny apically.

Thorax and scutellum shiny bronzy-black, sparsely clothed with delicate silvery and brown hairs; the ptero- and sterno-pleurae rather brownish. Wings faintly tinged with brown, iridescent, the stigma somewhat brownish; articulation ochreous. As Hutton has pointed out, the venation agrees with that of *fasciatum;* halteres ochreous. Legs ochreous, but the posterior pair much darker though brownish at the joints; coxae black.

Abdomen dark blue, rather shiny, immaculate; elongate, broad in the middle and narrowing basally and apically.

♀. Length, 6 mm.

Holotype: Hutton's collection, Canterbury Museum.

Habitat.—Christchurch (Hutton).

Genus PLATYCHEIRUS St. Far. et Serv. (1828).

The species of this genus are elongate and narrow; in colour black, blue, or metallic, with no yellow markings but sometimes hoary spots on the abdomen; antennae situated well above middle height of head; face more or less vertical and produced to prominence about middle of head, thence receding to oral margin below; orbito-facial groove present; eyes bare, holoptic in the male; anterior tarsi broadened in the female, the legs of the male peculiarly haired.

TABLE OF SPECIES.

(*a.*) Thorax shiny blue-black; face deep blue; 3rd antennal joint black with a greyish reflection; abdomen blue-black with indistinct greyish areas on 2nd, 3rd, and 4th segments .. .. *lignudus* n. sp.

(*b.*) Thorax bronzy-black; face black; 3rd antennal joint orange-red; abdomen blue-black without greyish areas except in some lights at anterior angles of 2nd, 3rd, and 4th segments of ♂ .. *clarkei* n. sp.

(*c.*) Thorax black; face pale yellow with a black stripe; abdomen black with oblique white spots; halteres emerald-green .. *atkinsoni* n. sp.

P. lignudus n. sp. (Plate XLVIII, fig. 5.)

A shiny blue-black narrow-bodied fly with indistinct greyish areas on the abdomen.

♀. Eyes bare, dichoptic; vertex and front shiny deep blue with a dense vestiture of black hairs; lunular area black. Antennae (fig. 44) situated high up on head; black and rather elongate, with a greyish reflection due to pubescence, which is minute on 1st and 2nd joints; 3rd joint elongate oval; arista black and pubescent. Face shiny blue-black clothed with scattered grey hairs and a greyish tomentum above orbito-facial groove; outline shown in fig. 42; oral margin shiny blue-black and sparsely clothed with erect greyish hairs; cheeks blue-black, silvery in some lights, and clothed with grey hairs; occiput blue-black with a silvery reflection and a dense vestiture of grey hairs along orbits and behind vertex; mouth-parts blue-black to brownish.

Thorax and scutellum shiny blue-black, clothed with a dense vestiture of greyish-brown hairs. Legs brownish-black but tawny at apex of femora and base of tibiae, the former clothed with delicate hairs, the latter and the tarsi covered with very short, golden to brownish, stiff hairs; anterior tibiae rather thickened distally, their tarsi distinctly broadened (fig. 45); anterior protarsi produced on each side as a process; mesotarsi broadest, the following joints shortening and narrowing; on lower side of anterior tarsi are golden bristle-like hairs; middle tibiae with a row of short blackish apical bristles beneath. Wings clear, stigma brownish, veins brown but paler basally; halteres pale brown.

Abdomen elongate and rather ovate (fig. 46), shiny blue-black with indistinct areas of pale-greyish tomentum and hairs on 2nd, 3rd, 4th, and 5th segments, arranged as in figure; sides of abdomen with short white hairs.

♀. Length, 7·5–8·5 mm.

Holotype: No. 557, D. M.

Habitat.—Central Otago and Moutere Inlet (D. M.); Waitati (C. E. Clarke).

P. clarkei n. sp.*

This species resembles *lignudus* in general form and colour.

♂. Front shiny black with a tinge of green and clothed with black hairs; eyes holoptic; antennae minutely pubescent, causing a greyish reflection; 1st and 2nd joints black; 3rd ovate, orange-red with a black upper edge and tip. Outline of face as in *lignudus* but the prominence not so pronounced; face shiny black, greyish-pruinose above orbito-facial groove, with golden reflections, and clothed with black hairs; cheeks black with black to brownish hairs; proboscis black, the labella orange-brown; occiput black with a greyish reflection, the orbits clothed with greyish hairs.

Thorax and scutellum shiny bronzy-black, thinly clothed with blackish hairs. Wings slightly dusky but clearer basally; stigma smoky; halteres brownish. Coxae blackish-brown and rather hairy; femora blackish-brown, golden-pruinose and brownish beneath basally, tawny apically; clothed with long, delicate, scattered, golden hairs, and a row of small black bristles along lower side, longer on posterior femora; tibiae tawny but brownish along the middle, the anterior pair with a distinct fringe of golden and black bristle-like hairs along lower side; posterior pair thickened distally; tarsi black with a golden or brownish reflection and clothed with short bristle-like hairs; the posterior and anterior tarsi with a distinct golden brush of short rigid hairs beneath; anterior tarsi slightly broadened, the posterior, particularly the protarsi, more so.

Abdomen elongate, the sides parallel; deep blue, dull; clothed with short silvery hairs, long and delicate along the margins of 1st and 2nd segments; a cupreous area sometimes silvery owing to arrangement of hairs, and seen only in some lights, at anterior angles of 2nd, 3rd, and 4th segments; surface of abdomen transversely rugose; genitalia brownish-yellow.

♀. Differs from ♂ in the following characters: 3rd antennal joint mostly black, the orange-red being restricted to lower half of joint. Dorsum of thorax shiny brownish-black; scutellum shiny blue-black. Anterior tibiae and tarsi thickened; the epi-, meso-, and meta-tarsi of anterior legs short and broad, the onychotarsi small (fig. 49).

Abdomen slightly ovate, with an olive-green tinge in some lights, and without the cupreous areas at anterior angles of segments.

♂ and ♀. Length, 8 mm.

Syntype: No. 1230, D. M.

Habitat.—Rotorua and Te Wairoa (D. M.).

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* Named after Mr. C. E. Clarke, of Dunedin.

P. atkinsoni n. sp.*

♂. A slender black fly with 4 pairs of white spots on the abdomen, and emerald-green halteres.

Head in profile decidedly flat above, the front curved down to antennae (fig. 47); eyes bare, holoptic, the posterior margin concave; ocellar triangle black and clothed with blackish hairs; ocelli vermilion; front pale tawny, clothed with black hairs, a short median brownish stripe extending on to front from confluence of eyes; lunular area testaceous with a blackish spot on the middle, bi-crescentic. Antennae broadly separated, inserted in pits well up on head; 1st and 2nd joints blackish-brown with a greyish reflection; 3rd joint ovate, brick-red with a blackish upper margin and covered by a silvery tomentum; arista black. Face as shown in fig. 47; a broad black median stripe, narrowing at oral margin, which it narrowly borders; on each side this stripe merges into testaceous, which in turn merges into the pale yellowish-green of face; insertion of each antennae surrounded by a pale-yellow area; a brownish-black spot extends from oral margin in front of cheeks to a point on lower eye-margin; face greyish-pruinose on each side and between and immediately below the antennae, and clothed with short tawny hairs except on blackish areas; orbito-facial groove pronounced; cheeks rather swollen, black with a greyish reflection, and clothed with short whitish hairs; occiput black, the orbits clothed with short white hairs; mouth-parts black, but the labella orange-brown.

Thorax shiny black, clothed with silvery hairs more scattered on the dorsum, on each side of which is a greyish area extending from a point at humerus, widening into incison of transverse suture and thence narrowing to the wing; scutellum dull brownish-yellow, margined with black and clothed with blackish hairs; the meso-, ptero-, and upper part of sternopleurae greyish-pruinose and clothed with long silvery hairs; remainder of pleurae black; halteres with brown shafts and large emerald-green heads. Wings clear, the stigma orange-brown, veins black; squamae opal-white and fringed with silvery hairs. Legs slender, the posterior tibiae and protarsi slightly thickened; anterior and middle tibiae sparsely clothed with stiff brownish hairs, orange-brown but lighter at the apex; posterior coxae black, greyish-pruinose, and clothed with silvery hairs; posterior femora blackish-brown, greyish in some lights, rather tawny at apex, and sparsely clothed with silvery hairs which are denser below distally; anterior and middle tibiae orange-brown, darker in some lights, the latter with minute black apical bristles below; posterior tibiae blackish-brown, paler basally and with a greyish reflection; anterior and middle tarsi blackish-brown, clothed with short silvery hairs, the former rather broadened, the protarsi of the latter with minute bristles beneath; posterior tarsi black with short golden hairs beneath, the protarsi somewhat thickened; all the tarsal joints bristly at angles; claws orange-brown with black tips; pulvilli orange-brown.

Abdomen (fig. 58) elongate, narrow, parallel-sided, shiny black, sparsely clothed with short silvery hairs which become longer at sides particularly on basal segments, but shortening and not extending to apex of 4th segment, their place being taken by small black bristles; 2nd, 3rd, 4th, and 5th segments each with a pair of oblique white spots, those of 2nd segment truncated above, and of the 5th somewhat yellow; genitalia greyish-yellow.

♂. Length, 9 mm.

Holotype: No. 1250, D. M.

Habitat.—Devil's Punch Bowl, Arthur's Pass (E. H. Atkinson).

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* Named after Mr. E. H. Atkinson, of Wellington.

Subfamily MILESIINAE.

Vein R_{4+5} moderately or slightly curved into cell R_5; cross-vein *r–m* at or beyond the middleof cell 1st M_2.

Genus XYLOTA Meigen (1822).

The chief characters by which the following species is placed in this genus are: vein R_{4+5} moderately curved into cell R_5; cross-vein *r–m* near middle of cell 1st M_2; face deeply dished beneath antennae; eyes bare; posterior femora broad and spinose beneath; body immaculate.

X. montana n. sp. (Plate XLIX, fig. 2.)

A robust medium-sized fly, blackish in colour and with no colour-pattern. It has some resemblance to *Lepidomyia decessum.*

Eyes bare, dichoptic in both sexes, but those of the male more approximated; ocelli orange-red; front and vertex shiny black with a silvery reflection due to pubescence and clothed with strong and rigid black hairs; frontal lunule brownish. Antennae black with a greyish tomentum; 3rd joint somewhat lighter in colour and more or less circular; arista black. Face deeply dished beneath antennae (fig. 48), being abruptly produced before descending almost vertically to the rather descending anterior oral margin, above which there is a slight prominence; face diagonally furrowed on each side, blue-black in colour but brownish to greyish pruinose above furrows; sparsely clothed above and on each side of produced portion with silvery hairs; lower facial orbits with erect greyish hairs; cheeks black with a silvery reflection particularly along the orbits, and clothed with whitish to brown hairs; occiput shiny blue-black with white hairs and greyish reflections; mouth-parts blue-black.

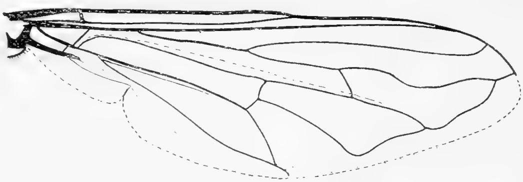

FIG. 3.—*Xylota montana* n. sp.: wing.

Thorax blue-black with indistinct stripes and a coppery reflection on the dorsum; sparsely clothed with delicate brownish and whitish hairs; humeri, margins of dorsum and alar regions greyish-pruinose in some lights; pleurae deep-blue and dull-greyish pruinose, the meso- and pteropleurae with a tuft of white hairs at their upper posterior angles; sternopleurae clothed with short black hairs; scutellum with long delicate greyish hairs. Wings (fig. 3) clear, stigma almost colourless, veins brownish-black; vein R_{4+5} moderately bent into cell R_5; cross-vein *r-m* at the middle of cell 1st M_2; squamae and anti-squamae translucent, the former fringed with greyish branched hairs, the latter with short simple ones; halteres brownish with darker heads. Legs shiny blue-black; femora clothed with scattered greyish hairs, the posterior pair broadened and spinose beneath on distal half (fig. 55), there being a double row of short stout spines, weakening proximally, along the middle, and larger bristles along the side to apex; anterior tibiae with short and stiff bristle-like golden hairs along lower side; similar hairs on lower side of all the tarsi; short black bristles at anterior angles of posterior tarsal joints.

Abdomen blue-black, sparsely clothed with short white hairs above and longer ones laterally; a slight tubercle at anterior angles of 1st segment; genitalia of ♂ shown in fig. 53.

♂. Length, 9 mm. ♀. Length, 10 mm.

Syntype: No. 1241, D. M.

Habitat.—Arthur's Pass (J. W. Campbell and G. V. Hudson)

Genus SYRITTA St. Farg. et Serv. (1828).

This genus is more or less allied to *Xylota,* but the posterior femora are very strongly thickened. No species, however, have been recorded from New Zealand beyond *S. oceanica* Macq., which Bigot is stated to have found also in Tahiti; since then it has not been recorded in the Dominion. Hutton* considered that it did not occur in New Zealand, but nevertheless I give the following description (apparently quoted from Macquart) from his *Cat. N.Z. Dipt.* (p. 42).

S. oceanica Macq.

S. oceanica Macquart, *Dipt. Exot., Supp.* 5, p. 112 (1854); Hutton, *Cat. N.Z. Dipt.*, p. 42 (1881).

"♀. Palpi small, black. Face rather concave, with silvery down and a black band in the middle. Anterior portion of front with white down, the rest shining black, prolonged into a point in front. The two first joints of the antennae brownish-testaceous; the third black, brown below. Thorax shining black the sides with white down. Abdomen dull black, the second segment with two yellow spots, shining, and reaching the anterior border; the third with two shining spots, the fourth entirely shining. Anterior and intermediate femora black, the extremity fulvous; the posterior pair entirely black; anterior and intermediate tibiae blackish, the base fulvous; the posterior pair black, with the knees and a ring in the middle fulvous; tarsi black the first joint fulvous. Poisers fulvous. Wings clear; veins normal.

"Length, 3 lines.

"Tahiti and New Zealand (Bigot)."

Genus TROPIDIA Meig. (1822).

It is doubtful to what genus the following species belongs; it was originally placed in *Milesia* by White† and later on retained therein by Walker; but since the cell R_1 of the wing is open it certainly does not belong to *Milesia.* Although there may be many excellent grounds for the establishment of a new genus upon this species, it is considered advisable, in the meantime at least, to retain it in the genus *Tropidia,* with which it coincides to a certain extent. The genus is characterized by the following: Eyes bare, holoptic at a point in the male, moderately dichoptic in the female; antennae short, 3rd joint rather rectangular; vein R_{4+5} gently curved into cell R_5; cross-vein *r–m* beyond middle of cell 1st M_2 and oblique. Face without central knob, practically vertical to oral

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* *Trans. N.Z. Inst.*, vol. 33, p. 95 (1901).

† Walker gives White as the author of this species, but there is no record to be found in the *Voy. "Erebus" and "Terror,"* to which Walker refers.

margin (which projects as a short snout in *bilineata*); posterior femora thickened and with an inferior triangular tooth near apex (in *bilineata* there is no triangular tooth, but a pronounced bristly swelling).

T. bilineata White. (Plate XLIX, fig. 3.)

Milesia bilineata White, *Voy.* "*Erebus*" *and* "*Terror*" (?); Walker, *Cat. Dipt. Brit. Mus.*, p. 566 (1849); Hutton, *Cat. Dipt. N.Z.* p. 43 (1881); *Trans. N.Z. Inst.*, vol. 33, p. 40 (1901).

A large elongate blackish fly with a pair of stripes on the dorsum of the thorax.

♀. Eyes bare, moderately dichoptic; ocellar triangle elongate, blackish-brown with blackish-brown hairs; ocelli situated well forward; vertex and upper part of front dullish black; lunular area and lower part of front shiny black, the latter region brownish centrally; across the front and separating the black into two areas is a tawny band as shown in fig. 51. The front anteriorly is cone-shaped and prominent; in profile it descends steeply to the prominence, which is more or less horizontal, thus forming an angle with the more oblique upper part (fig. 52). Vertex and upper black area of front clothed with black hairs; the tawny band with yellow hairs. Antennae inserted close together at about middle line of head; black and comparatively large; 1st joint short and bristly, 2nd triangular, bristly and with a long inferior bristle, the anterior margin forming three blunt processes for the reception of the 3rd joint, which is orbicular, and greyish-pruinose; arista black and long, bare distally but minutely pubescent proximally. Face vertical though somewhat receding and projecting abruptly to form a short snout at oral margin (fig. 52); lower margin of

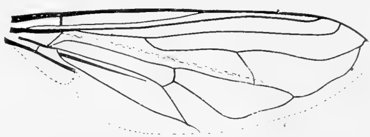

FIG. 4.—*Tropidia bilineata*: wing.

head almost horizontal but descending slightly at anterior oral margin; face with a shiny black median stripe and black areas along oral margin, otherwise tawny with brownish reflections and clothed with short delicate pale hairs; arrangement of colour-pattern shown in fig. 52; cheeks tawny and bearded with white hairs; an indistinct crescentic blackish reflection at lower corner of eye; a tawny spot on oral margin below cheeks; proboscis and palpi blackish-brown, the labella large and deeply bi-lobed; occiput greyish or whitish yellow with blackish reflections; somewhat swollen and hairy below, but slightly concave and bare above.

Thorax rectangular; dorsum with 3 black longitudinal stripes, the median one forked; except for black areas the dorsum is tawny, with greyish reflections; colour-pattern shown in fig. 54; alar regions clothed with long golden hairs, dorsum clothed with short brownish hairs; scutellum shiny blackish-brown and clothed with long brown hairs. In front of the mesopleurae the sides of the thorax are hollowed apparently for the reception of the anterior femora; pleurae for the most part black, golden-pruinose, the sternopleurae with a golden pubescent area above; the meso-, petro-, and sterno-pleurae clothed with long golden hairs. Legs robust, black, and bristly, the bristles short and black on the coxae and femora, longer, and golden, in some lights, on the tibiae and tarsi; coxae greyish-pruinose with long grey hairs, the anterior coxae large and flattened; femora with long pale bristle-like hairs along posterior side, those of the posterior femora shorter; the latter are broadened and have a densely spinose protuberance on lower side near apex (fig. 59); tibiae densely clothed with golden bristle-like hairs most conspicuous distally; posterior tibiae broadened and curved; tarsi broadened, a conspicuous bristle at anterior angle of each joint and a stiff golden brush beneath; metatarsi short and crescentic, each anterior angle being produced along each side of the onychotarsi; pulvilli pale yellow; empodium styliform (fig. 56); claws large and tawny with black tips. Wings tinged with brown, the stigma darker; veins blackish-brown; cell R_1 open; vein R_{4+5} slightly curved into cell R_5; cross-vein *r-m* beyond middle of cell 1st M_2 (fig. 4); anal angle fringed with short delicate hairs; squamae opaque and densely fringed with long greyish branched hairs; anti-squamae fringed with short hairs; halteres tawny.

Abdomen (fig. 67) elongate and conical, about as wide as the thorax, margined with delicate yellow hairs and the surface clothed with short ones; black bristle-like hairs on 5th segment and fringing the posterior margin of 4th; general colour dullish black; on the 2nd, 3rd, and 4th segments are yellowish-white triangular spots, indistinct in some lights, and arranged as in fig. 67; 5th segment shiny black and transversely rugose; retracted segments yellowish-brown.

♂. Eyes contiguous at a point on front (fig. 50), which is whitish-yellow to golden; face as in ♀ but the lighter areas whitish; black median stripe apparent only in certain lights, but a permanent black area beneath antennae; a shiny black band on each side from antennae to eye-margin; occiput cinereous. Wings comparatively clear and shorter than the abdomen, which is narrow, the sides more or less parallel though broader basally; spots on 3rd segment elongated; genital segments (fig. 61) densely covered with bristle-like black hairs; claspers very long and narrow.

♂. Length, 13 mm. ♀. Length, 12–17 mm.

Plesiotype: No. 1070, D. M.

Habitat.—Wellington (E. H. Atkinson); Central Otago (W. G. Howes); Nelson (D. M.).

Subfamily ERISTALINAE.

Eyes of male holoptic or dichoptic, bare or hairy; face with a central protuberance; cell R_1 open or closed; cross-vein *r-m* beyond middle of cell 1st M_2; vein R_{4+5} strongly curved into cell R_5; posterior femora frequently broadened.

Genus MALLOTA Meigen (1822).

On account of the pilosity of the body, the bristly legs, the bristly swelling on lower side of the posterior femora, the tuberculate scutellum, the shape of the face, and the wing-venation, the following species, originally described by Fabricius, belongs neither to *Eristalis* nor *Helophilus*, in which genera it was placed by Hutton. In 1881 Hutton, though he retained it in *Eristalis*, remarked that " the shape of the legs puts this species into the next genus " (*Mallota*); but when reconsidering the matter in 1900 he decided in favour of the genus *Helophilus.*

M. cingulata Fabricius. (Plate L, fig. 2.)

Syrphus cingulatus Fabr., *Syst. Ent.*, p. 767 (1775). *Eristalis cingulatus* Hutton, *Cat. Dipt. N.Z.*, p. 40 (1881). *Helophilus cingulatus* Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 37 (1901).

A large robust blackish pilose fly, with dense white hairs across base of abdomen.

♀. Eyes bare; vertex occupied by the large circular ocellar triangle, which is shiny ferruginous (sometimes brownish or greyish), except for a velvet-black area anterior to the posterior ocelli, and clothed with brownish-black hairs (fig. 57); front ferruginous, sometimes reddish-grey, a broad velvet-black band across the middle (its form shown in fig. 57); across the anterior margin of this band is a furrow, posterior to which the blackish pile, clothing the front, is erect but proclinate anterior to furrow; lunular area inclined to orange-yellow; 1st and 2nd antennal joints shiny black, the 3rd transversely oval, brownish-black but with a lighter reflection; arista orange-red but darker apically; a broad velvet-black band extending from eye to eye across roots of antennae and upper part of face beneath antennae (fig. 60). Face fulvous, darker in some lights; oral margin and lower part of face shiny black, as shown in fig. 60; a silvery area at lower eye-angle; a groove across face from eye to eye just beneath the protuberance; above this groove face clothed with delicate black hairs, but bare below; face deeply dished on upper half, thence produced to protuberance, below which it recedes to oral margin, which is descending; cheeks dull black, clothed with delicate black hairs; proboscis stout and black, the labella slightly reddish-black; occiput black with grey reflections, ferruginous from ocellar triangle to foramen and with a greyish area on each side of this.

Thorax robust, the dorsum, which is a rich velvet-black, clothed with short dense ferruginous pile; a pair of narrow greyish to white stripes narrowing posteriorly and ending abruptly before reaching the scutellum; humeri reddish-black with a tuft of black hairs; around the humeral suture and margining the lateral incisions of the transverse suture is an indistinct greyish stripe; in some lights there appears a broad chestnut stripe extending from the humeri to the scutellum; scutellum chestnut-brown to ferruginous, truncated apically, presenting a vertical posterior face, the upper

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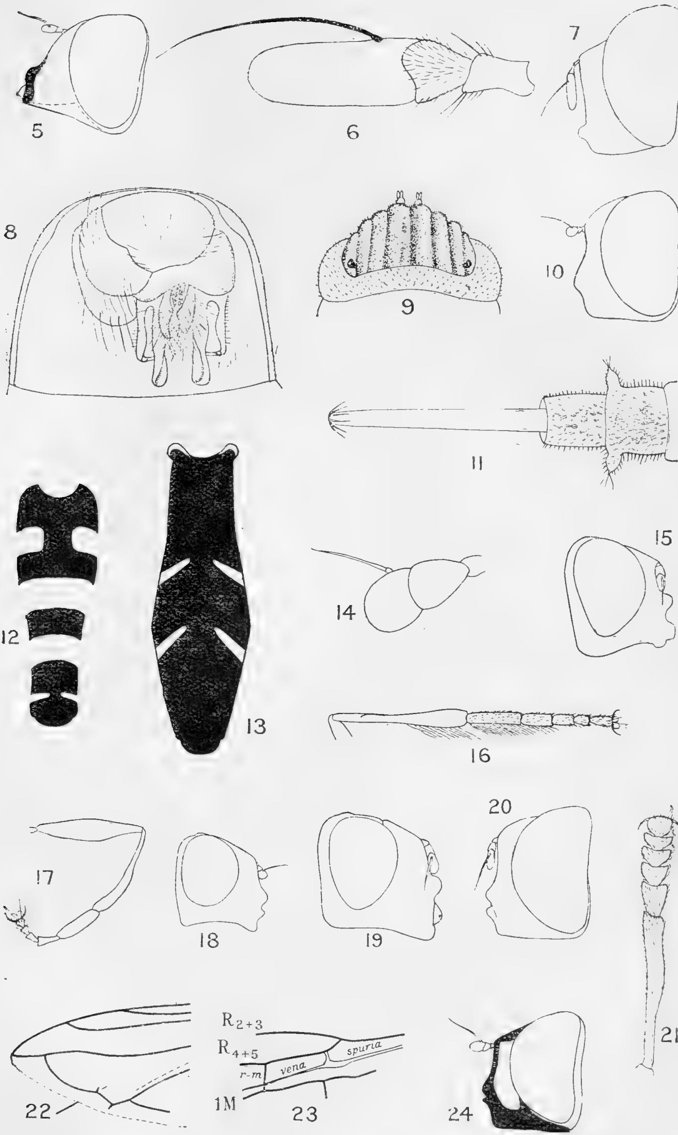
Fig. 5.—*Paragus pseudo-ropalus* n. sp.: outline of head of male in profile.
Fig. 6.—*Lepidomyia decessum*: antenna.
Fig. 7.—*L. decessum*: outline of head in profile.
Fig. 8.—*L. decessum*: genitalia of male.
Fig. 9.—*L. decessum*: anterior end of larva, contracted.
Fig. 10.—*Sphaerophoria ventralis* n. sp.: outline of head in profile.
Fig. 11.—*Lepidomyia decessum*: siphon of larva.
Fig. 12.—*Paragus pseudo-ropalus* n. sp.: diagram of abdomen of male.
Fig. 13.—*Sphaerophoria ventralis* n. sp.: diagram of abdomen of male.
Fig. 14.—*Cheilosia leptospermi* n. sp.: antenna.
Fig. 15.—*C. leptospermi* n. sp.: outline of head in profile.
Fig. 16.—*C. leptospermi* n. sp.: anterior tibia and tarsus of male.
Fig. 17.—*C. leptospermi* n. sp.: posterior leg of male.
Fig. 18.—*C. howesii* n. sp.: outline of head in profile.
Fig. 19.—*C. cunninghami* n. sp.: outline of head in profile.
Fig. 20.—*C. ronana* n. sp.: outline of head in profile.
Fig. 21.—*C. cunninghami* n. sp.: anterior tibia and tarsus of female.
Fig. 22.—*C. ronana* n. sp.: apex of wing.
Fig. 23.—*Syrphus harrisi* n. sp.: diagram of vena spuria, showing cross-vein.
Fig. 24.—*S. flavofaciens* n. sp.: outline of head in profile.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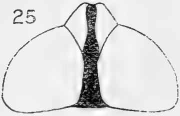

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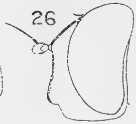

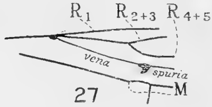

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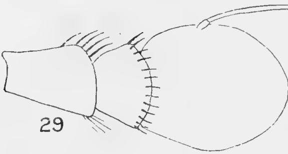
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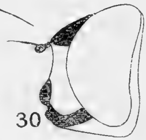
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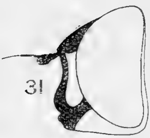
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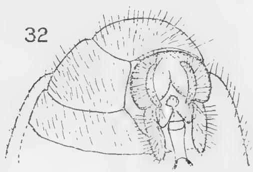

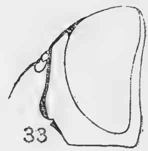
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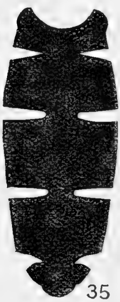
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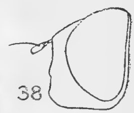
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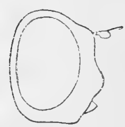
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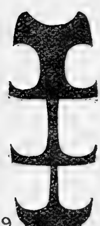
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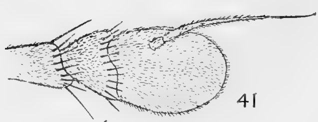
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margin produced on each side as a tubercle, the dorsal surface densely clothed with a short ferruginous pile and the vertical surface with long and delicate brownish hairs. Pleurae black, clothed with black hairs but bare above the coxae ; a reddish spot in some lights beneath the wings ; anterior and posterior stigmata tawny to orange-red, and protected by a palisade of erect closely-set hairs. Wings clear but blackish-brown at the base ; veins and stigma brown, the cubitus and medius paler basally ; cell R_1 open ; vein R_{4+5} deeply curved into cell R_5 ; cross-vein *r–m* just beyond the middle of cell 1st M_2 ; vena spuria indistinct basally, connected with R_{4+5} by a distinct cross-vein (absent in some wings) from the nodule ; supernumerary vein of cell Cu_2 very distinct and vein-like ; squamae and anti-squamae blackish and translucent, the former fringed with long branched pale hairs, the latter with shorter hairs ; halteres dark brown but reddish along lower edge. Legs blue-black and bristly ; coxae clothed with black hairs ; knees orange-yellow ; underside, apex, and base of tibiae ferruginous or altogether golden ; an orange-yellow area on lower side of posterior tibiae in the middle ; anterior and middle femora with dense black hairs below ; posterior femora (fig. 64) thickened and with a distinct swelling below, along which are distinct bristle-like hairs ; anterior and middle tibiae less bristly than the posterior ; the lighter area on lower side of posterior tibiae bare to the apex ; tarsi orange-yellow to golden with darker reflections, each joint with short rigid bristles at anterior angles ; pulvilli and claws pale tawny, the latter black at the tips ; empodium styliform.

Abdomen (fig. 65) black, a shiny blue-black area at anterior margin on each side of 3rd and 4th segments, the apical segment shining and greyish in some lights ; broadly ovate, broader than the thorax, clothed with delicate short black bristles, which become dense and stronger along the sides of the 2nd and 3rd segments ; 1st segment and an elongate anterior area on each side of the 2nd segment densely clothed with long silvery hairs ; when vestiture is removed these bearded areas are testaceous or tawny in ground-colour ; a pair of triangular white discal spots and a pair of lateral circular ones on the 3rd and 4th segments and a pair of triangular white spots on the anterior angles of 5th segment as shown in fig. 65 ; from the sides of the 4th segment are long hairs, black except those from the lateral spots which are white ; ventrally the abdomen is sparsely clothed with grey hairs ; the basal sternite greyish and transversely rugose, the remainder blue-black ; a pair of short orange-red styles project from apical segment.

FIG. 25.—*Syrphus hudsoni* n. sp. : dorsal view of head of male.
FIG. 26.—*S. hudsoni* n. sp. : outline of head in profile.
FIG. 27.—*S. hudsoni* n. sp. : part of venation, showing origin of vena spuria, &c.
FIG. 28.—*S. hudsoni* n. sp. : diagram of abdomen of male.
FIG. 29.—*S. novae-zealandiae* : antenna.
FIG. 30.—*S. novae-zealandiae* : outline of head in profile of male.
FIG. 31.—*S. novae-zealandiae* : outline of head in profile of female.
FIG. 32.—*S. novae-zealandiae* : genitalia of male.
FIG. 33.—*S. ortas* : outline of head in profile.
FIG. 34.—*S. novae-zealandiae* : diagram of abdomen of male.
FIG. 35.—*S. novae-zealandiae* : diagram of abdomen of female.
FIG. 36.—*S. ortas* : diagram of abdomen of female.
FIG. 37.—*S. ropalus* : diagram of abdomen of female.
FIG. 38.—*Melanostoma fasciatum* : outline of head in profile.
FIG. 39.—*M. fasciatum* : diagram of abdomen of male.
FIG. 40.—*M. fasciatum* : diagram of abdomen of female.
FIG. 41.—*M. fasciatum* : antenna.
FIG. 42.—*Platycheirus lignudus* n. sp. : outline of head in profile.

♂. Eyes approximated at a point anterior to ocellar triangle, the orbits being strongly angulated ; a naked area between the orbital angles and ocellar triangle, so that, in profile, there appears to be an upper and a lower tuft of hairs, the one on the ocellar triangle and the other on the lower front ; 3rd antennal joint ferruginous ; face darker than in ♀ and with darker reflections. Pleurae black with a greyish reflection, the hairs ferruginous just beneath the orange-red spot under wings. Bristles of hind-legs very distinct. Genital segments bristly, shown with the gentialia in fig. 62.

♂. Length, 13 mm. ♀. Length, 17 mm.

Plesiotype : ♂, No. 1240 ; ♀, No. 983, D. M.

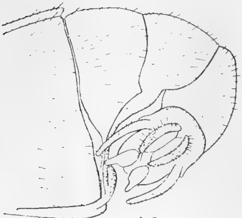
Habitat.—Throughout New Zealand ; uncommon in some parts, but very common in others—*e.g.*, Day's Bay, Wellington.

Genus Helophilus Meigen (1822).

The genus *Helophilus* may be characterized as follows : Eyes bare and dichoptic in both sexes, though approximated in the male ; face concave below antennae, but not dished, thence evenly convex ; oral margin from the cheeks strongly descending (fig. 77) ; body not densely but rather inconspicuously haired ; posterior femora thickened but not unusually so, and sometimes with a tooth below near the base ; cell R_1 of wing open ; vein R_{4+5} distinctly curved into cell R_5 ; cross-vein *r–m* beyond middle of cell 1st M_2. Species usually large and robust, including the largest of New Zealand Diptera ; metallic in colour or blue and black with yellow stripes and spots.

Of the ten species already recorded from New Zealand, one has been herein placed in the genus *Mallota;* another, described by the writer in 1910 as new, is now found to be a synonym of one of Walker's species. Further, after a careful examination of Hutton's syntypes of *vincinus*, all of which are females, it is apparent that this species is a variety intermediate between the male and female of Schiner's *antipodus*. *H. antipodus* and *H. trilineatus* resemble each other closely in both sexes, and since only the male of *antipodus* and the female of *trilineatus* have until now been described—the former by Schiner and the latter by Fabricius—the males and females of both species have been grouped by Hutton and others under *antipodus* and *trilineatus* respectively. From the original descriptions by Schiner and Fabricius the sexes and species can, however, readily be separated, the main character being the presence in *trilineatus* (♂ and ♀) of an inferior tooth near the base of the posterior femora—"(*femoribus*) *posticis unidentatis*" (Fabr.)—the presence or absence of which was not noted by later authors.

Fig. 43.—*Melanostoma fasciatum :* genitalia of male.
Fig. 44.—*Platycheirus lignudus* n. sp. : antenna.
Fig. 45.—*P. lignudus* n. sp. : anterior tibia and tarsus.
Fig. 46.—*P. lignudus* n. sp. : diagram of abdomen of female.
Fig. 47.—*P. atkinsoni* n. sp. : outline of head in profile.
Fig. 48.—*Xylota montana* n. sp. : outline of head in profile.
Fig. 49.—*Platycheirus clarkei* n. sp. : anterior tibia and tarsus.
Fig. 50.—*Tropidia bilineata :* dorsal view of head of male.
Fig. 51.—*T. bilineata :* dorsal view of head of female, showing colour-pattern.
Fig. 52.—*T. bilineata :* outline of head in profile.
Fig. 53.—*Xylota montana* n. sp. : genitalia of male.
Fig. 54.—*Tropidia bilineata :* diagram of thoracic dorsum, showing colour-pattern.
Fig. 55.—*Xylota montana* n. sp. : posterior femur.
Fig. 56.—*Tropidia bilineata :* onychotarsus and appendages.
Fig. 57.—*Mallota cingulata :* dorsal view of head of female, showing colour-pattern.



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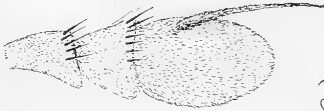

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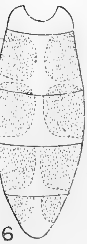

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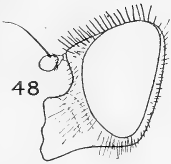

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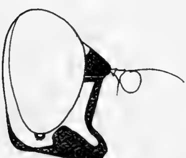

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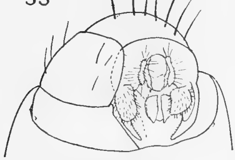

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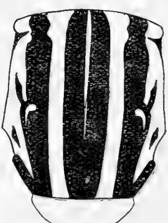

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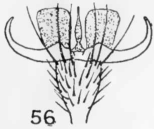

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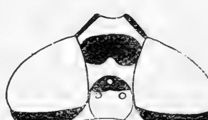

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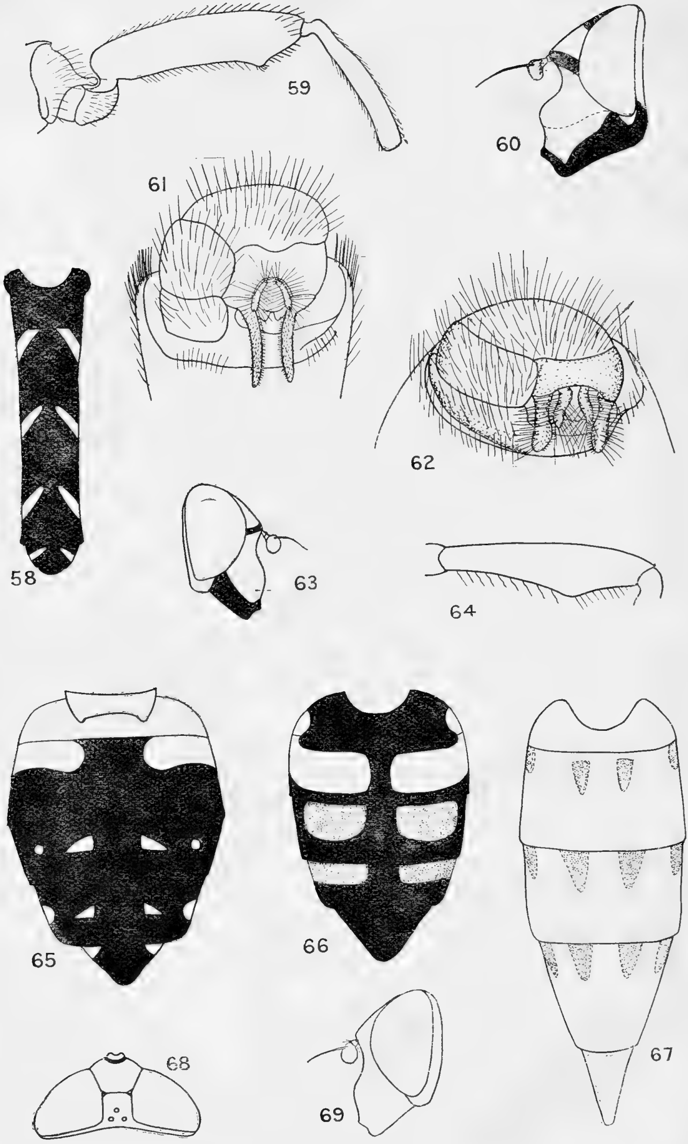
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TABLE OF SPECIES.

1	Abdomen with yellow markings	2
	Abdomen without yellow markings	5
2	Abdomen distinctly clothed with golden hairs; the yellow markings indistinct; indistinct yellow markings on posterior legs	*ineptus.*
	Abdomen not distinctly clothed with yellow hairs; the yellow markings distinct; posterior legs distinctly marked with yellow	3
3	A pair of large spots on 2nd abdominal segment of ♀ and on 2nd and 3rd segments of ♂ (figs. 66 and 71)	4
	All the abdominal segments with dark-yellow markings and pale-yellow circular spots (fig. 82)	*cargilli.*
4	Median thoracic black stripe divided centrally by a long narrow yellow stripe (fig. 70); apex of posterior tibiae black; no tooth at base of posterior femora	*antipodus.*
	(*a.*) A pair of small tawny spots at anterior angles of 3rd abdominal segment	*antipodus* var. *vincinus*, ♀
	Median thoracic stripe not divided; apex of posterior tibiae yellow; a distinct tooth at base of posterior femora (fig. 74)	*trilineatus.*
5	Abdomen deep blue or violet-black	*hochstetteri.*
	Abdomen bronzy, bronzy-green, or cupreous	6
6	Abdomen bronzy or bluish-green, without dead-black areas; scutellum golden-brown basally, yellow apically	*campbellicus.*
	Abdomen cupreous, with indistinct dead-black areas; scutellum tawny	*chathamensis.*

H. antipodus Schiner. (Plate L, figs. 1, 4.)

H. antipodus Schiner, *Reise der Freg.* "*Novara,*" *Dipt.*, p. 359 (1868). (♂) *H. antipodus* Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 38 (1901). (♀) *H. trilineatus* Hutton, *l.c.* *Mallota antipoda* Hutton, *Cat. Dipt. N.Z.*, p. 40 (1881). (♀) *H. interruptus* Lamb, *Subant. Islds. N.Z.*, vol. 1, p. 133 (1909).

A large black fly with yellow stripes on the thorax and a pair of yellow abdominal spots in the female and two in the male.

♀. Eyes bare; vertex and upper part of front velvet-black (the anterior margin of this colour being sinuated) and densely clothed with erect black hairs; lower part of front yellowish-brown but with a darker reflection owing to vestiture of black hairs; a black or brownish-black transverse band from eye to eye, across antennae and extending very slightly on to front just behind the shiny dark-brown lunular area. Antennae velvet-black with a greyish reflection on the circular 3rd joint; arista black, though somewhat reddish apically; minutely pubescent basally. Face pale yellow, with a dense greyish-yellow tomentum and scattered yellow hairs except on a broad triangular median area over prominence; face moderately

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FIG. 58.—*Platycheirus atkinsoni* n. sp.: diagram of abdomen of male.
FIG. 59.—*Tropidia bilineata:* posterior coxa, femur, and tibia.
FIG. 60.—*Mallota cingulata:* outline of head in profile.
FIG. 61.—*Tropidia bilineata:* genitalia of male.
FIG. 62.—*Mallota cingulata:* genitalia of male.
FIG. 63.—*Helophilus antipodus:* outline of head in profile.
FIG. 64.—*Mallota cingulata:* posterior femur.
FIG. 65.—*M. cingulata:* diagram of abdomen of female.
FIG. 66.—*Helophilus antipodus:* diagram of abdomen of female.
FIG. 67.—*Tropidia bilineata:* diagram of abdomen of female.
FIG. 68.—*Helophilus campbellicus:* dorsal view of head of male.
FIG. 69.—*H. campbellicus:* outline of head in profile.

concave beneath antennae, thence evenly convex; anterior oral margin notched and descending; a broad shiny blue-black band along oral margin extending from cheek and orbit to the anterior oral angle, where it narrows and is reflected upwards to follow the contour of the mouth (fig. 63); cheeks black, with a greyish reflection and greyish hairs; proboscis and palpi brownish-black; occiput greyish-yellow, with a slate-grey reflection and clothed with greyish hairs; the posterior orbits narrowly silvered for the most part, though narrowly black above.

Dorsum of thorax (fig. 70) clothed with a short yellowish-brown pile; 4 brownish-yellow stripes and 3 blackish-brown ones, the median being split anteriorly by a narrow yellow stripe; lateral black stripes with narrow projections around the posterior margin of the transverse suture; a narrow blackish-brown stripe on each side from humeri toward wings, but this stripe is indistinct in some lights; pleurae black in ground-colour, with a brownish or greyish tomentum and brownish-yellow hairs; anterior and posterior stigmata tawny or orange-yellow. Wings faintly tinged with brown, the veins and stigma brown; squamae and anti-squamae fringed with yellow hairs; halteres pale yellow; scutellum brownish-black or ranging to a lighter colour and clothed with black hairs and also a yellow pile basally.

Femora clothed with pale-yellow hairs, anterior and middle pair black but tawny at apex; posterior pair thickened, altogether black, clothed with short black hairs and rigid ones below; anterior and middle tibiae tawny with a fuscous band apically; posterior tibae black on basal and apical third, tawny in the middle, and with an indistinct tooth below distally; all the tarsi tawny.

Abdomen (fig. 66) broad, ovate and pointed apically, clothed with short black hairs and a short yellow pile on the lighter areas; general colour shiny black; a pair of large more or less rectangular tawny or testaceous areas on 2nd segment, extending upward on each side over the posterior angles of the 1st segment; the 3rd and 4th segments have each a pair of indistinct greyish-black areas as shown in fig. 66; the retracted segments have a pair of tawny styles at the apex.

Variations.—The fuscous apical band of middle tibiae is sometimes indistinct; the abdominal tawny areas may be narrower or broader, and in some cases are reduced to a pair of somewhat circular spots on the 2nd segment.

H. antipodus var. vincinus ♀ Hutton.

Helophilus vincinus Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 38 (1901).

This variety agrees with *antipodus* in all respects except that the tawny abdominal areas of the 2nd segment are larger and brighter and do not

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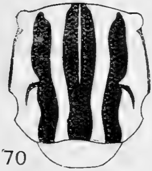
FIG. 70.—*Helophilus antipodus :* diagram of thoracic dorsum, showing colour-pattern.
FIG. 71.—*H. antipodus :* diagram of abdomen of male.
FIG. 72.—*H. antipodus :* genitalia of male, ventral view.
FIG. 73.—*H. antipodus :* genitalia of male, side view.
FIG. 74.—*H. trilineatus :* posterior femur and tibia.
FIG. 75.—*H. cargilli :* genitalia of male, partial side view.
FIG. 76.—*H. trilineatus :* genitalia of male, ventral view.
FIG. 77.—*H. trilineatus :* outline of head in profile.
FIG. 78.—*H. ineptus :* diagram of abdomen.
FIG. 79.—*H. trilineatus :* genitalia of male, side view.
FIG. 80.—*Myiatropa campbelli* n. sp. : diagram of thoracic dorsum, showing colour-pattern.
FIG. 81.—*Helophilus campbellicus :* diagram of thoracic dorsum, showing colour-pattern.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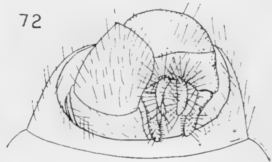
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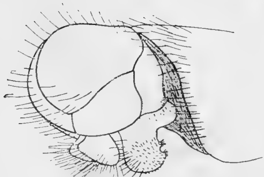
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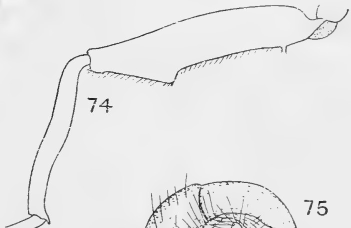
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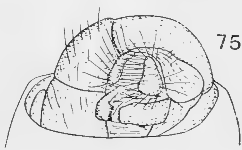
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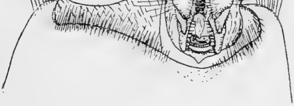
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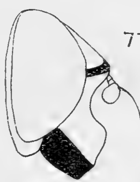
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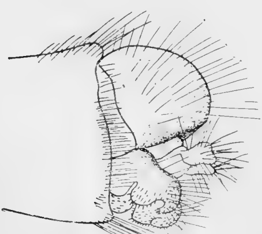
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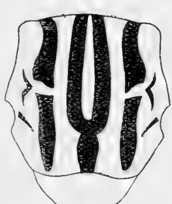
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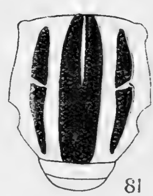
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reach quite to the posterior margin except where they are continued round the posterior angles and extend for a short distance as a spot on each side along the anterior margin of the 3rd segment; the tawny vestiture, also, is more distinct and forms orange-yellow hair most conspicuous along the sides of 3rd and 4th segments; in some cases the tawny areas of the 2nd segment may be confluent with those of the 3rd over the posterior margin of the former segment; there may also be a small tawny spot at anterior angles of 4th segment. All the known specimens of this variety are from the Chatham Islands. The development of the abdominal spots and the conspicuous orange-yellow vestiture tend to show that this variety is intermediate between the ♀ and ♂ *antipodus.*

The male of *antipodus* differs from the female in the following: Vestiture of face longer; posterior femora rather broader; apical markings of anterior and middle tibiae less distinct; abdomen with a more conspicuous vestiture and the 3rd segment with a distinct pair of tawny spots (fig. 71); tawny areas of 2nd segment much broader than ♀, thus resembling those of var. *vincinus* ♀; the indistinct greyish-black spots of 4th segment present as in ♀. Genital segments (figs. 72 and 73) blue-black, the genitalia tawny.

♂. Length, 11–12 mm. ♀. Length, 13–15 mm. ♀. Length, 14 mm. (var. *vincinus*).

Plesiotype: No. 977, D. M. Syntypes: Var. *vincinus*, Hutton's collection, Canterbury Museum.

Habitat.—Throughout New Zealand; Campbell Islands; var. *vincinus*, Chatham Islands.

H. trilineatus Fabricius.

Syrphus trilineatus Fabr., *Syst. Ent.*, p. 766 (1775). *Eristalis trilineatus* Fabr., *Syst. Antl.*, p. 238; Wied., *Auss. Zweif.*, ii, p. 168 (1830). *Helophilus trilineatus* White, *Voy. "Erebus" and "Terror," Ins.*, pl. 7, fig. 19 (1874); Walker, *Cat. Dipt. Brit. Mus.*, p. 607 (1848); Hutton, *Cat. Dipt. N.Z.*, p. 41 (1881); *Trans. N.Z. Inst.*, vol. 33, p. 38 (1901).

A fly closely resembling *antipodus*, but more robust and much larger.

♀. Differs from *antipodus* in the following characters: Eyes more approximated, the black of upper front, vertex, and ocellar triangle permanent in all lights only on the triangle, the yellowish-brown of lower front being reflected over upper front and vertex, thus forming brownish mottlings in some lights; transverse band across antennae broader at frontal lunule; vestiture of front and vertex short; oral margin broadly margined with blackish brown, which is not upturned to any extent along anterior margin; oral margin not distinctly notched in front (fig. 77); cheeks cinereous to pale yellow and clothed with whitish hairs; occiput cinereous.

Median black stripe of thoracic dorsum not narrowly spilt anteriorly; upper two-thirds of pleurae cinereous-yellow; scutellum black in some lights but otherwise as in *antipodus.* Anterior and middle femora blue-black on basal half, otherwise orange-red; posterior femora altogether blue-black, very much broadened to a bristly prominence distally below, and with a stout spinose tooth below near base (fig. 74); around this tooth and distal prominence of posterior femora orange-red, and the lower side distinctly spinose; anterior and middle tibiae and all the tarsi orange-red; posterior tibiae orange-red but for a broad blue-black area at base, and with a distinct apical tooth below.

Tawny areas of 2nd abdominal segment encroaching more over the posterior angles of 1st segment; no indistinct greyish areas on 3rd and 4th segments, but the 3rd segment transversely rugose and brownish-yellow in the middle in some lights.

♂. As *antipodus,* but the yellow of front is more brownish and of the face more greyish; cheeks with a denser beard; scutellum blue-black to brownish; legs differ from *antipodus* as do those of ♀; colour-pattern of abdomen paler. The points of difference in the genitalia of the two species is seen by comparing figs. 72 and 73 with 76 and 79.

♂. Length, 13 mm. ♀. Length, 17–19 mm.

Plesiotype: No. 1243, D. M.

Habitat.—Throughout New Zealand.

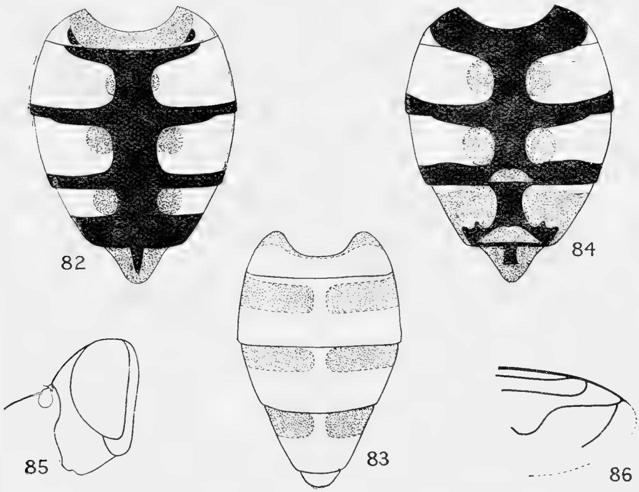

FIG. 82.—*Helophilus cargilli:* diagram of abdomen of female.
FIG. 83.—*H. campbellicus:* diagram of abdomen of male.
FIG. 84.—*Myiatropa campbelli* n. sp.: diagram of abdomen of female.
FIG. 85.—*Helophilus chathamensis:* outline of head in profile.
FIG. 86.—*Myiatropa campbelli* n. sp.: apex of wing, showing shape of R_{2+3}.

H. cargilli Miller.

H. cargilli Miller, *Trans. N.Z. Inst.*, vol. 43, p. 126 (1911).

A large robust fly with striped thorax and orange-red abdomen intersected by black transverse bands and a median stripe, with pale-yellow circular spots on segments (fig. 82). Resembles closely *Myiatropa campbelli* n. sp. (compare fig. 82 with fig. 84).

♀. Eyes bare; ocellar triangle dark brown occupying whole of vertex and clothed with dark-brown hairs; front orange-brown in some lights with pruinose reflections and clothed as ocellar triangle; at times the front is yellowish-brown or the upper half distinctly brown, this colour being produced forward as a point over the lower part; frontal lunule orange-brown and shiny; antennae and arista black. Face pale tawny with a golden tinge and clothed with tawny hairs; a shiny naked median area over prominence; oral margin broadly banded with shiny blackish-brown becoming lighter as it merges into the tawny of face above; face, in profile, gently concave beneath antennae; cheeks and occiput greyish-yellow, clothed with greyish hairs longer on the cheeks; proboscis and palpi blackish-brown.

Dorsum of thorax clothed with a short brownish pile; 3 blackish-brown and 4 greyish-yellow stripes arranged as in *antipodus;* pleurae greyish-black with yellowish areas in some lights and clothed with tawny hairs; scutellum orange-brown and clothed with brownish hairs; halteres tawny. Wings clear, the stigma hardly coloured; squamae yellowish and fringed with long branched hairs; anti-squamae fringed with shorter hairs. Legs hairy; tawny except for coxae, which are greyish, and for the trochanters, base of femora, the 1st four tarsal joints (except the posterior), and the posterior knees, which are blackish-brown; the onychotarsi inclined to tawny; posterior femora rather swollen and with delicate spines beneath on distal half; posterior tibiae inclined to fuscous apically; indistinct inferior, apical spines on anterior and middle tibiae; tarsi with minute black bristles beneath and a golden reflection in some lights, particularly on the posterior pair.

Abdomen (fig. 82) clothed with a short golden pile, longer at the sides; 1st segment orange-yellow laterally, otherwise greyish (except where covered by scutellum), a black spot on each side of greyish area; 2nd and 3rd segments orange-yellow but with an H-shaped black area, the sides of the H lying along the anterior and posterior margins and the cross forming a short median stripe; this black along the anterior margin does not reach to each angle of the segment; the anterior margin of the 3rd segment may be so covered by the overlapping posterior margin of the 2nd that the marking appears rather as an inverted T; 4th segment brownish-black but with an indistinct orange-yellow area on each side along anterior margin; 5th segment greyish-brown with a darker indistinct median stripe; on the 2nd, 3rd, and 4th segments is a pair of greyish spots, one on each side of median black stripe; these spots sometimes indistinct on 2nd segment; posterior margin of each segment rather brownish.

♂. Differs from ♀ only in the more pronounced character of the colour-pattern and in the broader posterior femora, their tibiae being blackish-brown distally. Genitalia shown in partial side view in fig. 75.

♂. Length, 12 mm. ♀. Length, 13 mm.

Holotype: No. 377, D. M.

Habitat.—Dunedin, Purakanui, and Wellington.

H. ineptus Walker

H. ineptus Walker, *Cat. Dipt. Brit. Mus.*, p. 608 (1849); Hutton, *Cat. Dipt. N.Z.*, p. 41 (1881); *Trans. N.Z. Inst.*, vol. 33, p. 39 (1901). *H. purehuensis* Miller, *Trans. N.Z. Inst.*, vol. 43, p. 125 (1911).

A large sombre-coloured fly, the abdomen clothed with yellow hairs and spotted toward the base.

♂. Eyes bare, dichoptic; ocellar triangle blackish-brown; upper part of front black, the lower greyish-yellow, the whole clothed with dark-brown hairs separated into two areas by a bare transverse area across middle of front; lunular area dark brown and shiny. Antennae black, 3rd joint with a silvery reflection at base; arista bare and with a silvery reflection. Face tawny with greyish reflections and tawny hairs; a bare median tawny area; moderately concave beneath antennae; oral margin broadly margined with blackish-brown; cheeks and occiput greyish-black and clothed with greyish hairs longer on the cheeks; an indistinct tawny spot at lower eye-margin.

Dorsum of thorax inclined to bronzy posteriorly with 3 broad black stripes, otherwise greyish-brown though rather silvery along anterior margin behind the head; clothed with a short golden to greyish-golden pile; scutellum bronzy to brownish, lighter in colour apically, and clothed with long brown hairs; pleurae blackish-grey in ground-colour but with a greyish-yellow reflection and rather golden hairs; halteres yellowish-brown. Wings clear, the stigma barely coloured; squamae yellowish-grey and fringed as in preceding species. Legs thinly clothed with yellow hairs, the tarsi with closely-set short golden ones beneath; general colour bronzy-black, the anterior and middle knees and basal half of the tibiae brownish-yellow.

Abdomen (fig. 78) shiny, clothed dorsally with an orange-yellow pile; 1st segment bronzy; 2nd bronzy-black except for two triangular orange spots, one on each side, their bases being along the sides of the segment and extending over the posterior angles of 1st segment; 3rd and 4th segments bronzy with a dome-shaped black spot from the centre of the anterior margin; posterior margin of each segment with a narrow transverse black band broader at the sides and in the middle; genital segments greyish-pruinose in some lights.

♀. Vestiture of front not divided by a bare area; lower part of front with darker reflections; abdomen more conspicuously haired, the hairs inclined to form golden areas at the anterior angles of the segments.

♂ and ♀. Length, 11 mm.

Plesiotype: ♂, No. 322, D. M.; ♀, No. 317, D. M.

Habitat.—Dunedin, Wellington, and Auckland.

H. hochstetteri Nowicki. (Plate L, fig. 3.)

H. hochstetteri Nowicki, *Mem. Krakauer Akad. Wissen.*, ii, p. 23 (1875); Hutton, *Cat. Dipt. N.Z.*, p. 42 (1881). *H. latifrons* Schiner, *Reise der Freg. "Novara," Dipt.*, p. 359 (1868); Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 39 (1901). *Mallota latifrons* Hutton, *Cat. Dipt. N.Z.*, p. 40 (1881). *Latifrons* preoccupied Loew, *Ber. Ento. Zeit.*, vii (1863).

A moderately large robust fly, recognized by the brilliant violet-blue to greenish abdomen and yellow-tipped scutellum.

♀. Eyes bare; front black with greyish reflections and clothed with dense black hairs; frontal orbits silvery in some lights; lunular area brilliant orange-yellow but margined with black posteriorly; 1st and 2nd antennal joints black; 3rd joint orange-yellow but margined with brownish-black along the upper and front edges; arista black. Face distinctly concave below antennae, the protuberance shiny brown, this colour descending as a broad bare area to anterior oral margin; oral margin bordered by shiny black; remainder of face dullish black and clothed with blackish hairs, silvery in some lights; facial orbits silvery; cheeks and occiput blackish-grey with lighter reflections, the former clothed with greyish hairs; a silvery spot at lower eye-angle; proboscis blackish-brown, the palpi paler.

Dorsum of thorax rather densely clothed with short black hairs; dull black with 4 indistinct blue-grey stripes and a very narrow medio-longitudinal one. The dorsum shows a shiny bluish and faintly metallic tinge towards the scutellum; pleurae blue-black with a greyish reflection, and clothed, anterior to the wings, as the dorsum; thoracic spiracles tawny; a brilliant orange-yellow spot beneath the root of wings; scutellum shiny, dark brown except for orange-yellow apex, and clothed with black hairs; in some cases the yellow almost covers the whole scutellum. Wings clear, the stigma faintly tinged, veins blackish-brown; squamae and anti-squamae tinged and margined with black, the former fringed with long black branched hairs and the latter with short hairs; halteres brownish-yellow. Femora blue-black with a greyish reflection and clothed with white hairs; posterior femora broad, with a yellowish area beneath at apex and short spines along lower side distally; tibiae and tarsi brownish-black; the anterior and middle tibiae paler brown basally; the posterior rather produced to a blunt inferior process apically; tarsi with lighter reflections, golden on the posterior pair.

Abdomen indistinctly clothed with short white hairs, longer at sides of apical segments and merging into brownish hairs along sides of 1st and 2nd segments; 1st segment dull, the remainder brilliant violet-blue, at times with a greenish tinge more distinct in some specimens; vestiture on 2nd, 3rd, and 4th segments arranged as a pair of indistinct areas separated in the middle by a longitudinal dull-black spot which arises from the anterior margin, narrows, thence widens, and ends before reaching the posterior margin.

♂. Eyes dichoptic; frontal orbits parallel half-way down the front, thence divergent; from the angles thus formed on each side a shining black triangle projects across front, forming a bare transverse area; in some specimens 3rd antennal joint not margined with blackish-brown but merely with a brownish area at insertion of arista; genitalia orange-yellow.

♂. Length, 9 mm. ♀. Length, 11 mm.

Plesiotype: No. 1244, D. M.

Habitat.—Throughout New Zealand.

H. campbellicus Hutton.

H. campbellicus Hutton, *Trans. N.Z. Inst.*, vol. 34, p. 170 (1902).

A moderately large sombre-coloured fly with an indistinctly-striped thorax, bronzy to bluish-green abdomen, and tawny scutellum.

♀. Eyes bare; front blackish-brown with a dense vestiture of blackish hairs and greyish reflections on lower half, becoming silvery along orbits; lunular area large and tawny, narrowly margined behind with black, the posterior margin cleft by a median groove; 1st and 2nd antennal joints black, 3rd joint orange-red broadly margined with black; arista black. Face (fig. 69) moderately concave beneath antennae, the protuberance and a broad area on each side bare and tawny; in some of the New Zealand specimens there is a black or brownish central stripe; remainder of face brownish-yellow with black and silvery reflections and clothed with silvery hairs; oral margin broadly margined with black; facial orbits silvery beneath ; cheeks and occiput blackish-grey, the former bearded with grey hairs ; proboscis and palpi black.

Dorsum of thorax clothed with a brownish pile which is silvery in some lights ; blackish-brown with four broad greyish stripes and a narrow medio-longitudinal one anteriorly (fig. 81) ; a brownish area with golden hairs extending from wing-articulation over alar regions ; pleurae greenish-black and clothed as dorsum ; spiracles tawny ; an orange spot beneath root of wings ; scutellum tawny, darker basally, and clothed with brownish hairs. Wings faintly tinged, veins blackish-brown, the stigma pale brown ; squamae translucent, greyish, margined with brown, and fringed with brownish hairs arranged as in preceding species ; halteres reddish-brown. Legs clothed with greyish hairs ; femora blackish-brown but fulvous distally ; posterior femora broadened and with short spines below distally ; tibiae fulvous, the anterior and posterior darker distally and with short hairs on lower side giving a golden reflection ; tarsi brownish-black, but with a greyish reflection above and golden beneath.

Abdomen broad, ovate, and clothed with short silvery hairs which lengthen along the sides to form a distinct fringe ; vestiture arranged in areas on 2nd, 3rd, and 4th segments giving an indistinctly spotted appearance as shown in fig. 83 (the areas in the ♀ are larger). All the segments brilliant bronzy-green with duller and indistinct blackish markings between the areas of hair.

♂. Front brownish with a narrow transverse blackish band from angles of orbits (fig. 68). Antennae varying in intensity of colour, the marginal black of 3rd joint sometimes absent. Abdomen duller bronzy-green, the areas of vestiture more distinctly white though narrower than those of ♀.

♂. Length, 11 mm. ♀. Length, 12 mm.

Holotype : ♀, Hutton's collection, Canterbury Museum ; ♂, No. 1079, D. M.

Habitat.—Campbell Islands (Hutton) and throughout New Zealand.

H. chathamensis Hutton.

H. chathamensis Hutton, *Trans. N.Z. Inst.*, vol. 33, p. 39 (1901).

This species has not so far been found in New Zealand ; Hutton's four specimens were captured on the Chatham Islands and preserved in spirit ; there are two females, one of which is the holotype, and two males. There is a rather close resemblance between *chathamensis* and *campbellicus*, though they differ distinctly in the colour of the abdomen ; but whether the action of the preservative has had any effect on the colour of the former species it is difficult to say.

The distinguishing features of *chathamensis* are the following :—

♀. Front blackish-brown, the lower half with a distinct yellowish-grey reflection ; face (fig. 85) clothed on each side with yellowish hairs and greyish-yellow tomentum ; the protuberance and oral margin shiny black ; proboscis and palpi brownish. Thorax, scutellum, wings, and legs as *campbellicus*, but the tarsi black and the posterior femora not as broad ; halteres pale-brown. Abdomen bronzy, clothed more or less with tawny hairs ; the " dead-black patches in the middle of each segment " mentioned by Hutton are, when present, very indistinct. The abdomen is narrower than that of *campellicus*.

♂. The markings of the tibiae are more or less distinctly defined; a distinct transverse groove across front at orbital angulations; genitalia tawny.

♂. Length, 9 mm. ♀. Length, 11 mm.

Holotype: Hutton's collection, Canterbury Museum.

Habitat.—Chatham Islands.

Genus Myiatropa Rond.

The species of this genus closely resemble those of *Helophilus*, from which they may be distinguished by the hairy eyes, those of the male being almost holoptic. *Myiatropa* differs from *Eristalis* by the open cell R_1.

M. campbelli n. sp.* (Plate LI, fig. 1.)

This fly is very nearly identical in form and colour with *Helophilus cargilli*.

♀. Eyes approximated on vertex, clothed with golden hairs indistinct above but conspicuous in front and below; front widening anteriorly, orange-brown with darker reflections, and clothed with a brownish pile; a medio-longitudinal fissure ending half-way down the front at a transverse, central, brownish area, below which the front has a transversely wrinkled appearance; lunular area orange-yellow but black posteriorly; a blackish area on front just behind lunule. Antennae shaped as in *Helophilus;* 1st and 2nd joints brownish-yellow to brownish-black; 3rd joint orange-yellow with a silvery reflection and faintly tinged around the border with brown; arista blackish-brown. Outline of face as in *Helophilus;* face a rich tawny colour, transversely wrinkled, and clothed on each side with tawny hairs; prominence bare, tawny on each side but centrally with a brownish-yellow stripe; oral margin bordered with blackish-brown, this colour narrowing to the anterior angles; cheeks and occiput tawny, the former bearded with tawny hairs; proboscis dark brown, palpi paler.

Dorsum of thorax clothed with short brownish to tawny hairs; 3 longitudinal broad black stripes, the median stripe furcate and the lateral ones interrupted (fig. 80); angles of transverse suture bordered with black; a short narrow and oblique black stripe at wing-articulation; dorsum otherwise tawny; suture from humerus to wing indistinctly black; pleurae black in ground-colour, the meso-, ptero-, and upper part of sterno-pleurae tawny-pruinose and clothed with tawny hairs; the stigmata pale tawny. Legs orange-red with a tawny reflection, except the shiny brownish-black basal part of the femora, all of which are clothed with tawny hairs; the posterior femora not broadened, tapering distally, and with spines below toward apex. Wings faintly tinged basally with yellow; the stigma pale yellow; veins brownish-yellow; vein R_{2+3} strongly upturned and curved slightly backward apically (fig. 86).

Abdomen broad and oval (fig. 84), clothed with short tawny hairs except on black parts; 2nd and 3rd segments with large orange-red areas separated from each other and from the posterior margin of each segment by black; on each of these areas centrally is a distinct greyish-yellow circular spot; the orange-red of 2nd segment encroaches over the posterior

* Named after Mr. J. W. Campbell, of Christchurch.

1

2

3

Fig. 1.—*Myiatropa campbelli* n. sp.: adult female. × 3½.
Fig. 2.—*Merodon equestris*: adult male. × 4.
Fig. 3.—*Eristalis tenax*: adult male. × 4.

1

2

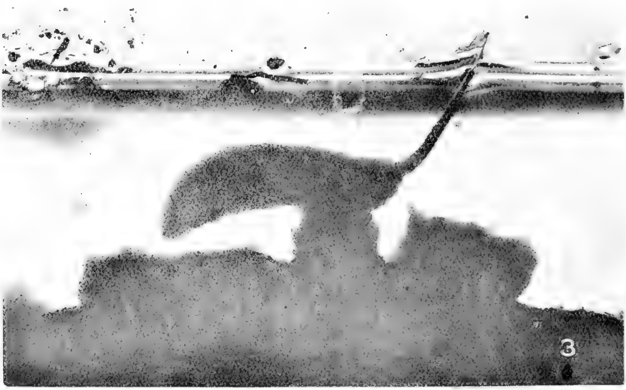

FIG. 1.—*Paragus pseudo-ropalus* n. sp.: adult male. × 4.
FIG. 2.—*Syrphus harrisi* n. sp.: adult female. × 4
FIG. 3.—*Eristalis tenax* larva submerged in water. Magnified.

angles of 1st segment; 3rd segment with a dome-shaped greyish-yellow spot on the black part in the middle at posterior margin; 4th segment with a much larger spot in middle at posterior margin, the orange-red of this segment confined to the anterior margin at each side, the remainder of the segment greyish-yellow except for the black, arranged as in fig. 84; 5th segment yellowish-grey, except for a median rectangular spot from anterior margin and for the brownish-yellow apex; 4th and 5th segments clothed with long tawny hairs; the sides of 1st and 2nd segments with golden hairs.

♀. Length, 14 mm.

Holotype: No. 1245, D. M.

Habitat.—Day's Bay (E. H. Atkinson); Otira (J. R. Harris).

Genus MERODON Meigen (1803).*

This genus is readily recognized by the hairy and bee-like nature of the species; the open cell R_1, together with the recurrent vein M_1, the elongated cell M, and the shortened cell 1st M_2; the extraordinarily large triangular process near the apex of the posterior femora on the underside; the swelling on the underside of the posterior tibiae just beyond the middle; and the apical inferior process.

There is only one species found in New Zealand, and that is the European narcissus-fly (*M. equestris* Fabr.) (Plate LI, fig. 2). The general colour is black and the wings clear; the thorax and abdomen are clothed with a dense pile, orange on anterior half of thorax and posterior half of abdomen but otherwise black. The head is clothed with golden pile, and in the male the eyes meet at a point on the middle of the front.

The larvae are fleshy maggots, and are well known for their attacks upon imported narcissi and other bulbs. This species is not universally established in New Zealand, but the adults have been found at Christchurch, Wellington, and Auckland.

Length, 11–14 mm.

Genus ERISTALIS Latr. (1804).†

This genus may be recognized by the hairy eyes, holoptic in the male; the pilose thorax and hairy legs, and the closed cell R_1.

The only species found in New Zealand is the European drone-fly (*E. tenax* Linn.) (Plate LI, fig. 3), which has become thoroughly established throughout the country and is one of our most common insects. The abdomen has a pair of transverse yellow triangular spots on the 2nd segment, the posterior margin of which is also yellow; there is also a pair of similar, but much smaller, spots on the 3rd segment. A considerable amount of variation occurs both in size and colour, the abdomen, for example, being at times completely blackish-brown. The larvae of the drone-fly are of the well-known "rat-tailed" type, frequenting weedy ponds and decaying filth (Plate LII, fig. 3).

Length, 11–16 mm.

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* Coquillett (*Type Species of N. Amer. Dipt.*, 1910) states that *Merodon* Meig. is a synonym of *Lampetia* Meig. (1800).

† Coquillett (*l.c.*) considers that *Eristalis* Latr. (1804) is a synonym of *Tubifera* Meig. (1800).

Art. XXXII.—*Notes and Descriptions of New Zealand Lepidoptera.*

By E. Meyrick, B.A., F.R.S.

Communicated by G. V. Hudson, F.E.S., F.N.Z.Inst.

[*Read before the Wellington Philosophical Society, 22nd September, 1920; received by Editor, 29th September, 1920; issued separately, 8th August, 1921.*]

Pyraustidae.

Scoparia crypsinoa Meyr.

Having by degrees received from Mr. Hudson a considerable series of this rather variable species, I am now of opinion that *agana* Meyr. can only be regarded as a synonym of it, as I find no constant distinction.

Tortricidae.

Harmologa brevicula n. sp.

♀. 23 mm. Head, palpi, and thorax yellow-whitish. Abdomen whitish. Forewings oblong, rather short, costa anteriorly gently arched, posteriorly nearly straight, apex obtuse, termen hardly oblique, rounded beneath; pale greyish suffusedly mixed with yellow-whitish, more yellowish-tinged towards dorsum; cilia white. Hindwings whitish, very faintly greyish-tinged on dorsal half; cilia white.

Arthur's Pass, 4,000 ft., in February (Hudson); one specimen. Much shorter-winged than *siraea* ♀, and with termen much less oblique than in *tritochlora* ♀, which are the two species nearest to it.

Glyphipterygidae.

Heliostibes chlorobela n. sp.

♂. 22 mm. Head dark grey. Palpi grey-whitish, anteriorly suffused with dark fuscous, terminal joint hardly half as long as second. Antennae fasciculate-ciliated (3). Thorax dark fuscous suffused with ferruginous. Abdomen dark fuscous, segmental margins light grey, anal tuft grey. Forewings elongate, gradually dilated, costa slightly arched, apex obtuse, termen straight, hardly oblique; dark fuscous, suffusedly overlaid with deep ferruginous; extreme costal edge white anteriorly except at base, and whitish marks on costal edge at $\frac{2}{3}$ and $\frac{3}{4}$; some scattered whitish hair-scales towards middle of disc, and between $\frac{3}{4}$ of costa and tornus; cilia grey, basal half dark fuscous. Hindwings blackish; a suffused gradually expanded ochreous-whitish median streak from near base to beyond cell; cilia ochreous-whitish, towards tornus and apex greyish, with dark-fuscous basal shade.

Mount Arthur, 3,600 ft., in January (Hudson); one specimen. Closely allied to *illita*, of which it might be supposed to be a mountain form with loss of orange colour of hindwings, but the difference in structure of palpi (terminal joint in *illita* about $\frac{2}{3}$ of second) indicates that it is probably distinct.

Charixena n. gen.

I propose this name in place of *Philpottia* Meyrick (*Trans. N.Z. Inst.*, vol. 48, p. 416), which, as Mr. Hudson has kindly pointed out to me, was unfortunately preoccupied by *Philpottia* Broun in Coleoptera the year before. I could not know this at the time.

HELIODINIDAE.

Stathmopoda phlegyra Meyr.

With increased material I find that *fusilis* Meyr. cannot be kept specifically separate from this.

ELACHISTIDAE.

Elachista exaula Meyr.

An abnormal variety (♀) from the Mataura River (Hudson) has posterior $\frac{3}{5}$ of forewing suffused with rather dark grey; the normal type occurs in the same locality, and I am confident that it is only a variety, though of much interest, as it seems to connect the species with the dark-winged group.

PLUTELLIDAE.

Orthenches cuprea Meyr.

A fine specimen now sent by Mr. Hudson shows that this species was wrongly placed in *Hyponomeuta*, the maxillary palpi being well developed, curved, ascending, as usual in *Orthenches*; they must have been damaged in the original type.

TINEIDAE.

Astrogenes n. gen.

Head with dense loosely-appressed hairs; ocelli posterior; tongue absent. Antennae $\frac{5}{6}$, in ♂ pubescent, basal joint short, without pecten. Labial palpi rather long, slightly curved, subascending, with appressed scales, second joint rough beneath, with lateral series of rather short bristles, terminal joint as long as second, transversely flattened, obtuse. Maxillary palpi rather long, several-jointed, folded, scaled. Posterior tibiae clothed with hairs above. Forewings with 2 from towards angle, 7 to costa, 11 from before middle. Hindwings 1, ovate-lanceolate, cilia nearly 1; 2 widely remote, 3–7 nearly parallel.

Allied to *Tinea*.

Astrogenes chrysograpta n. sp.

♂. 13 mm. Head, thorax, and abdomen dark fuscous. Palpi whitish, anterior surface forming a strong black streak with whitish edges. Forewings elongate, rather narrow, costa gently arched, apex obtuse, termen extremely obliquely rounded; dark bronzy-fuscous, with some bronzy suffusion in disc posteriorly; markings pale golden-metallic; a slender streak along basal half of fold; a slightly excurved transverse line before middle; five transverse dots on posterior half of costa, second confluent with a transverse mark in disc; a transverse mark from dorsum before tornus; a small transverse apical spot: cilia light greyish, with dark-fuscous subbasal shade, and within this some golden-metallic basal marks. Hindwings dark purple-grey; cilia grey.

Mount Arthur, 4,200 ft., in January (Miss Stella Hudson); one specimen. An interesting and beautiful insect.

Tinea fagicola n. sp.

♂ ♀. 10 mm. Head grey, face whitish. Palpi rather short, whitish banded with dark fuscous. Antennae whitish-grey ringed with black. Thorax blackish, somewhat pale-sprinkled. Abdomen dark grey. Forewings elongate, rather narrow, costa gently arched, apex obtuse-pointed, termen very obliquely rounded; dark fuscous irregularly speckled with whitish; variable short white costal strigulae, normally five or six on basal third, three about middle, two at $\frac{2}{3}$, one or two beyond this, and two before apex; oblique narrow blackish fasciae from costa before and beyond median group not reaching dorsum; two or three suffused white strigulae on middle of dorsum: cilia grey with black subbasal line and dark-fuscous subapical shade, marked with white on praeapical strigulae. Hindwings dark grey; cilia grey, with dark-fuscous subbasal line.

Day's Bay, Wellington, from December to February, on *Fagus* trunks (Hudson); seven specimens. Although very dissimilar to the normal form of *T. margaritis*, I have a mottled variety of that species which made me at first doubtful whether this might not be a dark local form of it; it may be useful, therefore, to point out that (as I find on closer study) the palpi in *margaritis* are much longer and more slender relatively, and the antennae in *margaritis* are relatively longer, with closer and much more numerous joints (nearly 50), whilst in this species they do not much exceed 30 and are more distinct.

Nepticulidae.

Nepticula progonopis n. sp.

♂. 6 mm. Head deep orange. Antennae dark grey, eye-caps whitish. Thorax dark purple-grey. Abdomen dark grey. Forewings lanceolate; dark purple-grey: cilia grey, toward base mixed with dark purple-grey. Hindwings with frenulum long, simple; dark grey; cilia grey.

Mount Arthur, 4,000 ft., in January (Hudson); one specimen.

Hepialidae.

Porina ascendens n. sp.

♀. 42–52 mm. Head, thorax, and abdomen pale ochreous. Forewings with costa almost straight, arched near apex, termen slightly rounded, oblique; pale bronzy-ochreous; an irregular-edged inverted-triangular patch of grey-whitish irroration extending beneath middle from base to $\frac{3}{4}$, more or less partially edged above by a dark-fuscous line and also anteriorly beneath; post-median and subterminal series of small whitish spots or marks finely edged with dark-fuscous irroration parallel to termen, placed in more or less developed bands of grey-whitish irroration: cilia pale ochreous sometimes mixed with dark fuscous, obscurely barred with whitish. Hindwings very pale rosy-grey, tinged with pale ochreous towards termen; cilia pale ochreous barred with whitish.

Mount Arthur, in January (Hudson); two examples. Although I have not seen a male, I venture to describe this, which is quite distinct from any other.

ART. XXXIII.—*Notes and Descriptions of New Zealand Lepidoptera.*

By ALFRED PHILPOTT, F.E.S., Assistant Entomologist, Cawthron Institute, Nelson.

[*Read before the Nelson Institute, 27th November, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

CARADRINIDAE

Aletia gourlayi n. sp.

♂. 35 mm. Head and thorax grey. Palpi ochreous-grey with black hairs laterally. Antennae serrate, ciliate, 1. Abdomen ochreous-grey. Legs ochreous-grey, tarsi obscurely banded with darker. Forewings, costa straight, apex rectangular, termen bowed, waved, oblique; *bluish-grey mixed with fuscous-brown;* lines whitish, obscure, indicated by fuscous margins; basal line very obscure, indicated chiefly by two blackish dots on costa; first line irregular, narrowly margined with fuscous which becomes prominent on costa as two blackish dots; orbicular circular, narrowly ringed with darker; *a rather prominent dentate curved brownish-fuscous median line;* reniform obscurely ringed with whitish followed by dark fuscous; a pair of black dots on costa above reniform; second line faint, evenly serrate, irregularly curved; subterminal irregularly serrate, anteriorly dark-margined, suffusedly on costa and, in a lesser degree, on dorsum; a terminal series of crescentic black dots: cilia ochreous mixed with fuscous and white; an obscure waved median line. Hindwings fuscous: cilia whitish-ochreous.

A neat and handsome species, distinguished from its allies by the delicate silvery-grey ground-colour.

Arthur's Pass. Several taken at flowers of *Dracophyllum* sp. in February by Mr. E. S. Gourlay, of Christchurch. Type in the discoverer's collection.

Melanchra fenwicki n. sp.

♂. 37 mm. Head, palpi, and thorax reddish-brown. Antennae reddish-brown, bipectinated, apex simple, pectinations $3\frac{1}{2}$. Abdomen greyish-brown, lateral and anal tufts reddish-ochreous. Legs reddish-brown, tarsi obscurely annulated with paler. Forewings moderate, costa slightly sinuate, termen evenly rounded, oblique; *dark reddish-brown;* an obscure basal fascia mixed with blackish; *stigmata ringed with ochreous-white, faintly margined with black;* orbicular circular, well defined; claviform sub-circular, obscure; reniform upright, regular; subterminal line parallel with termen, thin, slightly and irregularly serrate, ochreous-white, suffusedly margined anteriorly with brownish-black: cilia uniform reddish-brown. Hindwings and cilia pale reddish-fuscous, tips of cilia whitish.

Nearest to *M. insignis* (Walk.), but differing entirely in the form of the subterminal line and the longer antennal pectinations.

Dunedin, in September. One specimen, taken by Mr. C. C. Fenwick, after whom I have named the species, and in whose collection the type remains.

Hydriomenidae.

Xanthorhoe clandestina n. sp.

♂. 35 mm. Head and palpi grey-whitish. Eyes olive-brown. Antennae dark grey, pectinations 5 but appearing shorter owing to being basally appressed to the shaft. Thorax grey. Abdomen whitish-grey. Forewings elongate-triangular, costa sinuate, apex bluntly pointed, termen straight, oblique; *bluish-grey; lines faintly indicated in darker;* an irregular basal line at $\frac{1}{6}$; first line at $\frac{1}{3}$, double, slightly waved; discal spot rather elongate, transverse, dark; a fairly straight, slightly waved, median line; second line from $\frac{2}{3}$ costa to $\frac{3}{4}$ dorsum, excurved on upper half, faintly margined with white on veins: cilia white, basally mixed with grey. Hindwings grey, slightly darker round termen: cilia white.

The bluish-grey colour of this species recalls the much larger *X. subobscurata* (Walk.), but the latter differs in the presence of ochreous and whitish shades.

Arthur's Pass, in February. I am indebted to Mr. E. S. Gourlay for the opportunity of describing this species, he having captured a single specimen which, so far, remains unique. Type in the collection of its discoverer.

Xanthorhoe helias obscura n. subsp.

♂♀. 26–30 mm. Head and palpi ochreous, the latter usually darker. Antennae, shaft whitish-ochreous, pectinations darker. Thorax ochreous, tinged with reddish on shoulders. Abdomen ochreous mixed with fuscous, anal tuft bright ochreous. Legs whitish-ochreous, anterior pair suffused with fuscous. *Forewings dull fuscous shading to ochreous along costa;* first and second lines distinct, narrow, white; subterminal thin, whitish, sometimes partially obsolete: cilia pink. Hindwings ochreous, apical half fuscous; second line prominent, irregular, whitish, anteriorly fuscous-margined; one or two parallel ochreous lines sometimes follow second line, and there are indications occasionally of preceding lines also: cilia pink.

The Hump (Waiau), late in February. The males are fairly common in a damp scrub-filled gully, but only one female was taken. The latter sex is remarkable in having both fore and hind wings much narrowed.

I should not hesitate to accord this form specific rank but for the fact that some of the specimens, by loss of the fuscous colouring, approach the typical *helias*. It cannot be said from the material at hand, however, that the two forms really link up.

Notoreas arcuata n. sp.

♀. 27 mm. Head, palpi, and thorax golden-yellow with some whitish scales. Antennae black, annulated with whitish. Abdomen black, segmental divisions whitish. Legs ochreous-whitish, strongly infuscated, tarsi annulated with ochreous. Forewings triangular, apex obtuse, termen bowed, oblique; *dark fuscous, densely irrorated with yellow;* lines narrow, white, sometimes yellow-tinged; a basal line anteriorly broadly margined with black, curved, distinct, slightly irregular; first line strongly curved, irregular, posteriorly margined with black; a black discal dot; an obscure irregular yellow median line; second line anteriorly broadly margined with black and followed by narrow yellow margin indented above and below middle; subterminal irregular, dilated on costa and at middle, yellowish above dorsum: cilia white, prominently barred with blackish. Hindwings and cilia as forewings but basal line absent and subterminal wholly yellow. Undersides reproducing markings of upper surfaces but with the lines much broader and the basal area of costa suffused with clear yellow.

Mr. G. V. Hudson has two examples, both taken at Arthur's Pass, the first in December, 1908. Mr. R. Grimmett has a single specimen, captured on the St. Arnaud Range, Nelson.

Differs from *Notoreas mechanitis* (Meyr.) in the less triangular forewing, the costa being more arched; the form of the second line is also quite different. It is possible that when the male is discovered the species will have to be placed in *Dasyuris*. Type in Mr. Grimmett's collection, to whose kindness I am indebted for the opportunity of describing the species.

MONOCTENIADAE.

Adeixis griseata (Huds.), *Trans. N.Z. Inst.*, vol. 35, p. 244, pl. 30, fig. 5.

Having received, through the kindness of Mr. George Lyell, of Gisborne, and Dr. Jefferis Turner, of Adelaide, a number of examples of *Adeixis inostentata* (Walk.), I have come to the conclusion that the New Zealand insect hitherto regarded as being indentical with the Australian species is distinct, and therefore should be known as *A. griseata* (Huds.). Walker's material came from various parts of Australia, as did also Warren's, who redescribed the species under the name of *Adeixis insignata* (*Nov. Zool.*, 4, p. 27). *A. griseata* (Huds.) differs from *A. inostentata* (Walk.) chiefly in the well-marked white lines beneath costa and from apex to dorsum at $\frac{1}{2}$. In my "List of the Lepidoptera of Otago" (*Trans. N.Z. Inst.*, vol. 49, p. 210) I refer to *griseata* (under the name of *inostentata*) as being probably of recent Australian origin, having been found only in the vicinity of the Port of Bluff. Since the publication of the list, however, the species has been taken by Mr. G. V. Hudson and Mr. C. E. Clarke at remote localities in the North Island, and I have also met with it at Lake Manapouri. I am much indebted to Mr. H. Hamilton, of the Dominion Museum staff, for assistance in the matter of literature relating to the Australian insect.

SELIDOSEMIDAE.

Selidosema modica n. sp.

♂. 30–31 mm. Head and palpi brownish-grey mixed with white, pectinations 12. Thorax brownish-fuscous mixed with white, collar ochreous. Abdomen grey. Forewings triangular, costa gently arched, subsinuate, apex rectangular, termen rounded, more oblique on lower half; fuscous-brown; first line obscure, sharply angled outwards beneath costa, whitish; an obscure blackish discal dot; second line from $\frac{2}{3}$ costa to $\frac{2}{3}$ dorsum, upper half straight, lower half incurved, white; a broad clear brown band following second line; subterminal indicated by a series of white dots, preceded and followed by black ones, on veins; a series of black dots round termen: cilia brown mixed with whitish and grey. *Hindwings whitish-grey, densely sprinkled with darker;* a dark discal dot; an irregular series of blackish dots round termen: cilia grey-whitish.

Resembling *S. productata* (Walk.), but at once distinguished by the grey hindwings, those of the former species being always more or less ochreous. The antennal pectinations are also shorter in *modica*.

Port Hills, Christchurch, in February. Two males captured by Mr. E. S. Gourlay, who kindly presented one to me. The type is in the collection of Mr. Gourlay.

Gelechiadae.

Gelechia dividua n. sp.

♂♀. 9–12 mm. Head whitish-grey. Palpi grey, infuscated beneath. Antennae blackish. Thorax brown. Abdomen grey, ochreous-tinged basally. Legs fuscous-grey. Forewings narrow, costa slightly arched, faintly sinuate on apical half, apex round-pointed, termen extremely oblique; *brownish-grey; a black central streak from base to before $\frac{1}{2}$, attenuated apically*, sometimes margined beneath with ochreous; *a similar streak commencing slightly above and beyond basal streak and continuing to apex*, evenly widening from acute base: cilia brownish-grey. Hindwings shining grey-whitish: cilia as in forewings.

Near *G. monophragma* Meyr., but the ground-colour is much darker and the median black streak is not continuous as in that species.

Six specimens forwarded by Mr. C. C. Fenwick. Four of these are from Paradise, Lake Wakatipu, taken on the 1st January, and two from Alexandra, Central Otago, captured a fortnight later. Type in Mr. Fenwick's collection.

Oecophoridae.

Borkhausenia seclusa n. sp.

♂. 16–17 mm. Head and palpi grey, palpi infuscated beneath. Antennae grey, obscurely annulated with blackish. Thorax fuscous-grey, shoulders brown. Abdomen greyish-brown. Legs ochreous-grey, tarsi infuscated. Forewings rather elongate, costa moderately arched, apex rounded, termen strongly oblique; *brownish-grey mixed with white and fuscous; stigmata fuscous*, first and second discal in a line, obscurely white-margined; plical before first discal, submerged in oblique fuscous fascia from dorsum to beneath first discal; a subterminal curved fuscous line, indented beneath costa, submerged in brownish-fuscous patch above tornus and reappearing on dorsum before tornus as a triangular spot, broadly margined with white on upper portion; space above apical half of dorsum broadly suffused with white: cilia grey mixed with fuscous, round apex wholly fuscous. Hindwings and cilia grey.

Nearest *B. crotala* Meyr., but greyer than that species and without any ochreous admixture. The hindwings are also darker.

Known from the Wakatipu district only so far. A single male captured on Ben Lomond in December, and another secured at Lake Luna a few days afterwards. Both specimens were taken at elevations of from 1,500 ft. to 2,000 ft.

Izatha acmonias n. sp.

♂♀. 25–28 mm. Head white. Palpi white. Antennae brownish-black. Thorax white, anterior margin, a triangular central anterior mark, and a posterior spot black. Legs black, posterior tibiae grey, tarsi narrowly annulated with white. Forewings moderate, costa rather strongly arched basally, apex rounded, termen gently rounded, slightly oblique; *white, markings black*; a broad basal band including a minute spot of white next thorax, outer edge nearly straight to fold, thence produced along fold to an acute point, from whence it returns inwardly oblique to dorsum; an irregular fascia from costa at $\frac{1}{4}$ to fold before $\frac{1}{2}$, its apex turned inward along fold and almost connecting with basal band, a strong inward tooth beneath costa and a similar outward one at middle; a strong fascia from costa at $\frac{1}{2}$ to before tornus, having two prominent inward projections, the first beneath costa and the second, which points obliquely downwards, at middle; an irregular spot on tornus at $\frac{2}{3}$; a series of three spots, the central one twice the size of the others, between central fascia and apex; a small spot beneath first costal spot, and a larger one, touching central fascia, beneath this; a broad inwardly-oblique fascia from apex, somewhat constricted and then expanding as a triangular patch; a series of terminal dots, becoming progressively larger towards tornus: cilia white. Hindwings grey clouded with fuscous; an indistinct discal spot: cilia light fuscous-grey, a broad white bar beneath apex and an obscure dark basal line.

Practically the only difference between *I. acmonias* and *I. picarella* (Walk.) is the greater breadth of the transverse fasciae and other black markings in the former. It is usually a larger insect, but the smallest individuals are no greater in wing-expanse than the largest of *picarella*.

November and December. Rather rare, but distributed throughout the lowland forest country of the South Island. Several years ago this species was sent by Mr. G. V. Hudson to Mr. E. Meyrick, who gave it the MS. name of *acmonias*. He did not, however, publish a description, having subsequently arrived at the conclusion that the form was not specifically distinct from *picarella* (Walk.). I therefore adopt Mr. Meyrick's suggested name, my experience of the insects having convinced me of their distinctness.

Tineidae.

Taleporia cawthronella n. sp.

♂. 9 mm. Head and thorax ochreous-grey. Palpi whitish. Antennae grey annulated with black, ciliations 3. Abdomen grey-fuscous. Legs grey-whitish. Forewings, costa slightly arched, faintly sinuate, apex rounded, termen strongly oblique; whitish-grey, slightly ochreous and irrorated with fuscous especially on basal $\frac{3}{4}$; base of costa irregularly brownish-black to $\frac{1}{4}$; a rather large brownish-black spot on costa at $\frac{1}{2}$; three smaller brownish-black spots on costa on apical $\frac{1}{3}$; an irregular transverse brownish-black discal spot; a series of small blackish-brown spots round termen: cilia grey-whitish. Hindwings and cilia fuscous-grey.

Maitai Valley, Nelson. A large number bred from larvae found on the face of a gravelly cutting by the side of the Maitai River. Many hundreds of the larvae were to be found at this one spot, but search in similar situations in this and other valleys failed to result in the discovery of other colonies. The larva inhabits a case constructed of the fragments of a species of white lichen. The case is irregularly pyriform in shape, rough on the surface, and, when containing a full-grown larva, about 6 mm. long by 3·5 mm. broad. It is a rather fragile shelter, being easily pulled to pieces. In travelling, the head and thorax are projected from the case, and when a foothold is secured the case is lifted clear of the surface and drawn forward.

Should the case catch on a projection an extra high lift is given to clear the obstacle. The larvae began to pupate about the end of June, the first moth appeared on the 3rd August, and emerging continued till the middle of October. When preparing for pupation the larvae attaches the apex of its case to the surface of a stone or the stem or leaf of some plant. The attachment is not rigid, but permits the case to swing in all directions. The head of the pupa is well separated from the thorax, and the legs reach quite to the extremity of the abdomen. On the dorsal surface of the last abdominal segment there is a transverse row of stout recurved spines; these probably serve to keep the pupa from slipping from the case when the emergence of the imago is taking place.

As this is the first new species to be reared in the insectarium of the Cawthron Institute, I have thought it fitting to give it a name serving in some degree to mark the circumstance. The type and paratypes are in the collection of the Institute.

Micropterigadae.

Sabatinca ianthina n. sp.

♂♀. 9–10·5 mm. Head clothed with long bright ochreous hair. Antennae blackish, annulated with ochreous on basal half. Thorax ochreous mixed with black. Abdomen black, sparsely clothed with whitish-ochreous hair. Legs fuscous, tarsi annulated with ochreous. Forewings broadly lanceolate, apex less acute in ♀; *dark metallic violet;* a band of pale lemon-yellow at base; *a lemon-yellow band before* $\frac{1}{2}$, *faintly excurved, and dilated slightly on dorsal half;* a variable series of lemon-yellow dots on costa between median band and apex, and a similar series on dorsum, usually two in each case but sometimes four or five: cilia greyish-fuscous. Hindwings dark metallic violet, fuscous basally: cilia as in forewings.

A very handsome and distinct species.

Dun Mountain, Nelson, at about 2,000 ft. A fair number were taken on a rocky slope covered with various species of mosses and liverworts. Many plants of a species of *Gahnia* grew on the spot, and the moths were nearly all taken by sweeping from this plant. Search on *Gahnia,* however, in other situations where no moss or liverwort was present failed to produce any moths, so that it is probable that the food plant of the species will be found to be a moss or a liverwort.

ART. XXXIV.—*Description of a New Dragon-fly belonging to the Genus* Uropetala *Selys.*

By R. J. TILLYARD, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), F.L.S., F.E.S., Entomologist and Chief of the Biological Department, Cawthron Institute of Scientific Research, Nelson, N.Z.

[*Read before the Nelson Institute, 23rd December, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

Plate LIII.

THROUGH the much-appreciated kindness of Dr. C. Chilton, Professor of Biology at Canterbury College, Christchurch, I was enabled, during the summer of 1919–20, to spend a few days at the Cass Biological Laboratory. In company with Dr. Chilton and Mr. Charles Lindsay, of the Canterbury Museum, I collected a number of dragon-flies from the streams around Cass; later on I obtained a number of the same species from Arthur's Pass. In both localities a large *Uropetala* was seen flying about, and a number of specimens of both sexes were obtained. At first I took this fine dragon-fly to be *Uropetala carovei* White, recorded from many localities in New Zealand, and also being the only known member of the genus. Later on, however, I obtained specimens of *Uropetala* from Lake Wakatipu, and also from the North Island, which in many characters did not agree with those taken at Cass and Arthur's Pass. It became evident that there were two species of *Uropetala* present in my collections, one of which agreed closely with the descriptions given by White and de Selys for *U. carovei*, while the other was undescribed. It is this latter species which occurs at Cass and Arthur's Pass.

While at Cass we located an area in a small mountain-swamp where the holes made by the larvae of this dragon-fly were abundant. By merely inserting one's fingers into these holes, which are made in peaty soil, and are about ½ in. in diameter, and by working one's hand downwards, enlarging the hole at the same time, until a depth of from 10 in. to more than 1 ft. is attained, the larvae can be felt as hard inert objects at the bottom, and can be hauled out with ease. Unlike the larvae of *U. carovei*, which, as far as my experience goes, are very fierce and liable to snap at one's fingers when handled, these larvae were very inert, and could be handled with safety. As the last three instars were obtained, this habit is not likely to be due to the approach of ecdysis, for more than fifty larvae were taken out and handled. I hope later on to make a careful comparative study of these two larval forms, with a view to the discovery and recording of any morphological differences that may be present. In the meantime, Mr. W. C. Davies, Curator of the Cawthron Institute, has very kindly offered me an excellent photograph of the larva of *U. carovei*, taken from a specimen found in the Wairarapa district, for publication in this paper. From this photograph, which is reproduced in Plate LIII, a very good idea can be obtained of the general appearance of these larvae. As far as I know, no accurate figure has yet been published of the larva of *U. carovei*, and I wish to thank Mr. Davies for this excellent photograph.

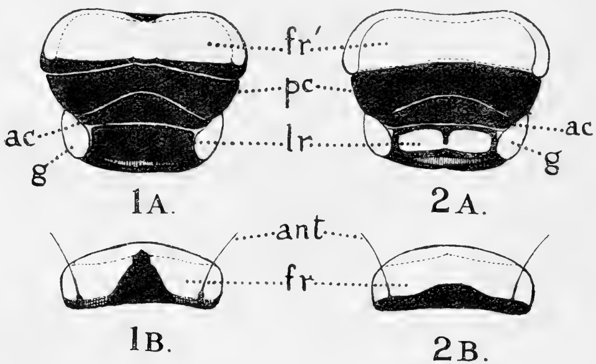
I wish to dedicate this new species, whose description follows, to Dr. Chilton as a memorial of the excellent work which he has done, and is doing, in connection with the Cass Biological Station.

Uropetala chiltoni n. sp.

♂. Total length, 83 mm.; abdomen, 60 mm.; forewing, 49 mm.; hindwing, 47 mm.; expanse, 102 mm.

General shape exactly as in *U. carovei.*

Head.—Eyes dark brown, the inner portion of the orbits blackish, the outer marked with a yellowish line. Occiput broadly yellow, as in *U. carovei.* Vertex black, the three ocelli brown. Frons yellow above, but with the black colour of the vertex encroaching basally for a short distance, as shown in text-fig. 2B; anterior portion of frons broadly yellow, this colour encroaching very slightly upon the upper portion of the postclypeus. Postclypeus and anteclypeus both black; genae yellow. Labrum with black margins surrounding a pair of partially fused subrectangular blocks of yellow, separated above only by a downward-projecting, short, median bar of black. Labium brown. The colouring of the facial portion of the head is shown in text-fig. 2A.



Colour-pattern of head in *Uropetala.*

Uropetala carovei White: Fig. 1A, face; fig. 1B, upper portion of frons.
Uropetala chiltoni n. sp.: Fig 2A, face; fig. 2B, upper portion of frons.

ac, anteclypeus; *ant,* antenna; *fr,* upper portion of frons; *fr′,* anterior portion of frons; *g,* gena; *lr,* labrum; *pc,* postclypeus.

Thorax.—Prothorax small, dark brown, hairy. Synthorax blackish brown, with paired dorsal and lateral stripes of yellow, very similar to those seen in *U. carovei.* The dorsal stripes are, however, broader than those in *U. carovei,* and stand closer to one another towards the middle line, leaving a narrower band of blackish brown along the mid-dorsal carina. The metanotum and lower part of the mesonotum are densely clothed with grey hairs, and similar hairs extend down on to the dorsal part of the first abdominal segment, and less abundantly on to the second also. Breast covered with long grey hairs. Legs entirely black. Wings as in *U. carovei*

Abdomen.—Shape narrow-cylindrical, segments 1–2 broader than the rest. Sides of 1–2 less hairy than in *U. carovei,* the edges of the lateral sheaths bordering the genital fossa almost hairless; in *U. carovei* the hairs on these parts are very distinct. Colour dark brown shading to black, with

Full-grown larva of *Uropetala carovei* White. × 2. From a photograph taken by Mr. W. C. Davies, Curator of the Cawthron Institute.

a pair of large basal yellow spots on each segment from 2 to 8; these spots are larger, squarer, and stand more closely together than do the corresponding spots in *U. carovei*. Segments 9–10 black, a brown mark low down on each side of 9, and a yellowish transverse line bordering the suture between it and 8; 10 with a pair of brown spots high up on the sides. Appendages: Superiors broadly black, foliate, as in *U. carovei;* inferior shorter, subtriangular, upcurved, downy beneath, blackish brown, tip very distinctly truncate, more so than in *U. carovei.*

♀. Slightly larger and stouter than ♂; general shape and coloration closely similar to that of ♂, but the upper part of the frons has the black colour encroaching upon it medially as a broadly triangular blotch, and the spots of the abdomen are considerably larger than in the ♂. Appendages short, 1 mm., black, separated by a brownish, downy tubercle.

Types.—♂ (holotype) and ♀ (allotype) taken together at Arthur's Pass, 19th January, 1920, and placed in the Cawthron Institute collection, which also contains a series of paratypes from the same locality.

Habitat.—Arthur's Pass and Cass, N.Z.

The specimens taken at Cass had only recently emerged, and were not in as good a condition for descriptive purposes as those taken a week later at Arthur's Pass; hence I have chosen the types from the latter series. It should be noted that all parts described here as yellow were in life pale creamy-yellow, not the rich lemon-yellow associated with mature examples of *U. carovei*. Possibly the new species assumes the deeper yellow colouring with advancing age, but we cannot be certain of this at present; it may equally well be that the creamy colour of the markings is a specific character.

Before deciding to describe this new species the specimens were taken to Europe and carefully compared with the specimens of *U. carovei* in the British Museum and in the de Selys collection at the Brussels Museum. This comparison established the fact that the specimens from Arthur's Pass and Cass were very distinct from any of the specimens of *U. carovei* in these collections. Whether the differences are of true specific value, or only indicate a subspecies or geographical race, it is not easy to decide; but they are so well marked, and so constant over the whole series of forms examined, that I have decided to consider them as of specific value.

The main differences between *U. carovei* White and *U. chiltoni* n. sp may be summed up as follows:—

The two species can at once be separated by the very distinct colour-patterns of the head, as may be seen from text-figs. 1 and 2. In *U. carovei* the labrum is entirely black, and the frons has much less yellow on it than in *U. chiltoni;* the manner in which the black encroaches on the frons both from above and below, in the case of *U. carovei*, is well shown in text-fig. 1. It should, however, be noted that, in the case of the females only, the pattern of the upper part of the frons is somewhat similar in both species.

On the thorax the dorsal bands are wider in *U. chiltoni;* also, the femora of this species are black, those of *U. carovei* being either brown or yellowish.

On the abdomen the arrangement and colour of the hairs at the base is very characteristic of each species, as already shown in the description, while the yellow spots in *U. chiltoni* are distinctly larger, squarer, and closer together than those in *U. carovei*. The appendages are closely similar in general appearance, but in the male of *U. chiltoni* the inferior appendage is distinctly more truncate at the tip than in *U. carovei.*

As the large and conspicuous dragon-flies belonging to the genus *Uropetala* appear to be common in many parts of New Zealand, it should not be a difficult matter to work out the distribution of the two species if collectors will send along specimens from new localities for determination. As long as there was supposed to be only one species present there was no inducement to do this. So far as known at present, *U. carovei* occurs over the whole of the North Island, and also in the Lake Wakatipu district of the South Island, while *U. chiltoni* occupies a middle position at Arthur's Pass and Cass. This suggests that *U. chiltoni* may possibly be the species that inhabits the west coast of the South Island, and that it may be encroaching upon the domain of the eastern species through the gap at Arthur's Pass. It would otherwise be difficult to explain the presence of the species typical of the North Island in a locality such as Lake Wakatipu. It is, in any case, clear that, as regards the genus *Uropetala*, each Island does not possess its own peculiar species, but that some other barrier than Cook Strait has operated to bring about the differences existing at present.

Art. XXXV.—*Studies of New Zealand Trichoptera, or Caddis-flies: No. 1, Description of a New Genus and Species belonging to the Family Sericostomatidae.*

By R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), F.L.S., F.E.S., Entomologist and Chief of the Biological Department, Cawthron Institute of Scientific Research, Nelson, N.Z.

[*Read before the Nelson Institute, 23rd December, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

Introduction.

At the present twenty-six species of caddis-flies are known from New Zealand, distributed between fifteen genera, belonging to six families—viz., Rhyacophlidae, Hydroptilidae, Polycentropidae, Hydropsychidae, Leptoceridae, and Sericostomatidae. The first five of these families belong to the more primitive suborder Aequipalpia, in which the maxillary palps of both sexes are five-jointed; the Sericostomatidae, on the other hand, belong to the suborder Inaequipalpia, in which the maxillary palps of the male are reduced to four or three joints.

The suborder Inaequipalpia contains only three families out of the dozen now recognized as valid by students of this Order. Of these, the Phryganeidae can be recognized readily enough by the presence of ocelli, and by the males having the maxillary palps four-jointed. No representatives of this family have so far been discovered in Australia or New Zealand; they are also absent from Africa. The Limnephilidae, which are the dominant family of caddis-flies in most parts of the world, are distinguished from the Phryganeidae by the males having the maxillary palpi only three-jointed, with the joints of normal cylindrical form, and never carrying specialized hairs or scales upon them. These also have not yet been found either in Australia, New Zealand, or Africa.

The family Sericostomatidae contains all those caddis-flies in which the maxillary palps of the male are reduced to three, or sometimes even to two joints, and are specialized by being of abnormal form and position, and carrying either long, thick hairs or sometimes even scales. They differ, too, from the Limnephilidae in having the ocelli nearly always absent.

The Sericostomatidae are the dominant family of caddis-flies in the fast-running rivers and mountain-streams of New Zealand. Our known species are placed in no less than seven genera, of which five are peculiar to New Zealand, one being found also in Australia, and one (*Helicopsyche*) found everywhere except in Africa.

In their life-histories the Phryganeidae and Limnephilidae differ from the Sericostomatidae both in the general habitat of the larva and in the form of its case. In the two first-named families the larva usually inhabits still or slowly moving water, and the case is formed of vegetable matter. A number of Limnephilidae, however, make use of other materials, such as shells of small mollusca, sand, &c. These cases are always portable. In the Sericostomatidae it is the exception for vegetable matter to be used in forming the case, and the larvae mostly inhabit running water. Most of the cases are formed of sand, or of a stiff, semitransparent chitinous material secreted by the larva. Occasionally small stones or pebbles are used, and much more rarely small pieces of twigs. The larvae are usually gregarious, and can be found in large numbers attached to rocks, stones, or sunken logs.

The classification of the family Sericostomatidae is a most difficult matter, and remains in a very unsatisfactory state, in spite of the excellent work of Ulmer. A large number of genera, including those found in New Zealand, are not placed in any definite subfamily or tribe, but are treated as a kind of appendix to the family proper. Amongst these one may easily single out the two New Zealand genera *Oeconesus* and *Pseudoeconesus* by their general superficial likeness to Limnephilidae. They have the broad, well-rounded wings usually found in this latter family; whereas most of the Sericostomatidae have the wings more narrowed or pointed. In life, too, they resemble Limnephilidae fairly closely. The larvae form cylindrical cases of small stones or pebbles, and these are usually found either singly, or two or three together, attached to rocks in swiftly running streams. They are very difficult to rear, as the larvae die very quickly when removed from the water.

In Mr. G. V. Hudson's collection at Karori, Wellington, there is a pair of very large caddis-flies evidently closely allied to the *Oeconesus* group. In size these are much larger than any other caddis-flies known in New Zealand, the male being 1½ in. in expanse, the female nearly 2 in. They were taken in the Routeburn Valley, above Lake Wakatipu. Mr. Hudson very kindly allowed me to study these insects in December, 1919, when I happened to be in Wellington, and I desire to thank him for giving me the opportunity. The present paper is the outcome of that work, written in the light of considerable further study of this difficult family.

While on a visit to Cass, in January, 1920, I found a number of very large cylindrical cases made of small pieces of beech-twigs arranged transversely. Later on I joined Mr. George Howes at Arthur's Pass, and we found the same cases in the streams around that locality. Those at Cass were all empty; but Mr. Howes was most fortunate in finding one at Arthur's Pass containing a pupa, which emerged soon afterwards. The insect proved to be the same species as that which I had been studying in Mr. Hudson's collection. These facts are given as a guide to any collector who might desire to obtain this insect by rearing it.

The full description of the imago is as follows:—

Family SERICOSTOMATIDAE.

Genus Zelandopsyche nov. gen.

Allied to *Oeconesus* McL., and to *Pseudoeconesus* McL., but more especially to the latter, the forewings having neither a costal fold nor a well-defined groove. Spurs 2, 4, 4; the two sets on the middle and hind tibiae close together. In the male the maxillary palps (fig. 2) are three-jointed and raised upwards, so as to lie close against the face; the first two joints are very short, cylindrical, the third very long, its basal two-thirds being fusiform, its apical third much narrower and cylindrical; the swollen basal portion carries some long soft hairs, the apical portion more numerous but much shorter ones. Antennae slightly longer than forewing in male, the basal joint thickened, as long as the next three taken together.

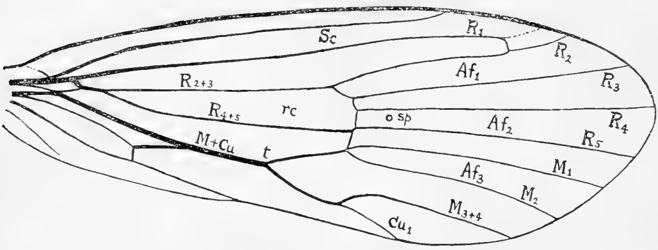


Fig. 1.—*Zelandopsyche ingens* n. g. et sp., ♂. Venation of forewing: Af_1, Af_2, Af_3, the first three apical forks respectively; Cu_1, first cubitus; M_1, M_2, M_{3+4}, the three branches of the media respectively; M + Cu, fused stems of media and cubitus; R_1 to R_5, the five branches of the radius; *rc*, radial or discoidal cell; Sc, subcosta; *sp*, wing-spot; *t*, thyridium.

Wing-venation differing considerably in the two sexes. In the female the venation is fairly normal; but R_1 ends up on R_2 instead of on the wing-margin, and the fork of Cu_1 is abnormal, in so far as Cu_{1b} is in the form of a cross-vein, and fuses with Cu_2 not far from its apex. The discoidal or radial cell is closed, the median cell open. From the thyridium (fig. 1, *t*), M_{3+4} runs obliquely downwards in a straight line to connect with Cu_1 by a very short cross-vein at the point of origin of Cu_{1b}, which continues this line downwards with a backward bend. Near the base, M, Cu, and 1A are all fused together; 2A and 3A junction with 1A after it has left M and Cu, which continue fused for a farther short distance. In the forewing of the male the venation is similar to that of the female from the costa down to M_2, except that the discoidal cell is much larger, Rs bifurcating very close to the base. Below this there is an area of high specialization, in which the thyridium and that portion of the main stem of M lying basad to it appear to have become completely fused with Cu_1, and also with Cu_2. M_{3+4} is unbranched, and leaves the cubitus distally in such a manner as to suggest a normal cubital fork. The anal venation is also abnormal, and cannot be interpreted with certainty. The hindwings of both sexes are closely similar, with fairly normal venation; the discoidal cell is closed, the median cell open, and apical forks 1, 2, 3, and 5 all present.

Genotype: *Zelandopsyche ingens* n. sp.

This genus differs from *Pseudoeconesus* and *Oeconesus* in the much larger size and the form of the maxillary palpi of the male; in the two genera mentioned the third joint is much swollen and of an oval shape. It also differs from both genera in the peculiar specialization mentioned in the male venation in the region of the thyridium of the forewing. It differs further from *Pseudoeconesus* in having R_{2+3}, forming the anterior border of the discoidal cell, straight, and from *Oeconesus* in lacking the costal fold and definite groove in the forewing.

The three genera *Oeconesus*, *Pseudoeconesus*, and *Zelandopsyche* appear to me to be so distinct from the rest of the family that they might legitimately be placed together in a single tribe Oeconesini, distinguished by their broadly rounded forewings and general superficially Limnephilid appearance. Representatives of this tribe occur very rarely also in Australia and Tasmania, but have not yet been described.

Zelandopsyche ingens n. sp. (Figs. 1–3.)

♂. Total length, 12·7 mm.; abdomen, 8·2 mm.; forewing, 19 mm.; hindwing, 16 mm.; expanse of wings, 38·5 mm.; antennae, 21·5 mm.

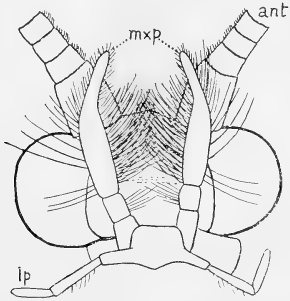


FIG. 2.—*Zelandopsyche ingens* n. g. et sp., ♂. Head viewed antero-ventrally, to show bases of antennae (*ant.*), maxillary palpi (*mxp.*), and labial palpi (*lp.*).

Head rich brown; eyes black; antennae brown, the articulations of the oints beyond the scape only faintly indicated. Maxillary palps as described or the genus, dark brown. Labial palps pale brown, slender, the basal joint shortest, the second and third about equal; viewed from below, the second joint is ridged along both edges, and carries short hairs. Fig. 2 shows the two pairs of palps and the base of the antennae *in situ*, as seen somewhat ventrally from in front.

Thorax dark brown; prothorax very short, mesothorax large and stoutly built, metathorax rather short. Legs pale brown, very long, the length of the hindleg when extended being about 21 mm.; the tibial spurs as in the generic definition. Forewings dull fuscous-brown, costal margin paler brown; hairs very short, the venation clearly visible; apical half of wing irrorated irregularly with small paler-brown areas, especially along the anastomosis and for 3 mm. to 4 mm. inside the apical margin. Hindwings of a paler brown, costal margin and distal end of Sc yellowish-brown; hairs exceedingly short, except at base of anal veins and along anal border, where very long pale-yellowish hairs are abundant. Venation as given in the generic definition; that of forewing of male is shown in fig. 1.

Abdomen dull greyish-brown, the first segment slightly paler. Appendages rich brown, shaped as shown in fig. 3.

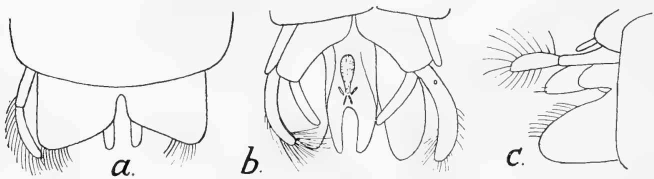


FIG. 3.—*Zelandopsyche ingens* n. g. et sp., ♂ Anal appendages viewed from three directions: *a*, dorsally and slightly from the left; *b*, ventrally and slightly from the left; *c*, laterally.

Female very similar to male, but larger. Forewings paler, with a large subquadrangular blotch of pale yellowish-brown between Cu and 1A about two-fifths from base; the paler irrorations are more definite, and tend to become arranged in transverse rows across the distal half of the wing. Maxillary palps with joints 1–2 short, 3–5 long and about equal. Abdomen stouter and longer than in male, the terminal portion (somewhat shrivelled) apparently carrying downward lateral flaps on segments 8–9.

Types.—Holotype, ♂, and allotype, ♀, in Mr. G. V. Hudson's collection.

Habitat.—Taken amongst stones at the water's edge, Routeburn Valley, near Lake Wakatipu.

ART. XXXVI.—*Descriptions (with Illustrations) of Four Fishes new to New Zealand.*

By L. T. GRIFFIN, F.Z.S., Assistant in the Auckland Museum.

[*Read before the Auckland Institute, 15th December, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

Plates LIV, LV.

DURING the past two or three years a good deal of systematic work has been done in the Auckland Museum in investigating the fish fauna of New Zealand, this work having been made possible by the advent of the trawling industry in the waters of the Auckland Provincial District. It is now thought desirable that particulars of exceptional interest should be placed on record. It is now possible, with the co-operation of the owners and masters of the boats, to obtain much fresh material; and good results are anticipated from this source, which will not only add to our collections, but also enable us to gain a better knowledge of local marine life generally.

The following are descriptions of four species new to our fish fauna, and are of particular interest, as three of them belong to genera not previously known from New Zealand.

Family MYRIDAE.

Genus MURAENICHTHYS Bleeker.

Muraenichthys breviceps Günther. (Plate LIV, fig. 1.)

Muraenichthys breviceps Günther, *Ann. Mag. Nat. Hist.* (4), vol. 17, p. 401, 1876; McCulloch, *Biol. Results*, "*Endeavour*," pt. 1, p. 21, fig. 7, 1911.

Body vermiform, scaleless, its greatest depth being rather more than 3 in the head. Head, by including its own length, is 10 times in the total, or 3¼ in the trunk, the latter measurement taken from the posterior margin of gill-opening to vent. Eye small, about 3 in the snout, which is 4½ in the head. Snout short, broad. The muscles on the occiput are swollen, rendering the upper profile concave. Anterior nostrils placed near the end of snout and contained in a small tube, the orifice of which is divided by a thin membrane, forming two single openings. A flap overhanging the lips covers the posterior nostril, which is situated just before and below the eye. Cleft of mouth extends far behind the eye. The lower jaw closes within the upper, and has a row of widely-spaced pores throughout its length. Pores are also found on upper surface of head and behind the eye. Tongue immovable. Teeth granular, obtusely pointed, and partly embedded in the membrane of mouth; they are arranged in a triple series on the palate, and in a single series in the jaws. Lateral line arched above the branchial sac, but from this point it continues in a straight line to the tip of tail. There is a row of numerous minute pores placed below and at short distances apart throughout its length. Dorsal and anal fins very low, many-rayed, and placed within a shallow groove; they extend round the end of tail. Origin of the dorsal much nearer the head than vent, whilst the origin of the anal is 52 mm. from centre of total length. Gill opening small, with its upper anterior margin dilated.

Colour in Alcohol.—Above lateral line uniform light brown, densely crowded with minute darker-brown dots, which are scarcely visible to the naked eye ; below the lateral line it is much paler, and shows the muscular structure through the skin.

Measurements.—Total length, 620 mm. ; vent to tip of snout, 250 mm. ; origin of dorsal to end of snout, 96 mm. ; middle of eye to tip of snout, 11 mm. ; vertical depth of body, 18 mm.

Described from a fine specimen sent me for identification by Mr. W. F. Worley, of Nelson, to whom I am greatly indebted for the privilege of examining it. Mr. Worley informs me that it was captured by Mr. Gossi in Tasman Bay, near Nelson, and, although he had fished in the neighbourhood daily for a number of years, he had never seen such an eel before.

From the above it would appear to be rare in the south of New Zealand ; but since receiving Mr. Worley's specimen the Auckland Museum has received three others, taken in the Manukau Harbour by Mr. Hugh Wright, of Epsom, who stated that they were not uncommon during November, and came up readily to a light when held close to the water at night-time. Our largest specimen from the Manukau Harbour is not quite so fine as the Nelson fish, the latter being apparently fully grown, but except in size I found no variation whatever.

In a letter to me, Mr. A. R. McCulloch says, " The adult of this species has never been properly described, and it is apparently very rare in museum collections. Its discovery in New Zealand waters creates a most interesting zoological record."

Loc.—Tasman Bay, near Nelson ; Manukau Harbour, Auckland.

Family SERRANIDAE.

Genus Callanthias.

Callanthias splendens n. sp. (Plate LV, fig. 1.)

D. xi/XI ; A. iii/XI ; V. i/V ; P. XXI ; C. XVI $\frac{3}{3}$. L. lat. 54–55 ; L. t. 4/15 = 19.

Body oblong, compressed, covered with moderate finely ctenoid scales the bases of which are furnished with small to minute scales of a similar character arranged in groups of from 3 to 5. Its depth is contained rather less than $3\frac{1}{2}$ times in the total length. Lateral line continuous, commencing at upper angle of the operculum, then ascending obliquely backwards, reaching its highest point near to the base of the 4th dorsal spine ; it then follows an even course close to the base of the dorsal fin and passes into the caudal. The tube is straight, almost covering each scale. Head, excepting the extreme tip of snout, covered with small ctenoid scales ; it is not contained quite 5 times in the total length, and barely $1\frac{1}{2}$ in the greatest height, which is vertical from the 1st anal spine. Operculum with 7 series of scales, and armed on its upper posterior margin with two moderately strong flattened spines placed close together, the lower being the longest. Preoperculum entire, its angle rounded and smooth. Eye moderate, 3 in the head. Interorbital space high, convex, covered with very small ctenoid scales. Maxillary not extending quite as far as the vertical from

Diagram of scales of *Callanthias splendens.* × 3.

FIG. 1.—*Muraenichthys breviceps.* From a three-quarter-grown specimen.

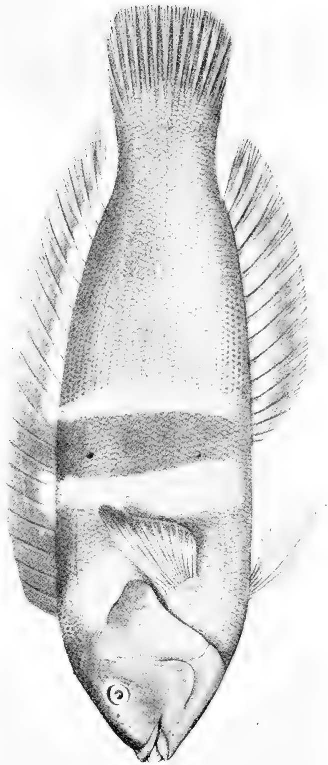


FIG. 2. *Coris sandeyeri.*

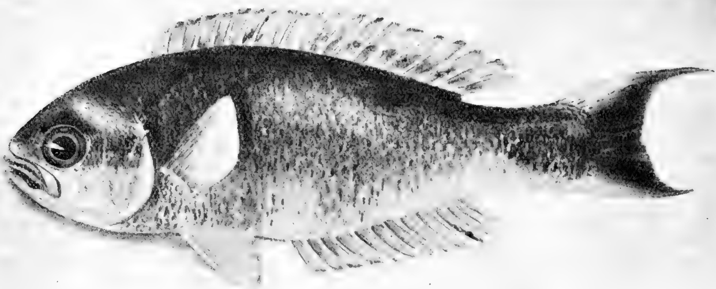


FIG. 1.—*Callanthias splendens* n. sp.

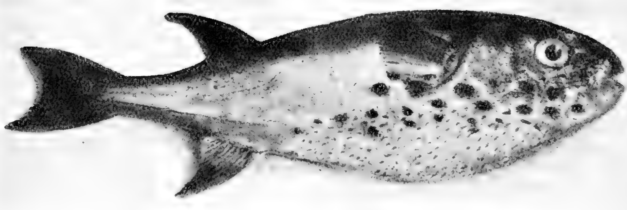


FIG. 2.—*Spheroides nitidus* n. sp.

centre of eye. Its base is completely hidden beneath the preorbital, and its distal end is very narrow and furnished with minute ctenoid scales. Mouth feebly protractile, oblique; the hinder margin of premaxillary fitting close to the anterior margin of preorbital. A very strong narrow membranous fringe depending from the upper angle of premaxillary hides the vomer. Jaws equal when the mouth is closed. A single series of villiform teeth in both jaws extending well into the angles. Those of the upper jaw are fewer in number than those of the lower. A few stronger and slightly hooked canines are found sparsely disposed among the smaller ones, and the two anterior canines of the lower jaw are produced outwards. Snout obtuse; the posterior nostril, situated above the anterior margin of eye, is a single, simple, oblong opening, whilst the anterior one is very minute, placed in a short tube, situated midway between its fellow and the tip of snout; there is a minute pore in front of and behind it. Various pores are scattered about top and sides of head. A line of pores commencing behind the eye completely surrounds that organ. Branchiostegals 6; gills $3\frac{1}{2}$; the membrane united in front. Gill-rakers 29, long and hair-like on the lower half of anterior arch. Pseudobranchii present. Dorsal fin moderate, and placed in a groove; it increases slightly in height backwards, the last four rays being the longest. Anal fin similar to the dorsal, but the soft rays are somewhat longer; it is placed in a groove, which, like that of the dorsal, is not deep enough to enclose the fin when laid back. The membrane of both fins is strong, and has a waved appearance. Pectoral rounded, the upper rays slightly the longest; it goes 6 times in the total length of fish, and $1\frac{1}{2}$ in the height. Ventrals with a moderate spine, the distal half being much flattened; they reach to the posterior margin of the vent. Caudal with its upper and lower outer rays produced; the upper, which is the largest, is 27 mm. beyond the margin of middle rays. All the rays of the caudal are covered with minute ctenoid scales almost to their outer margins.

Measurements.—Total length, 225 mm.; height, 65 mm.; thickness of body, 31 mm.; length of head, 45 mm.; eye, 15 mm.

Trawled at the entrance to the Hauraki Gulf, Auckland, September, 1920.

Colour.—The colour given for this specimen was determined by comparison with Ridgway's *Colour Standards and Nomenclature.* Top of head, excepting the extreme tip of snout, silvery light phlox-purple, joined on the shoulders by a broad triangular band of light vinaceous rufous, which reaches downwards, following the margin of operculum, to the base of the 1st pectoral spine. Behind the eye there is a band, lemon chrome-yellow in colour, and about half the diameter of the eye in width, which reaches to the posterior margin of operculum. This is joined below by another band of similar width, but of a dull lavender-violet colour. Lower half of head and opercles silvery-white, the margins of all the scales being greyish, and their centres touched with pale lemon-yellow. Maxillary silvery-white; the scales on its distal margin are dull lavender-violet. Tip of snout and premaxillary pinkish-white. Lower jaw very pale lemon-white. Eye lemon-yellow, streaked with zinc-orange, the lens being blue-black. Body, from top of back downwards to an uneven line drawn from centre of pectoral to the caudal peduncle, a light rosolane-purple hue over bright silver, and below this, reaching to the ventral surface, it is ivory-yellow, the centres of the scales reflecting olympic blue. Above the base of ventrals there is a patch, 30 mm. in width, which joins the body-colour behind the pectorals where all the scales are shaded with pale vinaceous rufous. A similar patch commences above the 4th anal ray, extending along the lower side of the fish, between the margins of the body-colour and the base of the anal fin, and reaches to the hinder margin of the caudal peduncle. On the latter all the scales are broadly margined with primuline yellow. In front of the ventrals, and reaching up to the base of the pectorals, all the scales are bright lemon-yellow in colour. The colour of the lateral line is somewhat deeper in tone than the body-colour, and a dull magenta-purple blotch is found on it situated below the 6th-7th soft dorsal rays. Spines and rays of the dorsal fin dusky white, the membrane being pale naples-yellow, streaked with greyish-white. The margin of the whole fin is tipped with a narrow band of rosolane-purple, and in the centre of the soft portion there is a medium band of thin coral-red throughout its length. A few black streaks are found between the 7th and 8th spines. Anal fin similar to the dorsal, with the exception of the coral-red band; there is a black streak posteriorly between the 10th and 11th soft rays. Ventrals yellowish-white, the spines and rays somewhat lighter. Pectorals with their anterior rays rosolane-purple, getting much lighter backwards, the lower rays being almost pure white. Caudal with its produced tips and central rays madder-violet, the procurrent rays of both lobes being light lavender-violet.

This beautiful genus appears to be either very little known or very rare, and it is most interesting to have discovered it in New Zealand waters. In the *British Museum Catalogue of Fishes* (vol. 1, 2nd ed., 1895) Boulenger gives an account of two species only—*i.e.*, *Callanthias peloritanus* from Madeira to the Mediterranean, and of *C. allporti* from the coast of Tasmania. A good figure of the latter is given on pl. xv of the same volume, and a comparison between *C. allporti* and my specimen shows several marked specific differences. In *C. splendens* the dorsal fin has an equal number of spines and soft rays, and the soft portion does not much exceed the spinose in height. The greatly produced rays of the caudal are another prominent feature. In *C. allporti* the soft dorsal has its hinder rays much longer in proportion and more elevated backwards, and there is one soft ray less in both the dorsal and anal fin, whilst the outer caudal rays are subequal and very little longer than the rest of the fin.

Family LABRIDAE.

Genus Coris Lacepède.

Coris sandeyeri (Hector). (Plate LIV, fig. 2.)

Cymolutes sandeyeri Hector in *Trans. N.Z. Inst.*, vol. 16, p. 323, 1884.
Coris rex Ramsay and Ogilby, *Proc. Linn. Soc. N.S.W.*, vol. 10, pt. iv, p. 850, 1886.

D. ix/XII; A. iii/XII; V. i/V; P. XIII; C. XIV. L. lat. 98.

A fine specimen of this handsome fish was caught by one of the assistant keepers at Cuvier Island lighthouse, near Auckland, in August, 1918. It was sent to Mr. T. F. Cheeseman, Curator of the Auckland Museum, for identification, and he handed it to me for examination. I came to the conclusion that it was similar to a fish very briefly described by the late Sir James Hector under the name of *Cymolutes sandeyeri*, reference to which is given above. If this is correct it is evident that Hector erred by placing it in the genus *Cymolutes*, for I found that it possessed strong anterior canines in the angles of the mouth, whereas the genus *Cymolutes* has none. Not being quite sure of its identity, owing to the absence of comparative material, I sent the specimen to Mr. A. R. McCulloch, the expert zoologist to the Australian Museum, Sydney, who recognized it at once as being the *Coris rex* of Ramsay and Ogilby. He suggested the possibility of Hector's type being the same species. I was fortunately able to obtain the loan of Hector's specimen from the Dominion Museum, and on making a comparison I found the two fishes to be identical, although Hector's specimen is somewhat the smaller. It is quite evident that the genus *Cymolutes* has not yet been found in New Zealand waters, and it is interesting to know that *Coris sandeyeri*, which is apparently very rare in museum collections, is a permanent resident with us. I have since heard that others have been taken at various times in the same locality. A fine description, with plate, by Mr. McCulloch is given in *Rec. Aust. Mus.*, vol. 13, No. 2, p. 67, pl. xiv, fig. 2, 1920, and to him I tender my best thanks for identification of the specimen and other valuable information. I also wish to express my thanks to Dr. J. Allan Thomson, Director of the Dominion Museum, for allowing me to examine Hector's type, and to Mr. W. J. Phillipps for his assistance.

For the convenience of students and for purposes of identification I am giving Mr. McCulloch's plate of *Coris sandeyeri*, with a brief description of my own and a colour-note made directly after the fish was captured.

Body oblong, compressed, covered with small cycloid scales. Its height is contained $3\frac{3}{4}$ in the total length. Head naked. Snout sharply conical, and the operculum produced into a broad flexible lobe. Mouth slightly oblique, with a double series of strong conical teeth in both jaws. The two anterior teeth in each project outwards as strong canines. A strong canine tooth in each angle of mouth. Gills $3\frac{1}{2}$; gill-rakers 11, on lower half of anterior arch. Lateral line curves upwards towards dorsal fin anteriorly, reaching its highest point beneath the 4th and 5th spines. It continues straight for some distance, but commences to bend downwards towards the centre of the height under the 9th soft dorsal ray. Dorsal fin with its origin above centre of operculum, its margin somewhat rounded. Origin of anal fin vertically beneath the 2nd dorsal ray; it is similar to the dorsal in form. Caudal subtruncate, with its basal third covered with scales.

Colour.—In giving a description of the colour I am relying entirely on a chart of the Cuvier Island specimen which was drawn directly after its capture. Never having seen the fish alive myself, I am unable to say whether the particulars given below are accurate, but my informant seems to have taken considerable pains to make them so.

Tip of snout to centre of interocular light green, deepening gradually on the shoulders as far as the 1st dorsal spine to dark green. Preorbital anteriorly dark green; nearer the eye it is red. Cheeks below eye red. Lips flesh-colour. Behind the eye the upper portion of the preoperculum is pink to a level with the bottom of eye, and below that it is light green as far as its rounded angle. Operculum pale violet, the tip of flexible lobe being deep violet. There is a light-blue patch in the angle of the mouth. Lower jaw light blue anteriorly, deepening into violet on the suboperculum. There is a patch on the throat almost bare of scales which is dark blue. The first vertical band is black anteriorly, blending into deep violet posteriorly, but towards the ventral surface it becomes much paler. Second vertical band deep black throughout. The dorsal surface of the fish in front of, between, and behind the second vertical band, and extending as far as the base of the caudal, deep orange-red, lighter in middle of fish, but there is a dark orange-red lateral streak about ½ in. in width above the base of anal fin. Membrane of the spinose dorsal light blue, the spines being deeper. Membrane of branched portion dark blue. There is a small light patch at base of 6th–7th spines of the dorsal, and a light band extends all along the base of the soft dorsal the colours of which have not been noted, but it appears as though it may have been pale orange-red. Pectorals dull orange tipped with dark blue. Caudal deep violet, a little lighter on margins. Ventral spines and rays dark blue, membrane light blue.

Measurements.—Total length, 380 mm.; total height, 100 mm.; length of head, 100 mm.; diameter of eye, 10 mm.; interocular space, 30 mm.

Loc.—Tiritiri Island, Hauraki Gulf; Cuvier Island, near Auckland; Bondi, near Sydney, N.S.W.

Family TETRAODONTIDAE.

Genus Spheroides Duméril, 1806.

Spheroides nitidus n. sp. (Plate LV, fig. 2.)

Tetrodon sp. Clarke in *Trans. N.Z. Inst.*, vol. 29, p. 247, 1897.

D. XIV; A. XIII; P. XIV; C. IX.

Body moderately elongate, naked above and on sides. Abdomen covered with about 30 rows of large subequal four-rooted spines, which commence beneath the vertical of anterior margin of eye, extending nearly to vent. Length of caudal peduncle equals distance from end of snout to posterior margin of eye. A ridge on lower side of tail extends a little beyond vent. Lateral line very indistinct; it crosses the snout anteriorly, and, passing under the nostrils, extends backwards over the eye, falling down behind that organ to about half its diameter, where it ends abruptly. The second and greater portion commences at top of operculum a little in advance of gill-opening; it extends along the upper part of back to about half the length of fish, then bending steeply downwards becomes lost on caudal peduncle. A fine branch line is present which reaches across the nape, but it fails to connect with its fellow on the other side. Dorsal and anal fins falcate, equal in height, and about 2½ in head; they are placed on raised muscular bases. The anterior rays are subequal in length; the remainder decrease rapidly backwards. Origin of anal is in the vertical from middle of dorsal. Caudal lunate, the rays of lower lobe being slightly the longest, about 1½ in the head. Interorbital space slightly convex, 1½ times as wide as eye; there is a slight mesial depression above the hinder portion of eyes. Nostrils each with two simple openings, situated much nearer the eye than end of snout. Gill-opening very oblique, broader than base of pectoral. Eye moderate, about 4 in the head, situated midway between gill-opening and tip of snout.

Loc.—Auckland and Tauranga Harbours.

Colour.—Dorsal uniform dark steel-blue. Sides bright silver; sides of head bright silver streaked with dusky purple; top of head black. A curved row of 4 black spots about the size of a pea below the eye; similar but smaller black spots are found on sides of opercles and cheeks. Three or four rows of black spots of various sizes are distributed over sides below pectoral and on upper portion of abdomen. Caudal and dorsal fin dark brown, almost black. Anal dirty yellowish-white. Pectoral with its upper rays dark brown, the lower being somewhat lighter. Eyes yellowish-silver and blue-black. Throat and belly creamy white.

Described from a small specimen trawled in Auckland Harbour in 1919. It is easily distinguished from other members of the genus by its completely smooth back, falcate dorsal and anal fins, and the lunate caudal. The black spots are also very conspicuous. The large specimen referred to by Clarke in reference at head was caught in Tauranga Harbour, and has been in the Auckland Museum for some years. On examination I find it to be specifically identical with the one described here, the only points of difference being in the position of the nostrils, and a slight difference in the branch line across the nape. In the large fish the nostrils are nearer the centre, between the eye and tip of snout, and the branch line across nape unites with its fellows on either side. The differences may be due to age only, and a comparison of the measurements will show that the small fish must be immature.

Measurements :—	Auckland Harbour Specimen.	Tauranga Harbour Specimen.
Total length	188 mm.	402 mm.
Length of head	50 mm.	94 mm.
Height, deflated	50 mm.	94 mm.
Interorbital width	20 mm.	40 mm.
Width of eye	13 mm.	18 mm.

ART. XXXVII. — *Observations on certain External Parasites found upon the New Zealand Huia* (Neomorpha acutirostris *Gould*) *and not previously recorded.*

By GEORGE E. MASON.

Communicated by H. Hamilton.

[*Read before the Wellington Philosophical Society, 7th September, 1920; received by Editor, 23rd November, 1920; issued separately, 8th August, 1921.*]

IN the course of compiling a table of measurements of the skin of a female specimen of the New Zealand huia (*Neomorpha acutirostris* Gould) formerly contained in the collection of Sir Walter L. Buller and now in my possession I detected upon the inner side of one of the large orange-coloured wattles which form so characteristic a feature at either side of the base of the bill of this bird a number of small wart-like excrescences which with the aid of a hand-lens proved to be a species of parasite belonging to the Ixodidae. The ticks, five in number, were scattered over the surface of the wattle, 2 mm. to 3 mm. separating the individuals, and so strongly were the mandibles embedded in the skin that considerable force was required to detach them. Although they were in a very shrunken and unsatisfactory condition for study, I was enabled by careful preparation to secure the specimens so that the identity of the species could be correctly established without question; and Mr. Cecil Warburton, of the Quick Laboratory, New Museums, Cambridge, to whom I had entrusted them for identification, has with his usual generosity and kindness furnished me with the following notes as the result of his examination:—

"One of the ticks is *Haemaphysalis leachi* Audouin, and the others *Hyalomma aegyptium* (Linn.). The result is surprising . . . neither of them is a true Australasian tick, but *H. leachi* has been in Australia a long time. *H. aegyptium*, however, we thought had only recently reached there from Africa. Both ticks are common in India. . . . Was the bird by any chance kept alive in some aviary there before dying and being preserved? . . . If it acquired the ticks in its native habitat we shall have to revise our views as to the quite recent introduction of these species into Australasia."

Fortunately, full and conclusive details bearing upon the origin and history of this identical huia's skin are available. The Indian theory we have to dismiss, for the skin formed one of the originals in a series of specimens collected jointly by Sir Walter L. Buller and Captain Mair on the Patitapu Range (some twenty miles from Masterton) on the 9th October, 1883, as recorded by Buller in his *Supplement to the Birds of New Zealand.* Sixteen specimens were then secured, and any doubt as to its being a New-Zealand-killed example may safely be set aside as invalid.

Another theory, however, strongly favouring the Indian origin of these parasites, may be traced directly to a period contemporary with the introduction of the mina (*Acridotheres tristis*) into New Zealand in the year 1875, and if the facts I have collected may be accepted as correct the introduction of the ticks *Haemaphysalis leachi* and *Hyalomma aegyptium* would likewise date approximately from that period. The strongest evidence we possess for supposing that the Indian mina acts as a host for both of these ticks is based upon the occurrence of examples of *Hyalomma aegyptium* in the larval phase upon a female of this bird from Burma, and eggs and an adult of *Haemaphysalis leachi* found upon a male shot in the Calcutta Botanical Gardens. Unfortunately, the remote probability of ever again meeting with the huia in a living state does not tend to assist in the successful prosecution of these inquiries; I am, however, awaiting the result of an examination of specimens of the mina living in New Zealand, which friends in Wellington and Hawke's Bay are kindly instituting on my behalf. Evidence as to the most probable means by which these ticks were transmitted to the huia may be gathered from the related experiences of early observers of the invasion by the mina of the particular areas of country comprising the huia's only known habitat in New Zealand. The aggressiveness of the imported foreigner led to many rival conflicts, during which a ready means of infection must have occurred. More retiring in its nature, the huia must have suffered severe and possibly fatal punishment from these attacks. Of this the late Mr. Taylor White was a frequent observer on his estate at Wimbledon, Patangata, Hawke's Bay, where the huia some twenty years ago was not uncommon.

Instances are known in which the pugnacious mina has been a leading factor in expatriating certain of the endemic bird fauna of many of the oceanic islands into which it has been introduced. For instance, Henry Palmer, when collecting in the Sandwich Islands, records in his diary how this species is "very numerous and very harmful to the native birds"; and, again, MM. Alphonse Milne-Edwards and E. Oustalet attributed the extinction of the native starling (*Fregilupus varius*) in Bourbon to the mina introduced by Poivre in 1755.

The food of the huia largely consists of insects occurring among ground-herbage, more particularly a species of Coleoptera, the larva of which burrows in dead timber; and in searching for this food the bird is again liable to become infested by at least one of the species of ticks under discussion, for Mr. C. W. Howard records (*Ann. Transvaal Museum,* vol. 1, 1908, p. 104) how unfed adults of *Hyalomma aegyptium* "may be frequently found moving about the ground or hidden under bark of trees," and there is no reason to doubt that a similar habit may also have been acquired by this species in New Zealand. Although we are without direct evidence, it is probable that *Haemaphysalis leachi* may be found in similar surroundings. From a date beginning about 1880 the huia, at all times an uncommon bird, seemed rapidly to decrease in numbers. This decrease and ultimate disappearance have given rise to much speculation, and it is possible that the persecution to which it has been subject by Maori hunters, the mercenary collector, and introduced animals cannot alone be called upon to account for its regrettable extinction. The question is raised as to whether we have not to recognize yet another of those disastrous factors by which the balance of nature has in this particular instance been disturbed through the introduction of these parasites into New Zealand, where they were previously unknown.

The specimen from which I collected the ticks under discussion had the wattles appreciably smaller and more shrunken than in any other example of the species I have at various times examined. Owing, however, to a distinct reduction in the length of the bill, and sundry white edgings to the under tail-coverts, I had looked upon this particular specimen as an immature bird Professor E. Ehlers has, however, gone to some length (*Abh. Ges. Götting.*, Bd. xxxix, pp. 35–43, 1894) in an endeavour to show that the length of the bill has no bearing upon the age of the individual.

We possess abundant evidence of the destruction caused by members of the Ixodidae in spreading disease and death among the animals they attack. A species of *Argas* has been know to infest fowls in South Africa, and to occasion so much loss of blood that the fowls die in great numbers. It has also been a subject for conjecture if the endemic New Zealand quail really owes its extinction altogether to the prevalence of bush and grass fires, and to the persecution of sportsmen and introduced carnivorous animals.

The two species of tick to which I have here directed attention are widely distributed throughout Africa, and *Hyalomma aegyptium* is also recorded from southern Europe, and ranges through Asia Minor to Persia and adjoining countries as far as China. Their hosts include almost all domestic and wild animals, numerous birds, and a tortoise. *Haemaphysalis leachi* transmits the distemper or malignant jaundice of dogs.

We have long known that the huia has been subject to attack from an endemic parasite belonging to the Mallophaga, but I am not aware if the identity of the species has ever been established, or if its specific characters are known. Every skin of *Neomorpha* that I have examined reveals the presence of the louse, by the great number of egg-cases, or nits, attached to the bases of the feathers, particularly in the orbital region; I have counted as many as ten of these nits attached to a single very small feather. The perfect insect I have never seen.

Art. XXXVIII.—*The Crab-eating Seal in New Zealand.*

By W. R. B. Oliver, F.L.S., F.Z.S., Dominion Museum, Wellington.

[*Read before the Wellington Philosophical Society, 17th November, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

Plate LVI.

So far as I am aware, the crab-eating seal (*Lobodon carcinophaga*)* has not hitherto been recorded in the New Zealand area, and I have therefore to note the two following instances. In both cases the specimen or a part of it has been preserved.

In the Wanganui Museum there is a stuffed skin with the skull included. It was stranded on the beach outside Wanganui Heads (S. lat. 39° 56′) some time previous to 1892, and was referred to *Leptonychotes weddelli* by Sir J. Hector.† It is entirely white, with the dental formula C. $\frac{2}{2}$, I. $\frac{1}{1}$, M. $\frac{5}{5}$ = 32.

The second specimen, an aged female, was observed in April, 1916, off Petone Beach (S. lat. 41° 14′), Wellington Harbour, where it remained a few days. It was then captured and taken to the Newtown Zoo, but died the following day. The skull is preserved in the Dominion Museum, Wellington (Plate LVI).

The record of this species in New Zealand is especially interesting on account of the great distance between the natural habitat of this seal, the Antarctic pack-ice, and the few northern localities where stragglers have been obtained. Besides the two specimens now recorded, stray examples have been taken at San Sidro (S. lat. 34° 28′), north of Buenos Ayres; at Melbourne (S. lat. 37° 45′); and at Portland (S. lat. 38° 20′), Victoria. The usual northern limit of the species is stated by Dr. Wilson to be between 58° and 60° S. lat. It is found chiefly in the pack-ice of the open sea, extending as far south as McMurdo Sound (S. lat. 77° 50′). It is the common seal of the pack-ice, and is found all round the Antarctic Circle. The occurrence of northern stragglers is, according to Dr. Wilson, explained by the fact that large masses of ice drift up into more northern waters from the south, no doubt very often with seals on them. But in this connection may be mentioned the following remark by Dr. Wilson‡: "Certain it is that *Lobodon*, notwithstanding its pelagic habit of life, tends to wander great distances at the approach of death, and to extraordinary heights up the glaciers of South Victoria Land."

The crab-eating seal is easily recognized, notwithstanding the variation in its colour, by the nature of the teeth. The molars have each a large lobe with a small lobe in front and two or three behind, the lobes being slightly recurved and the spaces between them deep. Quoting from Dr. Wilson again,§ "The use of the extraordinary development of the lobes of the post-canine teeth in this seal was suggested by Captain Barret Hamilton in an article on the seals of the Southern Cross collection. These lobes, as he pointed out, form a sieve when the jaws are closed, through which the water can be ejected from the mouth, while the mud and crustaceans are retained and swallowed."

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* Hombron and Jacquinot, Phoca, *Voy. Pole Sud*, t. 10, 1842.
† *Trans. N.Z. Inst.*, vol. 25, p. 258, 1893.
‡ Appendix II to Scott's *Voyage of the "Discovery,"* p. 476, 1905.
§ *Nat. Ant. Exped., Zool.*, vol. 2, p. 34, 1907.

Skull of crab-eating seal taken at Petone in 1916

Art. XXXIX.—*Variation in Amphineura.*

By W. R. B. Oliver, F.L.S., F.Z.S., Dominion Museum, Wellington.

[*Read before the New Zealand Science Congress, Palmerston North, 26th January, 1921 . received by Editor, 2nd February, 1921 ; issued separately, 8th August, 1921.*]

Variations in the shell-valves of the Amphineura from the normal number of eight have been recorded from time to time. The following list contains all the species I have been able to trace in which fewer than eight valves have been noted. I have found no reference to specimens having more than eight valves.

Chiton tuberculatus, a West Indian species, was described by Linné as having only seven valves (*Syst. Nat.*, ed. x, p. 667). A second specimen with seven valves was collected at Tobago. In this two of the valves were soldered together, the result of an injury (Pilsbry, *Man. Conch.*, vol. 14, p. 155).

Mopalia ciliata, from California, with seven valves (Pilsbry, *l.c*, p. 305).

Trachydermon cinereus, five valves, and *Callochiton laevis*, seven valves, from British seas (Jeffreys, *Br. Conch.*, vol. 3, pp. 224, 227).

Trachydermon ruber, six valves; *Ischnochiton conspicuus*, six valves; and *I. contractus*, three valves. In the last example the reduction is ascribed to the union of two or more valves (Sykes, *Proc. Mal. Soc.*, vol. 6, p. 268).

Plaxiphora egregia, six valves, and *Sypharochiton pellisserpentis*, five valves, from New Zealand (Iredale, *Trans. N.Z. Inst.*, vol. 40, 1908, p. 375, pl. 31).

Plaxiphora conspersa, with six valves, from South Australia (Bednall, *Proc. Mal. Soc.*, vol. 2, p. 154).

Onithochiton neglectus, with seven valves, from New Zealand ; *Cryptoplax striatus*, with three valves ; and *Trachydermon cinereus*, with six and seven valves, from France (Pelseneer, *Ann. Soc. Roy. Zool. Belg.*, vol. 50, p. 41, 1920).

It appears, therefore, that the variations are always of the nature of reductions, occur in various genera, and have been ascribed to injury, union, or suppression of the valves. (See Pilsbry, *Man. Conch.*, vol. 14, p. xiii ; also Sykes, *l.c.*, and Pelseneer, *l.c.*)

The specimen I have now to describe differs from all those previously recorded in that the reduction of the number of valves has occurred on the left side only. Here is a case of meristic variation disturbing the bilateral symmetry of the animal. A further result is to throw the median line of the anterior, second, and third valves about 10 degrees to the left of the median line of the remainder of the animal. The specimen was found under a stone near low-tide mark at Shag Point, Otago, and is a member of a species—*Callochiton platessa*—rather rare in New Zealand, though recorded from various points on the east coast between Stewart Island and Rangitoto. The third and fourth valves are fused. The left side is apparently normal, the lateral area belonging to the fourth valve, but the central area may be derived from the third valve. On the right side the third valve overlaps, but is fused to the fourth valve from the mantle to the apex, which is double. The composite valve, therefore, consists of the central and right lateral areas of the third valve fused to the right and left lateral areas of the fourth valve.

Art. XL.—*Notes on Specimens of New Zealand Ferns and Flowering-plants in London Herbaria.*

By W. R. B. Oliver, F.L.S., F.Z.S., Dominion Museum, Wellington.

[*Read before the Wellington Philosophical Society, 17th November, 1920; received by Editor, 9th December, 1920; issued separately, 8th August, 1921.*]

The following notes are extracted from a number I made during a short stay in London in 1919. I was able to spend a few weeks in the British Museum and Kew herbaria examining, among other things, some of the type specimens collected by the Forsters and R. Brown, and those described by Bentham.

Polystichum Richardi (Hook.) Diels.

Aspidium coriaceum var. *acutidentatum* A. Rich., *Voy.* "*Astrolabe*," *Bot.*, 71, 1832. *A. Richardi* Hook., *Sp. Fil.*, 4, 23, 1862. *A. oculatum* Hook., *Sp. Fil.*, 4, 24, 1862.

Specimens of *A. oculatum* in the British Museum marked "*Prope* Tigadu, Tologa, Opuragi, Totaranui—Sir J. Banks and Dr. Solander (1769)" are the ordinary coastal forms of *A. Richardi.*

The earliest name applied to this species was a varietal one—*acutidentatum* of Richard—and it would conduce to stability of nomenclature if, following the zoological practice, such names were adhered to, but in deference to the rules for botanical nomenclature I use *Richardi.*

Davallia scoparia (Mett.) Hook.

Adiantum clavatum Forst. (not Linn.), *Prodr.*, No. 459, 1786. *Lindsaya scoparia* Mett., *Fil. N. Caled.*, 64. *Davallia* (*Stenoloma*) *scoparia* (Mett.) Hook. & Bak., *Syn. Fil.*, 101, 1868. *D. Forsteri* Carr. in Seem., *Fl. Viti.*, 339, 1869 (no desc.); Baker, *Syn. Fil.*, ed. 2, 470, 1874.

The specimen (No. 1550) collected by Vieillard in New Caledonia and quoted by Hooker and Baker (*Syn. Fil.*, 101) is in the British Museum. On the same sheet are two specimens of a different species, labelled "Kanata, New Caledonia." Another sheet with three specimens is marked "New Zealand, Dusky Bay, Messrs. Forster," and, in a different handwriting, "*Adiantum clavatum* Forst." These are identical with the species collected by Vieillard. It is probable that Carruthers (*Fl. Viti.*, 339) gave them a new name on account of their difference from the Kanata specimens. In any case, *Davallia scoparia* is a tropical species, and, as suggested by Cheeseman, Forster's specimens were in all probability collected in some locality in Polynesia, and I would therefore recommend that the name *D. Forsteri* be omitted from the list of New Zealand plants.

Zannichellia palustris L.

Zannichellia palustris L., *Sp. Pl.*, 969, 1753. *Z. Preissii* Kirk (not Muell.), *Trans. N.Z. Inst.*, 10, App. xl, 1878. *Lepilaena Preissii* Kirk (not Muell.), *Trans. N.Z. Inst.*, 28, 499, 1896.

Specimens labelled "*Lepilaena Preissii*" and collected by T. Kirk at Rangiriri are in the British Museum. They are included with *Z. palustris*, being so determined by Ostenfeld. They appear to agree perfectly with specimens of *Z. palustris* collected by Cheeseman from the Waikato River.

Muehlenbeckia complexa (A. Cunn.) Meissn.

Polygonum complexum A. Cunn., *Ann. Nat. Hist.*, 1, 455, 1838. *Muehlenbeckia axillaris* Bentham (not Walp.), *Fl. Austr.*, 5, 275, 1870 (Lord Howe Island locality only); Oliver, *Trans. N.Z. Inst.*, 49, 135, 1917.

In the Kew Herbarium are specimens from Lord Howe Island marked "*M. axillaris.*" In all the leaves are identical with specimens from East Cape, New Zealand—that is, small orbicular leaves, 10–12 mm. long. Further, the flowers are in short racemes or spikes. I would therefore include the Lord Howe plant under *M. complexa.*

Phrygilanthus tenuiflorus (Hook. f.) Engl.

The only specimen known, that in the Kew Herbarium, is a small twig with five leaves and several flowers; leaves about 30 mm. long. A note on the sheet states, "Very near *L. celastroides.*" On comparing these I found the leaves to be very different, but the flowers and inflorescence similar. It is not like any other New Zealand species.

EDWARDSIA.

This genus was founded by Salisbury (*Trans. Linn. Soc.*, 9, 299, 1808) for the following three species: *E. chrysophylla* (Sandwich Islands); *E. microphylla* (New Zealand); *E. grandiflora* (New Zealand). These, with some others, differ from typical *Sophora* in the four-winged pod, short standard, and exserted stamens. The two groups are so distinct that I think *Edwardsia* should be reinstated as a separate genus, with *E. chrysophylla* Salisb. as genotype. This species is near to *E. tetraptera* (Mill.), but has larger leaves and smaller flowers. Other species are *E. mollis* and *E. interrupta*, both large-leaved forms from India.

Edwardsia microphylla (Aiton) Salisb.

Sophora tetraptera Linné (not Miller), *Suppl. Pl. Syst. Veg.*, 230, 1781; Forst., *Prodr.*, 32, 1786. *S. microphylla* Aiton, *Hort. Kew.*, ed. 1, 2, 43, 1808; Jacq., *Hort. Schonbr.*, 3, 17. *Edwardsia grandiflora* var. *microphylla* Hook. f., *Fl. Nov. Zel.*, 1, 52, 1853. *Sophora tetraptera* var. *microphylla* Hook. f., *Handb. N.Z. Fl.*, 1, 53, 1864. *Edwardsia Macnabiana* R. Grah., *Edin. N. Phil. Journ.*, 26, 195, 1838. *Sophora chathamica* Cockayne, *Trans. N.Z. Inst.*, 34, 319, 1902 (Chatham Island). *S. toromiro* Phillipi, *Bot. Zeit.*, 31, 743, 1873 (Easter Island).

Both Linné's and Salisbury's specimens came from New Zealand. *E. Macnabiana* is founded on Chilian examples. Specimens from Chile (including *E. Macnabiana*) and Juan Fernandez are indistinguishable from those from New Zealand. Those from Easter Island are similar, but the leaves and shoots are very hairy. In the Kew Herbarium they are kept as a separate species (*S. toromiro*). The Chatham Island form is a distinct variety or perhaps closely allied species.

Edwardsia prostrata (Buchanan).

Sophora prostrata Buchanan, *Trans. N.Z Inst.*, 16, 395, 1884. *S. tetraptera* var. *prostrata* Kirk, *Forest Fl. N.Z.*, 85, 1889.

Confined to the mountains of the South Island of New Zealand.

Edwardsia tetraptera (Miller).

Sophora tetraptera J. Miller, *Ic. Pl.*, t. 1, 1780 (also *S. tetraptera* of *Bot. Mag.*, t. 167; Lamarck, *Ill.*, t. 325; and Aiton, *Hort. Kew.*, ed. 1, 2, 43: *fide* Salisbury). *Edwardsia grandiflora* Salisb., *Trans. Linn. Soc.*, 9, 299, 1808. *Sophora tetraptera* var. *grandiflora* Hook. f., *Handb. N.Z. Fl.*, 1, 53, 1864. *S. tetraptera* var. *howinsula* Oliver, *Trans. N.Z. Inst.*, 49, 139, 1917 (Lord Howe Island).

Miller's *Sophora tetraptera* is founded on specimens flowering and fruiting at Chelsea and Islington (England) introduced from New Zealand. The plate is good, and represents the large New Zealand form. There is no description. Salisbury described *E. grandiflora* from specimens collected by Sir J. Banks in New Zealand, and gives the references quoted above. This species is confined to the North Island of New Zealand, with a variety in Lord Howe Island.

Coriaria ruscifolia L.

Coriaria ruscifolia Linné, *Sp. Pl.*, ed. 1, 1037, 1753. *C. sarmentosa* Forster, *Prodr.*, 71, 1786.

Linné's species is based on plate 12 of Feuillet's *Journ. Obs. Phys. Math. et Bot.*, 1725. The figure shows small broadly-ovate leaves in threes at the racemes and opposite elsewhere. Specimens agreeing with these, except that the leaves are all opposite, are in the British Museum from Talcahuano, Chile. A plant from Ternuco, Chile, has very large ovate acuminate leaves in both threes and twos. The South American forms cannot be distinguished as a species from those of New Zealand and Polynesia. Though the leaves may be more acuminate, and the racemes longer, with more scattered flowers, yet specimens from Fiji, Samoa, Sunday Island, and New Zealand are indistinguishable from Chilian examples.

Coriaria lurida Kirk.

Coriaria thymifolia Hook. f. (not Humb. & Bonpl.), *Fl. Nov. Zel.*, 1, 45, 1853. *C. lurida* Kirk, *Students' Fl. N.Z.*, 98, 1899.

This New Zealand species, hitherto referred to *C. thymifolia*, can easily be distinguished from all the American forms by the habit and shape of the leaves. *C. thymifolia* occurs from Mexico to Peru, and is a quite distinct species with small closely-set ovate acute leaves, which, though varying in size, are nearly constant in shape The New Zealand plant has the leaves on the shoots much more narrow and acuminate It passes by gradations into *C. ruscifolia*, and is possibly a derivative of that species. If the Andine *C. thymifolia* is likewise a derivative of the South American forms of *C. ruscifolia*, then the similarity of the two small-leaved mountain forms may be due to convergence in similar habitats; but they are nevertheless easily separated, and should not pass under the same name.

Aristotelia serrata (Forster).

> *Dicera serrata* Forst., *Char. Gen.*, 80, 1776. *Friesia racemosa* A. Cunn., *Ann. Nat. Hist.*, 24, 1840. *Aristotelia racemosa* Hook. f., *Fl. Nov. Zel.*, 1, 33, 1853.

Specimens marked "227 *Dicera serrata*, G. Forster Herbarium," in the British Museum, and which I presume are the type of Forster's species, are the ordinary form of the plant usually known as *Aristotelia racemosa*. There are also specimens of the same species in the Kew Herbarium labelled "Herb. Mus. Paris, *Dicera serrata* Forst. *Friesia racemosa* A. Cunn., N. Zélande (Akaroa), M. Ste. Croix de Bellegny." As Forster's name has more than fifty years' priority over Cunningham's it should be adopted.

Coprosma retusa Hook. f.

> *Coprosma retusa* Hook. f., *Journ. Bot.*, 3, 415, 1844. *C. Baueriana* Hook. f. (not Endl.), *Fl. Nov. Zel.*, 1, 104, 1853.

In my account of the vegetation of the Kermadec Islands (*Trans. N.Z. Inst.*, 42, 171, 1910) I omitted this, as I could find no specimens either on Sunday Island or in any New Zealand herbarium. There are two specimens in the Kew Herbarium collected on Sunday Island, August, 1887, by Cheeseman, so that the species should be reinstated in the Kermadec Island flora.

ART. XLI.—*Descriptions of New Native Flowering-plants, with a few Notes.*

By D. PETRIE, M.A., Ph.D., F.N.Z.Inst.

[*Read before the Auckland Institute, 15th December, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

Plates LVII, LVIII.

1. Note on **Pittosporum cornifolium** A. Cunn.

As existing descriptions of this interesting *Pittosporum* appear to be imperfect, if not inaccurate, the following observations, which may help to clear up the position, seem worthy of record.

In July last I was able to study, on Kawau Island, a number of these shrubs showing good flowers as well as ripe capsules. Most of them grew on clay soil just above low sea-washed rocky faces. The plants were of two kinds, which may be distinguished as male and female. The male plants were less common than the female, and of less vigorous growth. Not a single capsule was to be found on any of the males, while on the females they were plentiful, and just ripe enough for the valves to be opening and exposing the numerous rather large pitchy seeds. The male inflorescence was terminal on the branchlets, and consisted of an umbel of 10 or usually fewer (6–8) flowers on long very slender peduncles. These flowers had every appearance of being hermaphrodite, the pistils being well developed and equalling the stamens in height, while the stigmas were more or less coated with pollen. But as no capsules occurred on any of the male plants it is clear that fertilization did not take place. The pistils are probably sterile to the pollen of their own flowers; but more extended observations are needed before this conclusion can be considered established. In the female plants the inflorescence was reduced to a single terminal flower, rather smaller than the male ones, seated on a short stouter peduncle about as long as the flowers. Here the pistil hardly differs from that present in the males. The stamens are much shorter, with anthers greatly aborted, and destitute of pollen. As already noted, these plants produced a capsule at the end of almost every branchlet. In every case the capsule was two-valved, and this is the case in the considerable number of dried fruiting specimens in my herbarium, gathered from various widely-scattered stations in the North Island. Mr. H. B. Matthews, a very careful observer, has examined many plants bearing capsules, and in one case only has he seen a three-valved one, and in it the extra valve was much smaller than the other two. Both Mr. Kirk and Mr. Cheeseman give the number of the valves as three, but there can be no doubt that two is the normal number. Though the Kawau plants all showed solitary terminal female flowers, binate flowers are sometimes met with. Mr. H. Carse has sent me one or two such flowers, and I have one fruiting specimen with binate immature capsules.

The facts set forth above seem to show that the flowers of this *Pittosporum* are not truly polygamous. The conclusion that the plants are *never* truly terrestrial seems also devoid of warrant, for the great majority of the plants seen at Kawau grew in clay soil, though certainly close to a rocky shore.

2. Notospartium glabrescens sp. nov. (Plate LVII, fig. 1.)

Arbor subhumilis ramosus *N. Carmichaeliae* Hk. f. similis; differt truncis crassioribus; rhachide pedicellis et calyce glabris; floribus paullo majoribus purpureis; leguminibus multo crassioribus, 15–25 mm. longis ± 4 mm. latis, subteretibus oblongis ± coriaceis subacutis, breviter apiculatis, haud torulosis; seminibus subreniformibus haud complanatis, 2 mm. longis 1·75 mm. latis, rubris, punctibus atris ± maculatis.

A small round-headed leafless tree 15–30 ft. (4·5–9 m.) high, usually with several trunks up to 8 in. (2 dcm.) in diameter springing from the ground, in habit not unlike a weeping-willow, the lower branches and branchlets more or less pendulous, the upper erect or ascending; twigs flattened striate, often closely placed on the branchlets; stems, branches, and older branchlets terete.

Inflorescence usually erect or ascending, springing from the upper nodes of the twigs; rhachis glabrous, 4–7·5 cm. long, usually many-flowered; flowers like those of *N. Carmichaeliae* but somewhat larger and purplish in colour; pedicels glabrous, ± 8 mm. long, generally with two minute bracteoles near their tips; calyx $\frac{1}{2}$–$\frac{2}{3}$ as long as the pedicels, broadly campanulate with short subtriangular teeth, more or less distinctly ribbed, glabrous or with faint pubescence at the teeth and more or less on the edges between; standard broadly rounded in front, marked by numerous close delicate purplish nerves diverging from the rather broad claw, and with a large purplish blotch above the base covering more than half its upper surface; wings shorter than the keel, oblong, obtuse, narrow-clawed and with a triangulo-hastate expansion at the base opposite the claw. Pods 15–25 mm. long, ± 4 mm. broad, oblong, a little flattened or semiterete, subacute, shortly apiculate, not torulose, more or less wrinkled and marked by obvious distant divaricating veins; seeds subreniform, not flattened, 2 mm. long, 1·75 mm. broad, red when mature, more or less mottled with small black spots.

Hab.—Awatere Valley, Marlborough: T. Kirk! Mouth of Clarence River: G. Stevenson! Throughout the upper basin of the Clarence River and its tributary valleys: B. C. Aston!

I am deeply indebted to Mr. B. C. Aston for a fine series of specimens of this plant which he collected in 1915, the fruiting pieces in April and the flowering in December. The pods in his specimens are, however, still immature. Mr. G. Stevenson also deserves my warmest thanks for very fine flowering and fruiting specimens gathered near the Clarence Bridge. These show the mature pods. I have put off describing this species for several years, as I was long uncertain whether it might not prove to be a form of one of the species already described. Thanks to the much-valued help of Dr. L. Cockayne, and Mr. H. H. Allan of Ashburton, good specimens of the pods of *N. Carmichaeliae* and *N. torulosum* have now been available for study, with the result that I am satisfied that the present plant is quite distinct from both.

3. Observations on the Genus Notospartium. (Plate LVIII.)

The accurate investigation of this genus has been greatly delayed by the very incomplete material that has been available for examination by local botanists. The species appear to be nowhere plentiful, and some of them are confined to small areas more or less difficult of access. In my view the genus contains at least three well-marked species, the habitats of which seem nowhere to overlap—*N. Carmichaeliae* Hk. f., *N. torulosum* T. Kirk, and *N. glabrescens*, a new species described on page 366. The flowers of these species are all very much alike in size and form, and one has to fall back on the pods for characters that can be depended on in distinguishing the species.

N. Carmichaeliae appears to be confined to the valleys of tributaries flowing northwards into the Wairau River, and the Awatere Valley immediately to the south of these. It is distinguished when flowering by the pubescent rhachis, pedicels, and calyx, and by the pink colour of the flowers. Its pods were apparently first collected by Mr. Teschemaker a few years ago at the Avon River, a tributary of the Waihopai, a district in which only *N. Carmichaeliae* is known to grow. These fruiting pieces were sent to Dr. Cockayne, from whom I received about a dozen of the pods. They are thin, narrow, more or less curved, and much flattened. I consider it certain that the pods figured in the *Botanical Magazine* as those of *N. Carmichaeliae* do not truly belong to that plant; they may be immature pods of *N. glabrescens.* These pods were figured from material collected by Waitt in the northern part of North Canterbury, but it is now almost certain that the species does not extend even so far south as the Clarence Valley.

N. torulosum T. Kirk is, I think, a valid species. It has the widest distribution of all the species of the genus, extending from Amuri County and Mason River to Mount Peel in the Canterbury Alps. In this species the inflorescence is quite glabrous, the petals are purple, and the pods long, narrow, strongly torulose, almost square in cross-section, and produced into a fairly long slender apical bristle. The seeds are larger than those of *N. Carmichaeliae.* This is doubtless the plant of which, in its flowering state, Dr. Cockayne has given a minute description in *Trans. N.Z. Inst.*, vol. 49, p. 59, 1917.

The third species, *N. glabrescens*, is more distinct from the two others than these are one from another. So far as is at present known, it occurs only in the Clarence basin, coming down almost to sea-level at the Clarence mouth. It reaches the dimensions of a small tree, and has much thicker trunks than its congeners. Some specimens are as much as 30 ft. high, with trunks 8 in. in diameter. The inflorescence is glabrous, the petals are purplish, the pods are not torulose and are much stouter than those of the allied species. In order to make it easier to obtain further material, and especially flowers and fruit from the very same plants, the places from which the specimens in my herbarium came are set out below :—

N. Carmichaeliae.—Awatere Valley (J. Stevenson); Upper Awatere Valley (T. Kirk); Avondale, near Renwicktown (H. J. Matthews); Omaka River, near Blenheim (B. C. Aston); Avon River, tributary of Waihopai (Mr. Teschemaker).

N. torulosum.—Mason River, south-east Nelson (L. Cockayne); Whaleback, Amuri County (H. J. Matthews); Mount Kautu (back of), Waipara watershed (R. M. Laing); The Point, Rakaia Gorge (A. Wall); river-terrace scrub, Mount Peel (H. H. Allan); Lynn Stream, Mount Peel (R. M. Laing).

N. glabrescens n. sp.—Clarence mouth (G. Stevenson); Swale River, Clarence Valley (B. C. Aston); Nidd Valley, Clarence Valley (B. C. Aston); Dee River, Clarence Valley (B. C. Aston); Mead Valley, Clarence Valley (T. Kirk—this specimen was sent me named "*N. Carmichaeliae*"); Mead Gorge, Clarence Valley (B. C. Aston); Ure River, Clarence Valley (B. C. Aston).

All the species of the genus flower late in December or early in January, according to the altitude of the station; the pods are not ripe till well on in the following year.

Since this paper was written Mr. James Stevenson has sent me flowers and pods of *N. Carmichaelia* from the same plant. These pods exactly match that shown in Plate LVIII, fig. 3.

4. **Coriaria thymifolia** var. **undulata** var. nov.

A typo differt foliis tenuioribus ac secundum margines emorso-undulatis, floribus minoribus.

Hab.—Both flanks of the Kaimanawa Range: B. C. Aston! Te Whaiti (Whakatane County), *c.* 1,500 ft.

Mr. Aston writes me that this is the only form of the species that grows on the Kaimanawa Mountains. The edges of the leaves look as if a small insect had made a regular series of closely-placed bites all round.

[B. C. Aston, photo.

Fig. 1.—*Notospartium glabrescens* in flower, Nidd Valley, Clarence River, Marlborough.

[B. C. Aston, photo.

Fig. 2.—*Notospartium Carmichaeliae*, Tynterfield, Wairau Valley. (Inserted for comparison.)

1

2

3

FIG. 1.—Pods of *Notospartium glabrescens*, collected near Clarence Bridge by Mr. G. Stevenson. The actual length of the specimen here figured is 3½ in. (9 cm., nearly).

FIG. 2.—Pods of *Notospartium torulosum*, collected at Lynn Stream, Mount Peel, by Mr. H. H. Allan.

FIG. 3.—Pods of *Notospartium Carmichaeliae*, collected at Avon River, a tributary of the Waihopai, Marlborough, by Mr. Teschemaker.

All the figures in this plate are shown on the same scale.

5. **Epilobium nerterioides** A. Cunn.

Most local botanical workers refer A. Cunningham's *Epilobium nerterioides* to *E. nummularifolium* R. Cunn. as a variety. The seeds of *E. nerterioides*, however, always have a smooth testa, whereas the testa is papillose in all the forms of *E. nummularifolium*. As in addition to this constant difference the vegetative characters are also fairly distinctive, it seems to me that *E. nerterioides* should be considered a valid species. Its leaves are usually quite entire, though occasionally slightly sinuate at the edges, are generally marked by irregular shallow fairly-wide semidepressions on the upper surface, and when fresh show a general green hue more or less mottled with pale yellow. Its stems are prostrate, creeping and rooting, little branched, and up to 10 cm. long, though commonly shorter. The plants form more or less matted tufts from 8 cm. to 13 cm. across. There are two prevalent forms: one, occurring on damp sandy soil, has small rather thin orbicular leaves somewhat distantly placed, fairly long peduncles that may reach 5 cm. when in ripe fruit, and rather long capsules (= 2·5–3 cm.); the other form has the leaves closer, more coriaceous, larger, and longer (sometimes broadly elliptic and slightly reflexed with shallow sinuation at the edges), and peduncles equalling the short rather stout capsules. I find no variation in the size or form of the seeds. Mr. Cheeseman's variety *angustum* of *E. nummularifolium* and Mr. Kirk's variety *minimum* both belong to *E. nerterioides*. The species is widely spread throughout the Dominion, and occurs also on the Subantarctic Islands of New Zealand. I have examined specimens from Peria and Fairburn (Mongonui County), Mercury Bay, Gordon's Knob (Nelson), Cass River (Lake Tekapo), Speargrass Flat (Vincent County), Pembroke (Lake Wanaka), Ashburton, Mount Cargill (Dunedin), and Fortrose and Bluff (Southland).

6. Note on **Epilobium antipodum** Petrie.

For a considerable time I have been satisfied that my *Epilobium antipodum* is no other than *E. crassum* Hook. f. The latter was in cultivation for a year or two in my garden, and chance seedlings of it grew up where the seeds of the Antipodes Island plant had been sown some considerable distance away. Satisfactory foliage-bearing pieces of the island plant had not been seen, hence the regrettable failure to recognize what had happened.

7. **Epilobium Matthewsii** n. sp.

This name is proposed for my *Epilobium arcuatum*, a combination that now proves to have been preoccupied when the original name was published (*Trans. N.Z. Inst.*, vol. 45, p. 266, 1913). The plant was only coming into flower when I visited the Clinton Valley. Subsequently the late Henry J. Matthews collected a few ripe capsules, but no entire plants. Though the plant is still very imperfectly known, I consider it one of the most distinct of the native species. The unavoidable change of name affords me a welcome opportunity to commemorate the services of an enthusiastic student of the native flowering-plants of our Dominion.

8. **Aciphylla Poppelwelli** sp. nov.

Planta *A. Traillii* T. Kirk subsimilis, differt inflorescentia principali recta (haud flexuosa), bracteis floralibus pernumerosis (nonnunquam 40 v.

ultra) arctissime confertis trifoliolatis, umbellis quam bracteae multo brevioribus vaginas subtumidas vix excedentibus, fructibus paullo majoribus oblongis, apicem versus ± contractis.

Small, 12–22 cm. high, with scapes solitary or occasionally two from the same main root.

Leaves 6–12 cm. long, ± 3·5 mm. wide, linear, pungent-pointed, subcoriaceous scarcely stiff, striate, thickened along the margins, midrib inconspicuous; petiole short, gradually dilated downwards into a broad membranous subhyaline sheathing base.

Scapes rather stout for the size of the plant, ± 3·5 mm. across, the naked part (as long as the leaves) supporting a much longer spike-like main inflorescence with very numerous (sometimes 40 or more) densely-crowded floral bracts enclosing the umbels, bracts ± 3 cm. long trifoliolate with rather short slightly tumid sheaths; umbels both male and female compactly branched, much shorter than the bracts. Fruit oblong, rather large, more or less contracted at the top.

(*A. Trailii* Kirk, *Students' Flora*, p. 210, *pro parte;* also *A. Traillii* Kirk, Cheeseman's *Manual*, pp. 211–12, *pro parte.*)

Hab.—Mount Kyeburn (Maniototo County), 3,000 ft.; Rock and Pillar Range (Taieri County), 3,800 ft.: B. C. Aston! Arnold Wall! Garvie Mountains (Southland), 4,000 ft.: D. L. Poppelwell! Dr. L. Cockayne!

The Garvie Mountain plant is taken as the type.

Var. **major** var. nov.

Elatior, scapo nudo quam in typo ter quaterve longiore, inflorescentia principali scapo nudo multo breviore, bracteis umbellisque paucioribus, bractearum vaginis brevioribus paene aeque latis ac longis.

Hab.—Mount Buster (part of Mount Ida Range, Maniototo County), 3,500 ft.

I have authentic specimens of *A. Traillii* from Mr. T. Kirk, collected on Mount Anglem, Stewart Island, and others that exactly match these, collected in the same place by Mr. W. R. B. Oliver. In the Mount Anglem plant the floral bracts are placed far apart; the inflorescence is markedly zigzag, the bracts being seated on the bends; the bracts are long, few (5–8), and nearly always simple; the midribs are very prominent, and the space on the underside of the leaves between the midrib and the thickened margins is of a dull-brown colour; the male umbels have long delicate branches that greatly exceed the elongated sheaths enclosing them; the fruits also appear to be smaller than in the present species.

9. Note on **Veronica Willcoxii** Petrie.

Though this plant has been in cultivation for several years in the alpine garden of the late H. J. Matthews (now Dr. Hunter's) at Mornington, Dunedin, I have never succeeded in getting specimens in flower or fruit from there. For a few years two plants grew in my garden in Auckland, but they languished season by season, and died without flowering. The flowers and capsules described by me from plants growing in the University grounds at Dunedin most likely belong to this species, but it is highly desirable that flowering and fruiting pieces should be got from plants known to have come from the Lake Harris habitat, where alone the wild plant has so far been found. For the present there must remain some doubt as to whether the flowers and capsules ascribed to the species truly belong there.

10. **Veronica angustifolia** A. Rich. var. **abbreviata** var. nov.

Racemi foliis breviores 2–3 cm. longi, 1·2 cm. lati, obtusi, dense multiflori ; folia quam in forma typica subbreviora ; capsulis haud visis.

Valley of the Ure River, Marlborough : B. C. Aston!

Collected early April, 1915. Though collected very late in the season, Mr. Aston's specimens are in full flower. When ripe capsules can be examined this plant may be found to deserve specific rank.

11. **Carex Wallii** sp. nov.

Planta humilis laxe caespitans, in locis humidis v. uliginosis crescens.

Folia pauca filiformia flaccida plana v. leviter complicata striata apices versus delicatule scaberula, 6 cm. longa v. breviora ; vaginis valde tenuibus ± striatis in ligulam latam truncatam desinentibus. Culmi folia longe excedentes suberecti filiformes ± trigoni flaccidi nudi ad 12 cm. longi. Spiculae solitariae terminales parvae subovatae ad 5 mm. longae ebracteatae, floribus superioribus masculis, inferioribus (ad 6) femineis ; florum feminеorum glumis membranaceis late ovatis subacuminatis 1-nerviis pallide viridibus, marginibus ± scariosis, gluma infima nonnunquam bractiformi. Utriculi glumas excedentes 2 mm. longi semiteretes v. late biconvexi ovati subpaullo alati, dorso leviter 5-nervii, a basi ± rotundati, supra gradatim in rostrum gracile vix longum integrum abeuntes. Styli rami 3. Nux ± triquetro-biconvexa.

A more of less matted slender plant, growing in wet or damp spots.

Leaves, few, filiform, flaccid, flat or more or less folded striate, finely scaberulous towards the tips, 6 cm. long or less ; sheaths very thin, finely ribbed, and ending in a broad truncate ligule. Culms much exceeding the leaves, suberect, usually more or less curved, glabrous, filiform, more or less trigonous, flaccid, 12 cm. long or less. Spikelets solitary, terminal, small, ovoid in outline, ebracteate, 5 mm. long or rather less ; the upper flowers male, the lower (6 or fewer) female ; glumes of the female flowers membranous, broadly ovate, subacuminate, pale green, the edges more or less scarious ; the lowermost glume occasionally produced into a bractiform elongation. Utricles longer than the glumes, ± 2 mm long semiterete or broadly biconvex, slightly winged, rather faintly 5-nerved on the back, ovate rather wide near the more or less rounded base and gradually narrowed above into a slender short entire beak ; style-branches 3 ; nut more or less triquetrously biconvex.

Hab.—Wet ground at Centre Hill, Southland : Arnold Wall ! Collected February, 1920.

I have not seen much material of this plant, and most of the specimens were over-mature. It is very distinct from any other native species of *Carex*, but its position can hardly be determined with certainty until fuller material is available for examination. The present description may then prove to need amendment in some details.

Art. XLII.—*The Genus* Cordyceps *in New Zealand.*

By G. H. Cunningham.

With Special Entomological Notes on the Hosts, by J. G. Myers.

[*Read before the Wellington Philosophical Society, 27th October, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

Plates LIX–LXII.

In the genus *Cordyceps* are included those fungi which produce the so-called "vegetable caterpillars," "vegetable wasps," &c., which are insects that have been attacked by fungi and their tissues replaced by the vegetative portion of the attacking fungus.

In writings of about a century ago the various species of *Cordyceps* were supposed to be insects changing into plants. To quote one example, an author (25) in 1763, describing *Cordyceps sobolifera* Tul., which he called the "vegetable fly," states, "In the month of May it buries itself in the earth and begins to vegetate. By the latter end of July the tree arrives at its full growth and resembles a coral branch, and is about three inches high, and bears several little pods which, dropping off, become worms, and from thence flies, like the English caterpillar."

Naturally, the earlier systematists had some difficulty in placing such peculiar fungi. Species of this genus were first included under *Clavaria* (12), a Basidiomycete; they were then transferred to *Sphaeria* (19), a genus which at that time covered all the genera now included in the Pyrenomycetes; thence to *Cordyceps* by Link (11); from this to *Torrubia** by Tulasne; and, as this latter genus was not tenable, back to *Cordyceps*.

For the most part, the species of *Cordyceps* grow on insects, but two—*C. capitata* (Holmsk.) Link, and *C. ophioglossoides* (Ehr.) Link—grow on subterranean fungi, *Elaphomyces* spp. *C. ophioglossoides* has recently been recorded growing on a locust in Japan (15).

Distribution.

The genus *Cordyceps* is widely distributed, being found in Britain, Europe, North and South America, China, Ceylon, Japan, Australia, and New Zealand. Many species are extremely limited in their distribution, while others again are more or less cosmopolitan: *e.g.*, *Cordyceps gracilis* Grev. has been recorded from Britain, Europe, North America, Algeria, Australia, and, doubtfully, from New Zealand (as *Cordyceps entomorrhiza* (Dicks.) Link).

Biology.

Little is known of the life-history of *Cordyceps*. Tulasne (21) and de Bary (1) have worked out the life-history of the common European species, *C. militaris* (L.) Link. Their investigations tend to show that a spore, on coming in contact with a host, germinates and produces a germ-tube which penetrates the cuticle and body-wall. Inside the body-cavity this germ-tube branches, forming hyphae, which penetrate to all parts of the body. In the blood gemmae are produced: these are cells asexually produced from the ends of hyphae. They are exceedingly small, and are

* The genus *Cordyceps* of Link was by Tulasne (22) divided into two genera: (1) *Torrubia*, because of the presence of two spore-forms in the life-cycle; and (2) *Cordylia*, embracing all forms growing on subterranean fungi.

rapidly carried in the blood-stream to different parts of the body, where they in turn give rise to hyphae. In this manner the fungus rapidly spreads and quickly kills the host.

Infection of the host may occur from the germ-tube from an ascospore, or from hyphae developed from conidia borne by the Isarial form of *Cordyceps*. A conidium may germinate, and the subsequent hyphae live saprophytically on decaying wood or other organic matter for some considerable time. These hyphae on coming in contact with a host are capable of entering the host-tissues. In the decaying wood from which *Cordyceps Aemonae* Lloyd was taken, mycelial development was so pronounced as to be visible to the naked eye. The writer carried out some rough experiments to ascertain whether this mycelium was capable of attacking the larvae of *Aemona hirta* Fabr., the host of *C. Aemonae*. Healthy host larvae (quiescent) were obtained from rotting logs in which no sign of *Cordyceps* was found, and were buried in pots filled with sterilized sawdust in which were mixed fragments of infected wood taken from the centre of the log that contained *C. Aemonae*. The pots were kept moist and covered with bell jars. In two months' time these larvae were exhumed, and were all found to be dead and surrounded by hyphae. They were replaced, and in three months stromata bearing the Isarial stage of *C. Aemonae* appeared above the surface of the sawdust. Unfortunately this experiment was not carried further to determine whether the perithecial stage could be obtained; but at the time of the first experiment Isarial forms of *C. Aemonae* were brought into the laboratory from logs in the forest in which they were found, and were buried in sawdust with the stromata alone showing. The pots were kept moist and covered; in three months immature perithecia had appeared on one or two of the stromata. (Plate LIX, fig. 1, *b*). The sawdust used in these experiments was obtained by sawing up dead, sound, dry logs of mahoe (*Melicytus ramiflorus* Forst.).

In the host the hyphae continue to develop until finally the whole of the internal tissues are replaced by the mycelium of the fungus, when it forms a hard, compact mass, the cuticle and sometimes portions of the alimentary system alone remaining unaltered. (Plate LXI, fig. 2.) This mycelial mass is known as a sclerotium; from it, usually after a period of rest, the stromata bearing the fructifications of the fungus arise. The stromata vary considerably in shape, size, and number, according to the nature and habitat of the host. If the host is subterranean, then the stromata will necessarily have to be long enough to rise to the surface of the ground, so the length would be governed by the depth of the host. Again, if the host is exposed, as in the case of *Cordyceps clavulata* (Schw.) Ellis & Ev.,* the stromata would necessarily be short.

In some species there are two kinds of fructification: the first is known as the Isarial form, and bears conidia; the second form, which appears after the Isarial (when the latter is present), bears the ascospores. Conidia are simple, short-lived spores, and are abjointed in immense numbers from the ends of hyphae. They may be borne on a stroma, in which case they are abjointed from the terminals of the hyphae forming the stroma, or may occur on the terminals of hyphae which form a loose covering over the external surface of the host. The relationship between this Isarial and the later (or *Cordyceps*) stage is known in a few species only, and in the majority of cases is assumed merely on account of the occurrence of both forms from the same host. As mentioned above, *Isaria* is capable of

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* This species occurs on various species of *Lecanium*.

living as a saprophyte; *Isaria*-like forms also occur as the conidial stages in the life-cycle of *Xylaria*, the species of which are saprophytes, occurring on dead logs, grass, &c. The ascospores of *Cordyceps* are filiform, multicellular bodies borne in asci (cylindrical sacs), which in turn are enclosed in perithecia (variously shaped receptacles bearing asci on their inner walls). The perithecia are, as a rule, densely packed on the surface of or embedded in the substance of the stroma. Each is provided with a definite opening (ostiole) through which the spores escape at maturity. Each ascus bears a small cap on its distal end, pierced by a minute pore. The ascospores are filiform, and lie closely packed in parallel fascicles, eight in each ascus; they are at first continuous, but when mature are divided by many transverse septa—a hundred or more. Eventually they break up at these septa into secondary spores. Each secondary spore is capable of germinating and infecting a host. From this it is obvious in what enormous numbers these spores are produced. Assuming a stroma to bear 100 perithecia, each perithecium to contain 100 asci, and each ascospore to break up into 100 secondary spores, the number of ascospores produced would total 8,000,000—and this is, of course, a very modest estimate of the actual contents of each perithecium, ascus, &c.: for example, a large specimen of *Cordyceps Robertsii* Hook. contains many thousands of perithecia.

Distribution of Spores.

Conidia are light, minute bodies borne on the ends of hyphae, and are thus admirably adapted for wind distribution. Ascospores, being enclosed in perithecia, are primarily dependent on other means of distribution. If a mature perithecium be placed in water, in an hour or so enormous numbers of asci are seen to be collected outside the ostiolum. They have been forced out of the perithecium by the swelling of certain hyphal tissue at the base of the asci. No doubt in nature a similar condition exists: here the spores are forced out and remain on the exterior of the perithecia, or are washed on to the ground, leaves, logs, &c., and when dry may be carried by wind, insects, or other agency to some distance from their source.

Technical Description of the Species.

Although a large number of species have been described, five only are definitely known to occur in New Zealand; of these, four are endemic, and one occurs also in Australia and Tasmania.

Cordyceps* (Fries) Link, *Handbk.*, vol. 3, p. 347, 1833 (emended).

Sphaeria § *Cordyceps* Fries, *Syst. Myc.*, vol. 2, p. 323, 1823; *Torrubia* Lév. Tulasne in *Fung. Carp.*, vol. 3, p. 5, 1865.

Stromata† arising from a sclerotium composed of mycelial tissue within the bodies of insects (rarely in other fungi), simple or branched; sterile below, fertile on upper portion.

Perithecia immersed or superficial, seated on or in fertile portion of stroma; spherical, oval, flask-shaped, &c.; ostiolate.

Asci cylindric, 8-spored, hyaline, distal end capitate; paraphyses absent.

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* The name *Cordyceps* was first used by Fries as the name of a tribe of the Pyrenomycetes, including the genera *Cordyceps* and *Xylaria*. *Torrubia* was first used by Léveillé in manuscript in the Paris Museum Herbarium, and was later adopted by Tulasne (*l.c.*).

† Stromata: This term is used very loosely by the various mycologists who have worked on this genus; as here used it includes both fertile and sterile portions of the clubs.

Spores hyaline, filiform, multiseptate, arranged in the asci in parallel fascicles, or interwoven ; breaking up in the asci into secondary spores, or remaining entire.

Isarial stage when present forming an effused downy weft or an erect simple or variously branched stroma, consisting of hyphae bearing the hyaline continuous conidia on their apices.

1. **Cordyceps Sinclairii** Berk., *Fl. N.Z.*, vol. 2, p. 338, 1855. (Plate LXII, fig. 2.)

Sphaeria Basili Taylor, *N.Z. and its Inhabitants*, p. 424, 1844. *Torrubia caespitosa* Tulasne; *Select. Fung. Carp.*, vol. 3, p. 11, 1865. *Cordyceps caespitosa* Sacc., *Syll.*, vol. 2, p. 565, 1883.

Isarial Stage: Stromata growing from head of host, yellowish, from 18 mm. to 25 mm. high ; stems cylindrical, slender, simple or forked, sometimes confluent, 8 mm. or more high, divided above into numerous more or less cylindrical simple or slightly-lobed heads, which are sometimes disposed into a flabelliform mass clothed with innumerable oblong conidia 7–8 μ long. (Berkeley.)

Perithecia unknown.

Hosts.—*Melampsalta cingulata* Fabr. ; *M. cruentata* Fabr. (Plate LXII, fig. 3.)

Type Locality.—Tauranga, Poverty Bay, in loose gravelly soil in garden of Bishop Williams ; "growing from larva of some orthopterous [*sic*] insect."

Distribution.—Tauranga (Colenso) ; Farewell Spit, Nelson (Benham) (2) ; Weraroa (E. H. Atkinson) ! Hokitika (unknown collector) !

There is a fine specimen in the Canterbury Museum collection ! (Plate LXII, fig. 2, *c*).

No. 79, Biol. Lab. Herb. (Crypt.), Wellington.

This form should really have been named as an *Isaria*, as only he conidial form is known. It is possible that this may be the conidial stage of *Cordyceps sobolifera* Tul., as this species occurs on cicada in Japan. As all the other species occurring in New Zealand are endemic, with the exception of *Cordyceps Robertsii*, which is found only in Australia and New Zealand, it is, however, more likely that *Cordyceps* (?) *Sinclairii* is also endemic.

It is a very variable form, and assumes many different shapes. The colour of the stroma ranges from white in the most immature specimens, through yellow (colour mentioned by Berkeley), light brown, in more mature forms becoming pink, deepening in colour with age.

Although specimens are fairly plentiful in the New Zealand museums, none are known in any of the mycological collections abroad (14). A most interesting account of this species (with plate) is given by Benham (2).

Notes on the Hosts (by J. G. Myers).—Of the four specimens available for study, only two are in at all a good state from an entomological point of view ; but it is significant that all four hosts are nymphs of the final instar, with wing-pads well developed and the whole appearance suggestive of almost immediate emergence. This is of interest in that it is an indication that the nymphs are, of course, full-grown—a fact which enables an estimate of their species to be made with greater accuracy than would otherwise be possible. The two large specimens can be assigned almost certainly to *Melampsalta cingulata* Fabr. (6), while the two others, both of the same size and smaller than the other two, belong to one of the smaller cicadas, most probably to *Melampsalta cruentata* Fabr. (6).

2. Cordyceps Craigii Lloyd, *Myc. Notes,* p. 527, f. 718, 1911 (emended). (Plate LX, fig, 3; and text-figs. 1, 2.)

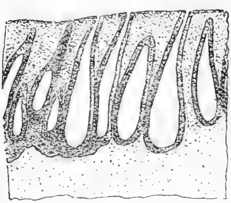
Isarial stage unknown.

Stroma solitary, 5–7 cm. long; growing from head of host; stem 3–4 mm. thick, 3–4 cm. long; fertile portion brown when fresh, blackening with age, flattened, falcate, 2–3 cm. long, 8–10 mm. wide, 3–4 mm. thick; surface smooth, or punctate with ostioles of perithecia.

Perithecia completely immersed, densely packed in stroma, flask-shaped, with long slender slightly curved necks; up to 1,500 μ long, 300–500 μ wide; walls 35 μ thick.

Asci hyaline, narrowly cylindrical, tapering slightly towards distal end, markedly towards proximal end, terminating in a long slender pedicel, not constricted below cap; 250–330 × 6–7 μ.

Spores in parallel fascicles in asci, same thickness throughout, ends bluntly pointed, 180–260 × 2 μ; secondary spores 3–4 × 2 μ; readily separable in asci.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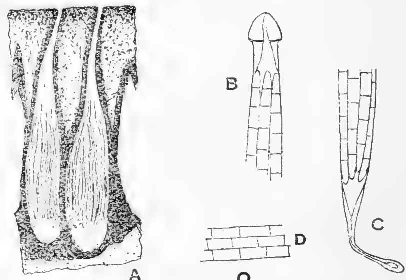

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[*Drawn by E. H. Atkinson.*

Cordyceps Craigii Lloyd.

Fig. 1.—Transverse section through fertile portion of stroma.
Fig. 2.—A. Perithecia (enlarged). B. Capitate apex of ascus. C. Base of ascus. D. Secondary spores, 3–4 × 2 μ.

Host.—*Porina enysii* Butl.; growing from head. (Plate LX, fig. 2.)

Type Locality.—Old and abandoned kumara (*Ipomoea batatas* Poir) beds, Auckland.

Distribution.—Auckland (E. Craig); Wellington, in ground under a karaka (*Corynocarpus laevigata* Forst.), in forest, vicinity of Wireless Hill (unknown collector)!

No. 192, Biol. Lab. Herb. (Crypt.), Wellington.

" Mr. Craig also sends two specimens collected in the bush which are very similar and probably the same species. I could not say positively, however, from the specimens, as they are both immature." (Lloyd.)

Specimen 192 was given me by Mr. H. Hamilton, of the Dominion Museum. He obtained it from a man who dug it up in the forest under a karaka.

Note on the Host (by J. G. Myers).—As this species has so far been recorded only from the North Island, the host, taking its size into consideration, is almost certainly *Porina enysii* Butl. (1), the larva of which, in the North Island, is the victim also of *Cordyceps Robertsii* Hook.

[E. Bruce Levy, photo.

Fig. 1.—*Cordyceps Aemonae* Lloyd. × 6. *a*, *c*. Showing characteristic fasciculate growth of stromata. *b*. Isarial form. Arrow points to developing perithecia.

Fig. 2.

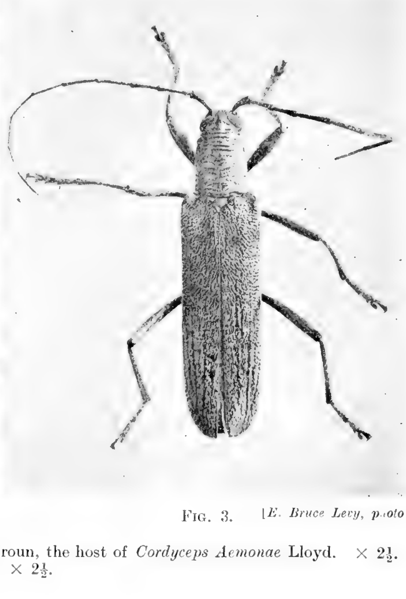
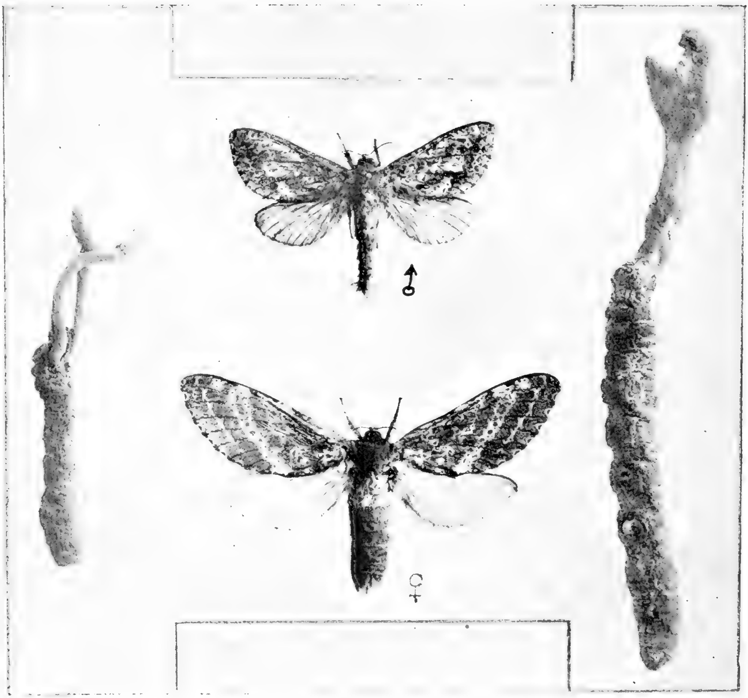


Fig. 3. [E. Bruce Levy, photo.

Fig. 2.—Larva of *Aemona hirta* Broun, the host of *Cordyceps Aemonae* Lloyd. × 2½.
Fig. 3.—Imago of *Aemona hirta*. × 2½.



[E. Bruce Levy, photo.

FIG. 1. FIG. 2 FIG. 3.

FIG. 1.—*Cordyceps consumpta* n. sp. Natural size.
FIG. 2.—*Porina enysii* Butl., the larva of which is the host of *C. Craigii* and *C. Robertsii.* Natural size.
FIG. 3.—*Cordyceps Craigii* Lloyd. Natural size.

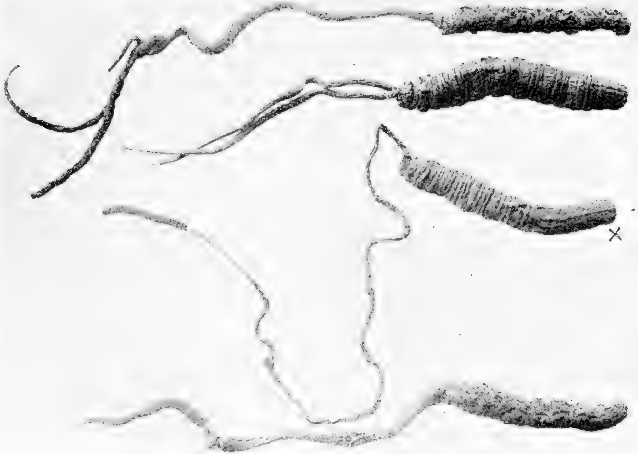


FIG. 1.

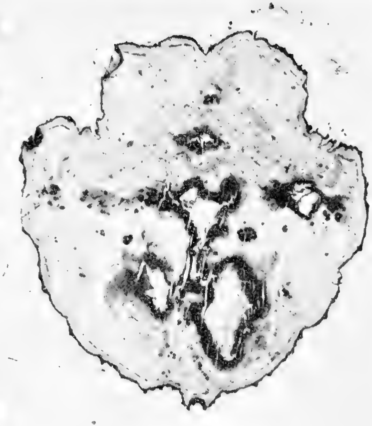
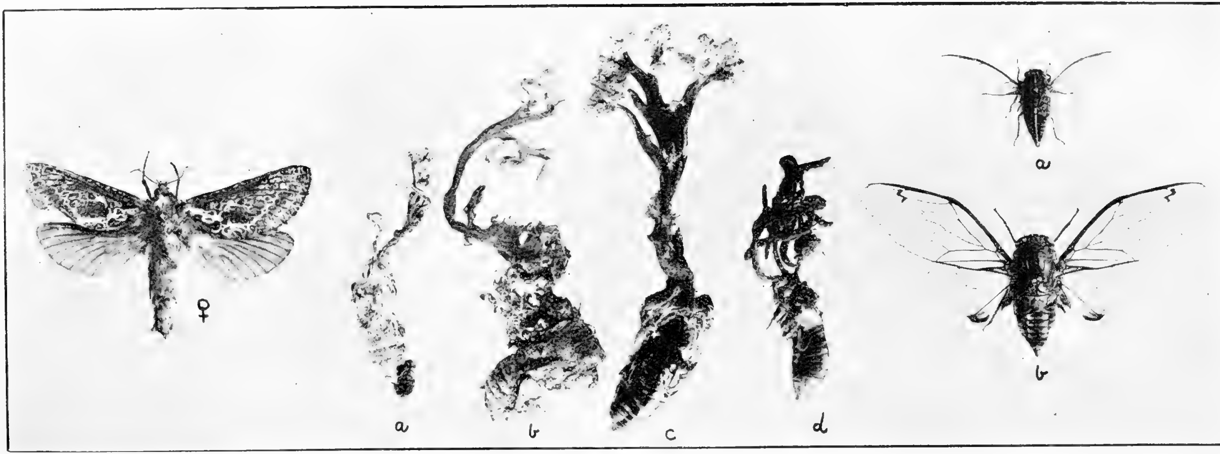


FIG. 2. [E. Bruce Levy, photo.

FIG. 1.—*Cordyceps Robertsii* Hook. Reduced ½.
FIG. 2. Transverse section through sclerotium; taken from anal portion of specimen marked in fig. 1. × 10.



[E. Bruce Levy, photo.

Fig. 1. Fig. 2. Fig. 3.

Fig. 1.—*Porina dinodes* Meyr., the larva of which, in the South Island, is the host of *C. Robertsii*. Natural size.

Fig. 2.—*Cordyceps Sinclairii* Berk. Specimens from *a* to *d* show gradual development of the stroma; the colour ranges from white in *a*, through yellow in *b*, brown in *c*, to pink in *d*. In *a*, *b*, and *c* the conidia are borne on the tufted apices; in *d* they form a packed mass round the central axis. Reduced $\frac{2}{3}$.

Fig. 3.—*a*. *Melampsalta cruentata* Fabr., the nymphs of which are the hosts of *a* and *d*. *b*. *Melampsalta cingulata* Fabr., the nymphs of which are the hosts of *b* and *c*. Reduced $\frac{2}{3}$.

3. Cordyceps consumpta, n. sp. (Plate LX, fig. 1; and text-figs. 3, 4.)

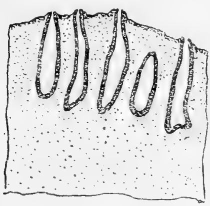
Isarial stage unknown.

Stromata gregarious, two springing from head; 2–3 cm. long; fertile portion cylindrical, curved, apex obtuse, black, 8–10 mm. long, 2–3 mm. thick; rough with projecting necks of the perithecia; sterile portion slender, cylindrical, straight or curved, glabrous, black, 20 mm. long, 1–5 mm. thick.

Perithecia completely immersed, flask-shaped, or more frequently very irregular and distorted; not crowded in the stroma, each perithecium being separated by stromal hyphae; necks protruding; 1,000–1,200 μ long, 200–500 μ wide; necks short; walls 30 μ thick.

Asci hyaline, narrowly cylindrical, tapering slightly towards distal end, markedly towards proximal end, not constricted below capitate apex; $250 \times 7\ \mu$.

Spores in parallel fascicles in asci, same thickness throughout, ends bluntly pointed, 180–220 μ; secondary spores $4\text{–}5 \times 1\text{–}1{\cdot}5\ \mu$, readily separable in asci.



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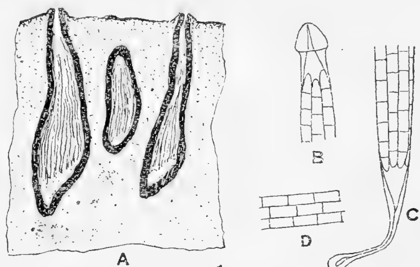

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[Drawn by E. H. Atkinson.

Cordyceps consumpta.

FIG. 3.—Transverse section through fertile portion of stroma.
FIG. 4.—A. Perithecia (enlarged: note distortion). B. Capitate apex of ascus. C. Base of ascus. D. Secondary spores, $4\text{–}5 \times 1{\cdot}5\ \mu$.

Host.—*Porina* sp. (see note); growing from head.

Type Locality.—Rotorua, N.Z., growing from larva buried in soil (A. Lush)!

Distribution.—Known only from type locality.

No. 230, Canterbury Museum collection. (Type.)

In macroscopic characters this species resembles *Cordyceps falcata* Berk., but differs in having the perithecia completely immersed; in *C. falcata* they are perfectly superficial. In microscopic characters there is a strong resemblance to *Cordyceps Craigii* Lloyd; but the difference in perithecial characters, together with the difference in all macroscopic characters, indicates that this is a valid species. It bears a closer resemblance to *C. falcata* and *C. Craigii* than to any other described species.

This specimen, together with many others, was kindly forwarded for examination by Mr. G. Archey, of the Canterbury Museum. It was collected by Mr. A. Lush at Rotorua in June, 1920. Unfortunately, no particulars as to exact locality were appended.

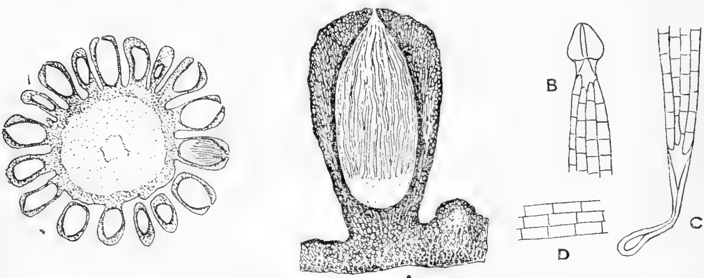
Note on the Host (by J. G. Myers).—The larva infected, unless it be immature, must in this case be that of one of the three smaller common species of the genus *Porina*—namely, *P. cervinata* Walk. (23), *P. signata* Walk. (24), or *P. umbraculata* Guen. (8). At present we have no ascertained constant structural characters by which to distinguish these larvae. The insect is far too small for a larva of *Porina enysii* Butl. (5)—at any rate, for a full-grown one.

4. **Cordyceps Robertsii** Hook., *Fl. N.Z.*, vol. 2, p. 202, 1855 (emended). (Plate LXI, figs. 1, 2; and text-figs. 5, 6.)

?*Sphaeria larvarum* Westw., *Proc. Ent. Soc. Lond.*, vol. 2, p. 6, 1836. *Sphaeria Robertsii* Hook., *Icon. Pl.*, vol. 1, t. 11, 1837. *S. Hugelii* Corda, *Icon.*, vol. 4, 44 F, p. 129, 1840. *S. Forbesii* Berk. in *Lond. Jour. Bot.*, vol. 7, p. 578, 1848. *Torrubia Robertsii* Tul., *Sel. Fung. Carp.*, vol. 3, p. 6, t. 1, 1865. *Cordyceps Selkirkii* Olliff in *Ag. Gaz. N.S.W.*, vol. 6. p. 411, 1895. ?*C. Coxii* Olliff, *l.c.* *C. larvarum* (Westw.) Olliff, *l.c.*

Isarial stage unknown.

Stroma slender, 10–38 cm. long; fertile portion 6–12 cm. long, 3–4 mm. thick, acute, densely covered with superficial perithecia, which reach to apex of stem; brown, becoming black with age; sterile portion slender, 5–15 cm. long, 2–3 mm. thick, same colour as fertile portion.



5 6

[*Drawn by E. H. Atkinson.*

Cordyceps Robertsii Hook.

Fig. 5.—Transverse section through fertile portion of stroma.

Fig. 6.—A. Perithecium (enlarged). B. Capitate apex of ascus (note constriction below cap). C. Base of ascus. D. Secondary spores, 5–6 × 3 μ.

Perithecia superficial, small, elongate-obovate or elliptical, densely packed around central axis, easily separable; dark brown, composed of coarse hyphal threads; 600–880 × 300–400 μ; wall thick, 30–50 μ.

Asci hyaline, narrowly cylindrical, tapering slightly towards distal end, markedly towards proximal end, terminating in a long slender pedicel; slightly constricted below capitate apex; 280–400 × 9–10 μ.

Spores in parallel fascicles, filiform, equally thick throughout, bluntly pointed, multiseptate, 280 × 3 μ; secondary spores 5–6 × 3 μ, not readily separable in asci.

Hosts.—*Porina enysii* Butl.; *P. dinodes* Meyr. Growing usually from head, rarely from anal region. (Plate LX, fig. 2; Plate LXII, fig. 1.)

Type Locality.—Given in *Icones Plantarum* as "N.Z."

Distribution.—More or less general throughout the North Island. Specimens have been recorded from the following localities: Rotorua

(H. Hill) (10), Petane (A. Hamilton) (9), Auckland (E. Craig) (13), Waikanae (H. C. Field) (7), Raurimu (E. H. Atkinson)! In the South Island this species appears to be less common. Specimens have been recorded from the following localities: Catlin's and Tokonui Range, near Gore (*teste* Benham); Riverton (W. G. Howes)! Lloyd (16) states that it has been collected in Australia by Cheel. Rodway (20) records its incidence in Tasmania. Australia, N.S.W. (E. Cheel). Tasmania (L. Rodway), gully at foot of Mount Wellington.

No. 191, Biol. Lab. Herb. (Crypt.), Wellington.

Many improbable tales of the life-history of this species may be found in the earlier articles on the subject. One assertion that has gained credence is that these fungi are found only under the rata (*Metrosideros* spp.). It is true that they are often found under the rata, but they occur as frequently in areas in which no rata is found growing; for example, Hamilton (9) records its occurrence under *Coprosma grandifolia* Hook. f.

Frequent mention is made of its being used as food by the Maori. I am informed by Mr. Elsdon Best, that, although in times of famine the Maori undoubtedly made use of certain terrestrial and arboreal fungi as articles of food, they certainly did not eat the *awheto*, as this fungus is called by them.

The sclerotium of *Cordyceps Robertsii* was, however, made use of in tattooing, Mr. Best stating that the vegetative portion of the fungus, or *awheto*—the living grub being known as *ngutara*—was burnt and pulverized, and the powder so obtained mixed with water to form a black paste. The pattern of the tattoo having been marked out on the limbs and body (the pigment was not used on the face, as it did not give a deep enough black), the edge of the *uhi whakatataramoa* was placed on a line of the pattern and the back struck with the *take rarauhe*,* causing the skin to be severed. A second implement, the *uhi puru* (which had a serrated edge), was then dipped in the pigment, applied to the cut made by the *uhi* first used, and struck with the *take rarauhe*, the pigment remaining on removal of the *uhi*.

Cordyceps Robertsii is an extremely variable form. (Plate LXI, fig. 1.) I have specimens with a single stroma; with stromata occurring in pairs from the head; with a single stroma bifurcate about half-way between apex and base; and with stromata growing from both head and anal regions.

Specimens are most plentiful in the summer months. Hill (10) states that the mature stage is most common in October, November, and December, but he has seen Maori children offering them for sale along the Rotorua railway-line as late as March.

Note on the Hosts (by J. G. Myers).—Practically all the earlier naturalists accepted without question the current belief that the host of this species was *Hepialus virescens* Dbld. Hamilton, Field, Maskell, and other writers in the early volumes of the *Transactions of the New Zealand Institute* considered this to be the only larva large enough to coincide with the "vegetable caterpillar" in size. This was, however, merely a conjecture. G. V. Hudson was the first to point out the improbability of the arboreal *Hepialus* as a host, seeing that the infected larvae were invariably found underground. He suggested *Porina mairi* Buller as the host; but only one specimen of this moth has been taken, and the supposition rests only on its large size,

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* The *take rarauhe* was made from a piece of fern-stalk (*Pteridium esculentum* Cockayne), lashed round at the end to prevent its splitting. Fuller information on tattooing as practised by the Maori may be obtained in the *Journal of the Polynesian Society*, vol. 13, p. 166, 1904.

its metamorphosis being unknown. The argument that its rarity may be due to the heavy larval mortality consequent on the attacks of *Cordyceps Robertsii* is obviously inadmissible. *Porina mairi* may be a host, but that it is the usual host is highly improbable.

In 1895 Olliff (*Ag. Gaz. N.S.W.*, vol. 6, p. 407) supported the hypothesis that the victim was the larva of a species (not necessarily *P. mairi*) of *Pielus* (syn. *Porina*), a view which subsequent evidence has justified.

The first experimental indications of the host's specific identity were published in 1903, when A. Philpott registered his opinion that the larva of *Porina dinodes* Meyr. "is the vegetable caterpillar. No other moth in this district [Southland] known to me is large enough to warrant the assumption that its larva may be the host of the fungus. I have several times found the fungus-attacked larvae here, and, so far as a comparison between these and the living larvae of *P. dinodes* can be trusted, I think it bears out my opinion."

W. G. Howes gives similar evidence (1910) regarding *Cordyceps* found plentifully at Riverton. He found "along with the fungi . . . an apparently healthy larvae of *Porina dinodes*, and, so far as I can see, all the vegetable caterpillars there were those of this moth. The largest specimen I took was 5 in., but I have never seen a living *dinodes* larva of this length, and suppose that the fungus growth distends the skin of the host."

As *Porina dinodes* is confined to the South Island, definite evidence of the North Island host was lacking. This evidence was, however, forthcoming in 1905, when G. V. Hudson, at Karori, received "two Hepialid larvae, one very recently dead and infested with *Sphaeria* [*Cordyceps*] fungus . . . the other an identical larva unaffected by the fungus—alive and very healthy. Both the larvae were found in the earth, close together, amongst the roots of some native shrubs." The healthy larvae was successfully reared, and proved to be that of *Porina enysii* Butl. As distinguished from the smaller and commoner species of the genus, this frequents the bush, and is by no means rare in the localities where *Cordyceps* abounds. It is interesting to note that the abundance of the imago, like that of many other Lepidoptera, is somewhat periodic. One season may produce large numbers in a locality where the moth was at other times rare.

It seems probable that the usual host of *Cordyceps Robertsii* is *Porina dinodes* Meyr. in the South Island, and *P. enysii* Butl. in the North.

For the suggestion that the larva of *Sphinx convolvuli* L. may sometimes be the victim no grounds of evidence exist. Moreover, an affected caterpillar of this species would be immediately recognizable by Sphingid characters which no fungous attack would completely obscure.

5. **Cordyceps Aemonae** Lloyd, *Myc. Notes*, p. 932, fig. 1695, 1920. (Plate LIX, fig. 1; and text-figs. 7, 8.)

Isarial stage preceding the perithecial on the same stroma; at first white and pruinose with conidia, becoming light brown; conidia hyaline, subglobose, 4–6 μ.

Stromata fasciculate, 3–5; stipitate, short, 2–3 mm. long; tipped with sterile apices, light brown; growing from head of host.

Perithecia subsuperficial, irregularly globose, obtuse, contiguous; light brown, becoming dark with age; 300–500 μ in diameter; wall thick, up to 80 μ.

Asci hyaline, narrowly cylindrical, tapering slightly towards distal end, markedly towards proximal end, terminating in a long slender pedicel; not constricted below capitate apex; 180–220 $\times$ 5–6 μ.

Spores in parallel fascicles in asci, filiform, same thickness throughout, ends bluntly pointed, multiseptate, 100–120 × 2–2·5 μ; secondary spores easily separable in ascus, 3–4 × 2–2·5 μ.

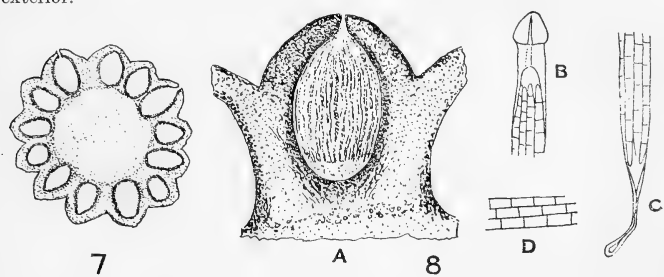
Host.—Larva of *Aemona hirta* Fabr.; growing from head. (Plate LIX, figs. 2, 3.)

Type Locality.—Weraroa (G. H. C.), in rotting logs of mahoe (*Melicytus ramiflorus* Forst.).

Distribution.—Known only from type locality.

No. 78, Biol. Lab. Herb. (Crypt.), Wellington. (Co-type.)

These specimens were collected by the author and sent to C. G. Lloyd. They were obtained from rotting logs of mahoe. This is a brittle, soft wood, soon decaying on contact with the ground. The parasitized larvae were all found with their heads towards the surface of the log. It is apparently necessary for the stromata to make their way through about 5 mm. of solid wood before coming to the surface; frequently, however, they follow the old larval tunnels until they come to an opening at the exterior.



[*Drawn by E. H. Atkinson.*

Cordyceps Aemonae Lloyd.

FIG. 7.—Transverse section through fertile portion of stroma. (Enlarged.)
FIG. 8.—A. Perithecium (enlarged), showing coalescence of walls. B. Capitate apex of ascus. C. Base of ascus, showing hyaline pedicel. D. Secondary spores, 3–4 × 2–2·5 μ.

Although the perithecia are superficial, in section they appear to be immersed. That this is due to the coalescence of the perithecial walls with the formation of a pseudo-stromal tissue, careful microscopic examination shows. (Text-fig. 2, A.)

Note on the Host (by J. G. Myers).—*Aemona hirta* Fabr., Broun in *Man. N.Z. Coleopt.*, p. 570, 1275: This fairly common Cerambycid beetle was reared by David Miller, Government Entomologist, from healthy larvae taken with specimens undoubtedly of the same species, infested with the mycelium of *Cordyceps Aemonae* Lloyd. This beetle is variable in size, colour, and relative quantity of pubescence, one variety formerly ranking as a distinct species under the name of *Aemona humilis* Newman. The latter species, commonly known as the "flat-headed lemon-tree borer," falls, according to Broun (3), into synonymy with *Aemona hirta* Fabr. under the name of *A. humilis.* The species has been recorded as a pest of lemon-trees in the Auckland District (4).

The beetle passes its larval and pupal stages in manuka (*Leptospermum scoparium* Forst.) (3), mahoe, and a variety of other trees and shrubs (*teste* W. W. Smith, Taranaki).

Doubtful Species.

The following have been recorded as occurring in New Zealand, but as no specimens have to my knowledge been collected, and as none from this biological area exist in any of the mycological herbariums abroad, they are here recorded as doubtful.

Cordyceps gracilis Grev.

Host.—" Larvae of insects."

Massee (17) states that this species—determined by him as *Cordyceps entomorrhiza* (Dicks.) Link—was collected by Colenso and sent to Kew. There are no specimens of this fungus from New Zealand in the Kew Herbarium (14).

Cordyceps Gunnii Berk.

Olliff (*l.c.*) doubtfully records this species for New Zealand without mention as to who collected it, where it was collected, or where the original reference was obtained. It is probable that a specimen of *Cordyceps Craigii* Lloyd has been mistaken for it.

Frequent mention is made of a species of *Cordyceps* attacking *Hepialus virescens* Dbld. Unfortunately, I have not seen any specimens, and so cannot do more than record this animal as a host. The following particulars have been supplied by Mr. Myers :—

In the *Entomologist*, London, vol. 31, p. 128, 1898, W. G. Howes records the discovery of " vegetable caterpillars " in the trunks of trees buried at a considerable depth and exposed by mining operations at Orepuki, Southland. The situation of these infected larvae was taken as indubitable proof that *Hepialus* was the host [of *C. Robertsii*]. The matter, however, must remain extremely uncertain, since *Hepialus virescens* is confined to the North Island.

The second case occurred about 1903, when G. V. Hudson was " shown a specimen of a vegetable caterpillar in the trunk of a tree. . . . On examination I at once recognized the insect as a larva of *Hepialus virescens*, and the portion of the tree-trunk with the burrow in which this larva was situated precisely agreed with the usual habitat of that species."

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ART. XLIII.—*Unrecorded Plant-habitats for the Eastern Botanical District of the South Island of New Zealand.*

By W. MARTIN, B.Sc.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1920; received by Editor, 31st December, 1920; issued separately, 8th August, 1921.*]

THIS paper records the habitats of certain plants growing in the Eastern Botanical District of the South Island as defined by Cockayne (1). Only such plants are included in the list as have not previously been recorded from this district or are of rare occurrence; or such as have been omitted from published lists of the florulae of defined areas; or such, again, as add to our knowledge of their distribution.

No catalogue has been prepared of the species occurring in the above district other than that of J. B. Armstrong (2), and, as it is by no means certain that all of his identifications were correct, there is room for a revision of the flora. Again, Armstrong's habitats are so vague as to be of little service to students of this district. Most of the plants named in this paper have already been recorded from Canterbury, though the specific habitats given are new.

Twelve native plants are added to the sixty-eight already recorded by Dr. Cockayne as occurring in the Riccarton Bush, Christchurch (3 and 4). *Hymenophyllum minimum* is recorded from this botanical district for the first time. *Helichrysum Purdiei* has previously been collected in Canterbury by Dr. Cockayne, Professor Wall, and Mr. H. H. Allan. *Eryngium vesiculosum* and *Deyeuxia Billardieri* are new records for Banks Peninsula. The habitat mentioned for *Carex Berggreni* is the most northerly for this species, while the genus *Gahnia* seems to have eluded the notice of observers since Armstrong recorded five species in his catalogue (2). The recorded habitat for *Gleichenia Cunninghamii* is worthy of note.

Aciphylla Colensoi Hook. f. var. *maxima* Kirk. In stream-bed at foot of patch of *Nothofagus Solanderi* between Hororata and South Malvern.
Agropyrum scabrum Beauv. Hagley Park, Christchurch.
Angelica geniculata Hook. f. Upper Rakaia Bridge, on the island.
Asplenium flabellifolium Cav. Riccarton Bush, Christchurch.
Asplenium Lyallii Moore. Mount Oxford; Mount Somers; Omihi Hills.
Asplenium Richardi Hook. f. Kaituna Bush; Balgueri Valley, Akaroa.
Astelia nervosa Banks & Sol. Riccarton Bush, Christchurch.
Blechnum Patersoni Met. Kaituna Reserve.
Blechnum penna marinum Kuhn. Riccarton Bush, Christchurch.
Blechnum vulcanicum Kuhn. Kaituna Reserve, Omihi Hills.
Bulbinella Hookeri Benth. & Hook. Summit Road, at head of Le Bon's Bay. This is a "species inquirendae" of Laing (5).
Carex Berggreni Petrie. Arthur's Pass, close to the railway-station.
Carmichaelia Monroi Hook. f. Left bank of the Rakaia, quarter of a mile from the lower bridge, near the Mead Road.

Carmichaelia subulata Kirk. Riccarton Bush, Christchurch.
Carmichaelia sp.? Shingle terrace, Birdling's Flat. Apparently close to or a form of *C. subulata*, but so prone as not to exceed 2 in. in height.
Celmisia Mackaui Raoul. This disappearing species is growing freely on the upper part of the cliffs at The Caves, Akaroa.
Cheilanthes Sieberi Kunze. Canterbury Plains, Templeton.
Cheilanthes tenuifolia Swartz. Two plants of this also fast-disappearing species were gathered on Birdling's Flat, near Lake Forsyth.
Clematis afoliata Buch. Abundant in the gorge of the Hurunui River near Ethelton.
Clematis australis Kirk. Le Bon's Bay; Rakaia Gorge; River Grey.
Clematis foetida Raoul. Rakaia Gorge.
Corokia Cotoneaster Raoul. Rakaia Gorge.
Cyclophorus serpens C. Chr. Riccarton Bush, Christchurch.
Cystopteris novae-zealandiae Armstr. Mount Oxford, 1,000 ft. This fern is still common at about the same level on Mount Somers where it was noted and recorded by Potts (6).
Dacrydium cupressinum Soland. Mount Grey, where it was once fairly common.
Deyeuxia Billardieri Kunth. On coastal rocks at Akaroa beyond the abattoirs.
Dianella intermedia Endl. Beside the beech plantation near the source of the Omihi Stream; River Grey.
Drosera binata Labill. Swamp near intersection of road from Lincoln College and that between Greenpark and Springston.
Dryopteris pennigera C. Chr. Omihi Stream.
Dryopteris punctata C. Chr. Riccarton Bush, Christchurch.
Echinopogon ovatus Beauv. Mount Grey.
Elaeocarpus Hookerianus Raoul. Mount Grey; Kaituna Reserve, Banks Peninsula.
Erectites prenanthoides DC. Riccarton Bush, Christchurch.
Eryngium vesiculosum Labill. On shingle close to the outlet to Lake Forsyth; on roadside exactly two miles beyond the rabbit-proof fence on the road to Akaroa.
Gahnia sp.? Near the source of a stream between the River Grey and the Little Grey River. Probably *G. lacera*.
Gleichenia Cunninghamii Heward. This fern was collected on Mount Somers on an open shingle-slope, facing north, at an elevation of 3,500 ft. The only shelter from the howling nor'-westers was a boulder about 18 in. high, while from the glare of the sun there was none.
Helichrysum Purdiei Petrie. Bed of River Grey; Mr. Anderson, of West Oxford, has sent me specimens of this rare plant from near the source of Gammon's Creek, on Mount Oxford.
Hoheria angustifolia (Raoul) Cockayne. Rakaia Gorge.
Hymenophyllum minimum A. Rich. Near source of Gammon's Creek, Mount Oxford.
Iphigenia novae-zealandiae Baker. Tarn near Lake Coleridge.
Juncus caespiticius E. Mey. Beside water-race, Rolleston.
Juncus pallidus R. Br. Swamp between Kaituna and Birdling's Flat.
Korthalsella Lindsayi Engl. Island in Rakaia Gorge; parasitic on *Myrtus obcordata* and on *Coprosma rotundifolia*.
Korthalsella salicornioides Van Tiegh. On *Leptospermum ericoides*, at Kaituna Reserve; abundant.

Leptocarpus simplex A. Rich. Inland shore of Lake Ellesmere; head of Le Bon's; Barry's Bay; Onawe Peninsula.

Leptolepia novae-zealandiae Kuhn. Mount Oxford, 1,500 ft.

Libertia ixioides Spreng. Island in Rakaia Gorge; Mount Grey.

Loranthus micranthus Hook. f. Riccarton Bush, Christchurch.

Mariscus ustulatus C. B. Clarke. Roadsides between Tai Tapu and Motukarara.

Metrosideros lucida A. Rich. Abundant on hill near Omihi; also on shore of Lake Coleridge.

Muehlenbeckia ephedrioides Hook. f. This plant has been recorded from the shingle ridge near the mouth of the Rakaia River, and it is now recorded from the end of the same ridge, twenty miles or so farther north, near the outlet to Lake Forsyth, where it is the commonest plant in the first zone of vegetation. It is abundant on the beach shingle at Otaio, in South Canterbury; old bed of the River Waimakariri, not far from the Paparua Prison, beyond Yaldhurst; banks of stream near Cust.

Nothofagus Solanderi (Hook. f.) Oerst. Hills near source of Omihi Stream.

Olearia arborescens Cockayne and Laing. Mount Grey; common in light bush.

Ophioglossum costatum R. Br. Mount Grey; vicinity of Lake Coleridge.

Panax simplex Forst. Mount Grey.

Parietaria debilis Forst. Riccarton Bush, Christchurch.

Parsonsia capsularis (Forst. f.) R. Br. var. *rosea* (Raoul) Cockayne. Island in Rakaia Gorge.

Paesia scaberula Kuhn. Omihi; Mount Grey; Mount Oxford.

Polypodium diversifolium (Willd.) C. Chr. Riccarton Bush, Christchurch.

Polystichum vestitum Presl. Riccarton Bush, Christchurch.

Pseudopanax ferox Kirk. Island in Rakaia Gorge.

Raoulia Monroi Hook. f. Old bed of Waimakariri; island in Rakaia Gorge; Amberley Beach; Maronan Road, Ashburton.

Scirpus sulcatus Thouars var. *distigmatosa* Clarke. Between Greenpark and Springston, in manuka swamp.

Tetrapathaea australis Raoul. Kaituna Reserve.

Uncinia leptostachya Raoul. Riccarton Bush, Christchurch.

Urtica incisa Poir. Outlet to Lake Forsyth.

Utricularia monanthos Hook. f. Tarns near Lake Coleridge.

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Art. XLIV.—*Further Studies on the Prothallus, Embryo, and Young Sporophyte of* Tmesipteris.

By the Rev. J. E. Holloway, D.Sc., F.N.Z.Inst., Hutton Memorial Medallist.

Read before the Philosophical Institute of Canterbury, 1st December, 1920 ; received by Editor, 31st December, 1920 ; issued separately, 12th August, 1921.]

Plate LXIII.

Introductory.

The first accounts of the prothallus of *Tmesipteris* to be published were those contained in the two papers of Professor A. A. Lawson (11, 12), in the latter of which the author also described the prothallus of *Psilotum.* In the same year Darnell-Smith (3) published an account of the prothallus of *Psilotum,* and described his successful attempts to germinate the spores experimentally. Lawson's two accounts relate to the mature prothallus and sexual organs of both *Tmesipteris* and *Psilotum,* there being shown to be a more or less close resemblance between the two plants with regard to the gametophyte generation. A single embryo of *Tmesipteris* was figured also in his first paper.

In the following year I published an account (7) of the prothallus and young plant of *Tmesipteris,* based on abundant material obtained in the wet forests of Westland, New Zealand. The development of the sexual organs and of the embryo was described, but in the case of the latter the series obtained was incomplete, although it indicated the absence of root, suspensor, and cotyledon. The main object of the present paper is to trace more fully the development of the embryo and of the young plant. The absence of a root organ from the adult plant, and its probable absence also from the embryo, together with the discovery of the rootless Rhynie plant fossils in the Scottish Early Devonian (8, 9, 10), gives to the *Tmesipteris* embryo and young plant an exceptional interest. Although the series of embryos studied for the purpose of the present paper is still not altogether complete, the results obtained seem to be such as to warrant immediate publication.

The new material on which this account is based has, as before, all been obtained in Westland. It embraces about seven hundred prothalli in all, many of which bore embryos of different ages and attached plantlets, and also a full series of detached plantlets.

It may be mentioned that the embedding in paraffin was practically all done at home by the aid of the simple brass table illustrated by Chamberlain on page 14 of the third edition of his *Methods in Plant Histology* (Chicago, 1915), the results obtained being quite satisfactory. The stain used throughout was Delafield's haematoxylin, this being chosen on account of its clear differentiation of embryos. In some cases safranin was used in conjunction with it. The drawings were made with the aid of a Leitz camera lucida. I have to thank Dr. Charles Chilton, of the Canterbury College Biological Laboratory, for permission to work in the laboratory from time to time, and for his interest in my work.

GENERAL.

The climate of Westland is a continuously wet one, there being practically no really dry periods at any season of the year. For example, at Hokitika, on the coast, as shown in the Meteorological Office records, for the ten years 1909 to 1918 the average annual rainfall was 117·36 in., the lowest for any one year being 100·97 in. and the highest 134·32 in. A detailed examination of these records shows that during this decade twice only was the monthly rainfall less than 2 in., while generally speaking the annual total was fairly evenly distributed over the twelve months, and no one month in the year showed usually a markedly less rainfall than any other. As a general rule, also, the Westland climate is characterized by the absence of dry winds. On the main mountain-ranges, which run more or less parallel with the coast, the rainfall is, of course, much heavier than at sea-level, this being especially so in the gorges and on the lower flanks of the ranges. For example, at Otira, at the western end of the tunnel which pierces the main divide, on the Midland Railway, lying at an altitude of 1,255 ft., the average rainfall for the five years 1914 to 1918 was 198·73 in.

On account of the wet climate and constantly high humidity the whole district from sea-coast to the mountain-ranges is covered with heavy forest, and the growth of ferns and other cryptogamic plants is luxuriant both epiphytically and on the floor. Tree-ferns, especially *Dicksonia squarrosa*, are abundant in the lowland forest and up to the bases of the mountains. Away from the coast *Metrosideros lucida* (the southern rata) is a common member of the forest, and its large much-branched and irregularly-growing trunks frequently show thick accumulations of epiphytic humus with colonies of Pteridophytes.

In the coastal forest *Tmesipteris* occurs abundantly on the stems of *Dicksonia*, being frequently accompanied in this station by *Lycopodium Billardieri* var. *gracile* and by the two filmy ferns *Hymenophyllum ferrugineum* and *Trichomanes venosum*. In this part of the district the mature plants of *Tmesipteris* also occur, but far less frequently, in the forks of large trees or even on the ground. Colonies of young plants can often be found on the tree-fern stems, the youngest plants being invariably at the uppermost limit of the colony. The most favourable place for the germination of the spores is clearly that part of the stem in which the bases of the frond-stipites are beginning to form a firm but not too dense substratum with an accumulating humus by the extension upwards of the tree-fern's clothing of aerial rootlets. As the *Dicksonia* grows in height the *Tmesipteris* plantlets extend upwards, those farther down the stem exhibiting progressively older stages of development. These are favourable places for finding prothalli, in some cases in relative abundance. I have dissected out from selected portions of tree-fern stems a total of considerably over one hundred prothalli. In this coastal forest, and even farther inland wherever *Dicksonia* occurs commonly, one can always be sure of obtaining the young plants and prothalli, although the work of dissecting them out from the tree-fern-stem surface is generally tedious and requires considerable care. Undoubtedly the easiest places in which to find the prothalli of *Tmesipteris* are the large overhanging trunks of the rata, where, as has been mentioned previously, humus frequently accumulates to a considerable depth on the upper sides of the trunks and lower limbs and in the crevices, within easy reach of the ground. Here colonies of large mature plants are to be met with, the humus being permeated with their rhizomes. The young plants, if present, occur quite indiscriminately, there being an absence of the useful grading which is invariably to be found on tree-fern stems, but with the different advantage that the humus lacks the irritating entanglement of tough aerial tree-fern rootlets and is easily crumbled down. I have found that *Tmesipteris* occurs in this station more particularly at middle altitudes in the district, on the lower parts of the mountain-flanks and in the valleys, where the rainfall is even heavier than at the sea-coast; and, although I have not often found large colonies of the young plants in these situations, I feel sure that a systematic investigation of these large overhanging tree-trunks would show that the plantlets occur not infrequently. From one particular rata in the valley of the Greenstone River, on the lower parts of the Hohonu Range, at an altitude of about 1,300 ft., I took home on each of three occasions a parcel of humus and secured altogether no less than 580 prothalli.

On the flanks of the ranges *Tmesipteris* is frequently to be met with growing in the thick humus on the forest-floor either as single plants or in colonies, although here, owing to the dense accumulation of undecayed vegetable debris, germination of the spores probably does not take place frequently.

The Prothallus.

I have already given (7) a fairly complete account of the form and structure of the prothallus and development of the sexual organs. As a result, however, of the study of the very large number of prothalli since discovered by me there are some additional facts to be noted.

Of the total number of prothalli found on the one rata, as mentioned in the previous section of this paper, about one hundred were quite young—that is, they were from 1 mm. to 2 mm. in length. A good many of these showed the original spore still attached. The youngest found was just under 1 mm. in length, and is shown in general view in fig. 1. It had developed no sexual organs. Its lower two-thirds was brown in colour, as also were the rhizoids, but the head was colourless. Throughout the brown region the cell-walls showed very distinctly, as is always the case in the *Tmesipteris* prothallus, while the cells themselves each contained a circular compact fungal skein. At the uppermost limit of the brown region, however, the fungal skeins were thin and delicate. The browning of the cell-walls extended slightly beyond the point reached by the fungus, and also a slight general tinge was beginning to show on the left side of the head. This brown or almost golden-yellow colour is characteristic of both young and old prothalli of *Tmesipteris*, except for the actual head, and it seems to arise very early in the development. Darnell-Smith (3, p. 86) notes that in *Psilotum* the first cells formed on germination of the spore are light brown in colour, and that the fungus begins to infect the prothallus at the three-cell stage. He also notes (*ibid.*, p. 88) that the small bulbils borne on the older prothalli are colourless in the early stages of growth, but later become brown. The cells of the head of the prothallus shown in fig. 1 were large and bulging, and contained much starch. There was no basal filament of a single cell in thickness, as is sometimes to be seen even in older prothalli (7, figs. 1, 11), but the prothallus began immediately from the spore to increase gradually in width by cell-multiplication. The fungus was present in the lowest cells of the prothallus and in the spore also. The basal region of another young prothallus with the spore attached is shown in fig. 2. The wall of the spore is thick, and its outer surface pimpled.

Older prothalli not infrequently show the basal end intact, and in some cases the spore can still be seen attached. Fig. 4 shows in general view

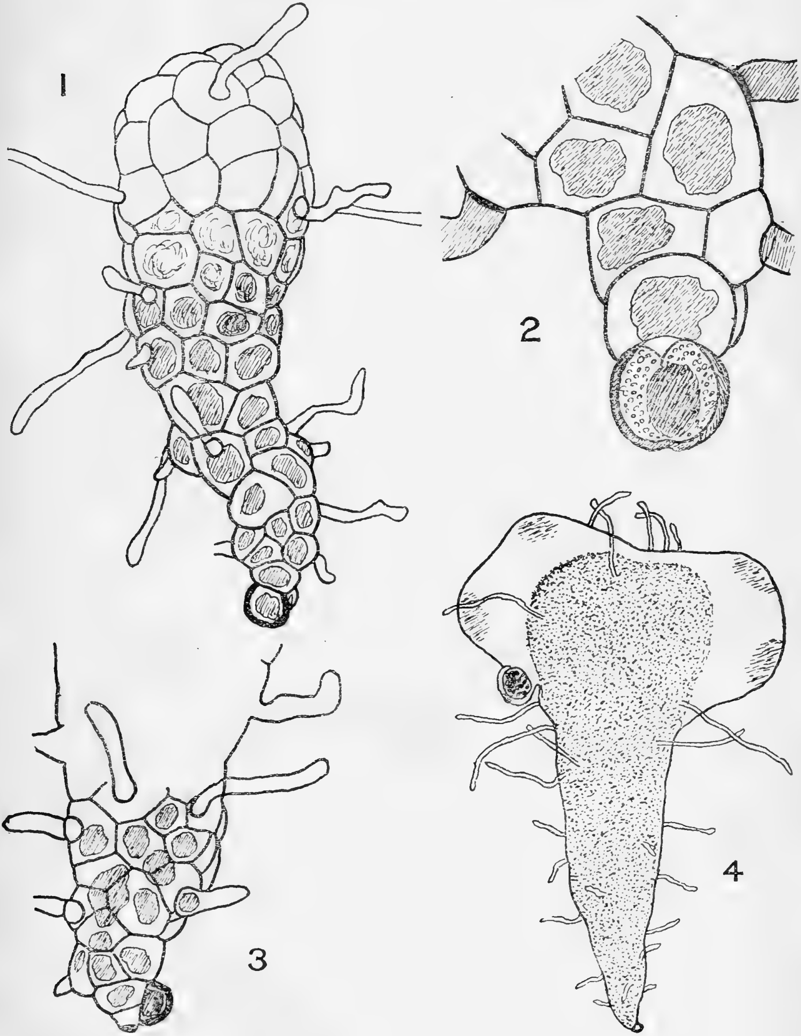

FIG. 1.—A very young complete prothallus in general view. × 110.
FIG. 2.—Basal end of a young prothallus in general view, showing the spore. × 270.
FIG. 3.—Basal end of the prothallus shown in fig. 4. × 110.
FIG. 4.—Medium-aged prothallus in general view, showing twofold forking of the head, and also the distribution of the fungus. × 35.

a medium-aged prothallus which is beginning to fork, and fig. 3 its basal end. Fig. 5 is a median longitudinal section of the lower regions of a still older prothallus, in which the gradual extension in width in a series of gentle swellings is clearly seen. The latter prothallus had preserved the unbranched carrot form unusually long (fig. 6), and was rather more attenuated in form than usual, but it illustrates well the manner in which the *Tmesipteris* prothallus always increases in girth. That shown in fig. 4 is more typical. In the latter the first forking of the head had already taken place, and the two large swollen apices were in the act of forking again. The shaded area in the main body shows the extent of the fungal distribution, the two apices being quite clear.

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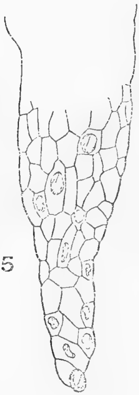
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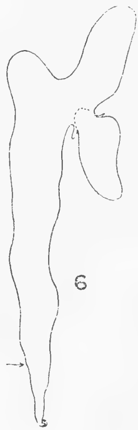


Fig. 5.—Longitudinal section of the basal end of the prothallus shown in fig. 6. × 63.

Fig. 6.—General longitudinal section of a prothallus, showing its gradual extension in width, and also an attached plantlet. × 12.

The prothalli vary a good deal in both length and thickness. Measurements of mature specimens showed variations in thickness from 0·3 mm. to 1·25 mm., and an extreme length of 18 mm. has been observed Generally speaking, it is the more attenuated prothalli which show the greater tendency to an extension in size by a second forking of the apices, the thicker individuals seldom appearing to fork more than once unless one of the first branches has ceased to grow. The stouter prothalli frequently possess much-swollen heads. The apex of the attenuated form was given in longitudinal section in my previous paper at fig. 21, while that of the stouter form is shown in the present paper in longitudinal section in fig. 7, and in transverse section in fig. 8. There is always a single apical cell of the same form as is found throughout the life of the sporophyte. I have found that serial sections of large thick prothalli may show the presence of several fertilized archegonia and very young developing embryos in close proximity to one another, but I have seldom found more than one plantlet attached to a single prothallus.

The close similarity in general appearance between the prothallus and the very young sporophyte must be noted. This, of course, arises mainly from the fact that the prothallus possesses an extended and branched chlorophyll-less body with a fairly regular radial growth, and that the young sporophyte consists at first of a simple branching rhizome devoid of appendages, both being brown in colour and covered with the same long brown rhizoids. It is sometimes quite impossible to be sure to which of the two a fragment belongs until it is closely examined under the microscope. This similarity is more marked in the case of *Tmesipteris* than in any other Pteridophyte. The young adventitiously-produced plantlet of *Psilotum* is also similar in appearance to the prothallus.

Some additional figures illustrating the development of the sexual organs are given in the present paper. That of the antheridium is easily followed (figs. 9 to 19). It begins at an early stage to project from the surface, and at the mature stage does so very strongly. The number of sperm-cells is much less than in either *Lycopodium* or in the Ophioglossaceae.

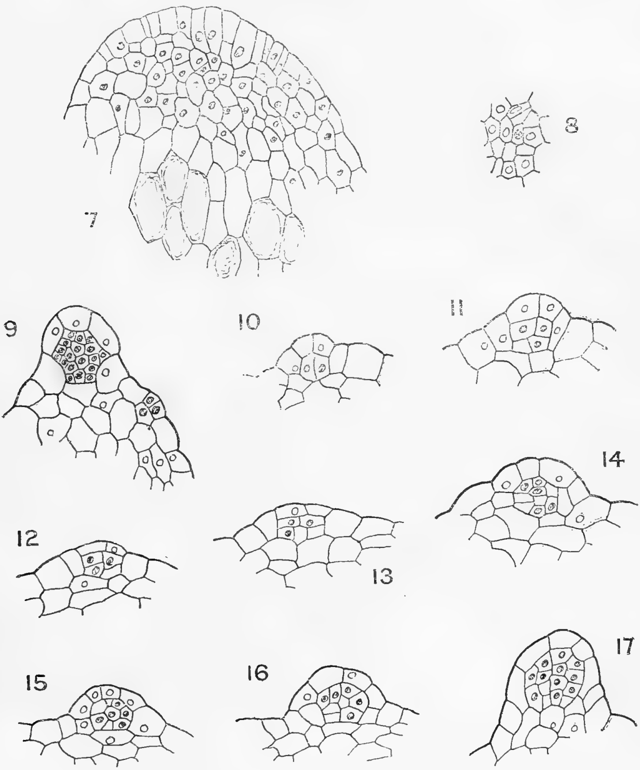


FIG. 7.—Longitudinal section of a stout apex of a prothallus, showing the apical cell. × 100.
FIG. 8.—Transverse section of a stout apex of a prothallus, showing the apical cell. × 100.
FIGS. 9–17.—Developmental series of antheridia in longitudinal section. × 100.

Spermatogenesis was not followed, but Lawson states that the spermatozoids of *Psilotum* are multiciliate (12, p. 105). Two additional figures illustrating the development of the archegonium are also given (figs. 20, 21). It is clear that there is here no basal cell. The demonstration of neck-canal cells and the ventral-canal cell which was left over from my previous paper I have not been able to determine satisfactorily. As with the antheridium, the archegonium projects strongly from the surface, practically only the venter being sunk.

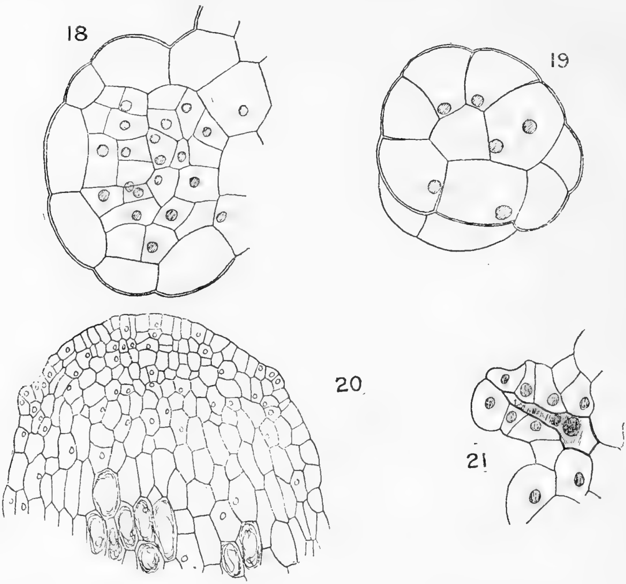


Fig. 18.—Transverse section of a large antheridium, showing the main divisions. × 250.
Fig. 19.—The same antheridium as in fig. 18, showing the opercular cell. × 250.
Fig. 20.—Longitudinal section of a stout apex of a prothallus, showing two young archegonia but not the apical cell. × 75.
Fig. 21.—Longitudinal section of a medium-aged archegonium. × 170.

Adventitious Prothallial Buds.

Three instances of portions of old prothalli bearing small adventitious buds were noticed. On one of these three young buds had been formed, these being shown in longitudinal section in figs. 22 to 24. Fig. 24 shows the actual apex of the bud marked X in fig. 23, from which it is clear that there is a single apical cell. On another fragment of an old prothallus three buds in different stages of development were found, one (fig. 25) being quite young, and the other two (figs. 26, 27) much older. The two latter became detached from the prothallus. Sexual organs were present on both these fragments, so that their prothallial nature is beyond question. The buds were in every case packed with starch, and fungal coils were present in the prothallial cells which immediately adjoined them. The buds arise from the superficial cell-layer of the prothallus, but it is not quite clear whether one or two of these cells are concerned in their formation. The sections shown in figs. 22 and 23 make it appear that the buds arise from two cells, but the bud shown in general view in fig. 26, judging from the old point of attachment at its base, seems to have arisen from a single cell. The two largest buds found (figs. 26, 27) were somewhat brown in colour in their lower portions, the cell-walls being strongly marked as in the case of prothalli formed from the spores. The cells in this region showed the presence of fungal coils. From fig. 22 it is clear that the fungus had infected this particular bud through a rhizoid Nothing was found to illustrate the further history of these structures.

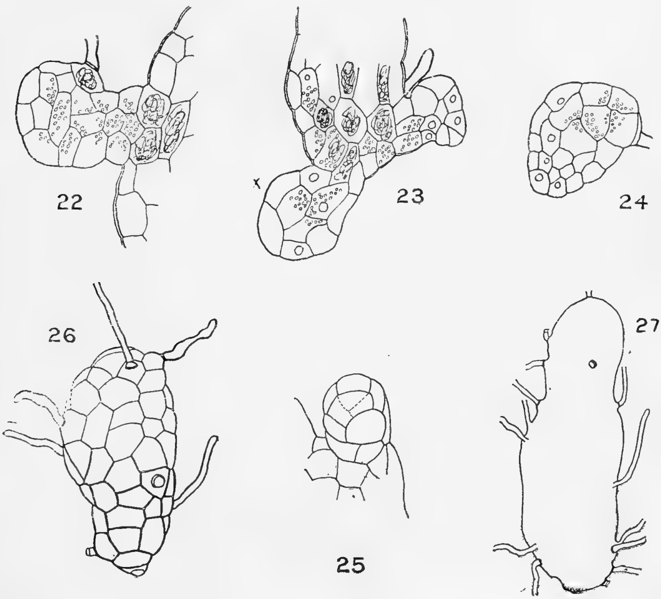


FIG. 22, 23.—Young prothallial adventitious buds in longitudinal section. × 75.
FIG. 24.—Longitudinal section of the bud marked X in fig. 23, showing its apical cell. × 75.
FIGS. 25–27.—Prothallial buds of different ages in general view. Fig. 25 × 75; fig. 26 × 44; fig. 27 × 30.

Darnell-Smith notes (3, p. 87) that the prothallus of *Psilotum* (presumably *P. triquetrum*) frequently bears small bulbils which are carried upon short stalks one cell in width. I have found on old rhizomes of *P. triquetrum* collected on the scoria islet of Rangitoto, Auckland Harbour, an abundance of the bulbils which were first described by Solms Laubach (14). But no corresponding structures have been observed on the rhizomes of *Tmesipteris,* so that it is interesting to find that the prothallus of the latter bears under certain conditions small superficial buds. The occurrence of adventitious buds in both generations of the Psilotaceae increases the similarity between them noted above.

The Embryo.

A. *General Observations.*

From the study of the limited number of embryos described in my former paper I drew the following conclusions. The first wall to be formed in the zygote, the basal wall, is transverse to the direction of the axis of the archegonium, and separates the embryo into its two main regions, the hypobasal (lower) region wholly giving rise to the foot, and the epibasal wholly to the shoot. There is no suspensor, cotyledon, or root. The superficial cells of the foot develop into haustorial protuberances. The initiation of an apical meristem in the shoot-region was not traced, although, judging from one particular embryo found, a single apical cell had apparently been set apart very early. The position of the second apex of growth in the young plantlet was described. I have since been able to study a much larger number of embryos, although the series is still not quite complete, lacking certain stages as seen in transverse section. The present study confirms my previous conclusions, and makes more clear the main segmentations of the embryo. It also determines the early initiation of the apical meristem in the shoot, as well as that of the latter's secondary apex of growth.

The majority of the large number of prothalli which I have examined in external appearance apparently bore no embryos at all. On the other hand, a few, and they almost always of the stouter type, showed the presence of several (Plate LXIII, fig. 1). A good number of very young embryos were found showing only the first one or two segmentations, some of the stouter prothalli bearing from two to five of these. In most instances a prothallus did not bear more than one developing embryo, although one or more undeveloped fertilized archegonia might be present. This condition of things may be compared with what I have found in the prothalli of those New Zealand species of *Lycopodium* which belong to the two large subterranean types. For example, one large prothallus of *L. fastigiatum*, which conforms to the *clavatum* type, bore no fewer than eleven young embryos as well as three young plants. This was, of course, an exceptionally large number, but many of the prothalli of *L. volubile*, *L. fastigiatum*, and *L. scariosum* which I have sectioned showed three or four developing embryos, and it is quite usual for these prothalli to be found with two or three well-grown young plantlets attached to them.

Generally speaking, all stages in embryo development except the very youngest can be detected in external examination. The two general features which make them thus apparent are, firstly, a superficial localized swelling of the prothallial tissue, and, secondly, the presence of an old archegonium neck at the apex of this swelling. These were what one always looked for. In the case of fairly well advanced embryos, which, however, had not as yet ruptured the prothallial tissues, the interior of this swollen region always appeared somewhat darker than the surrounding tissues.

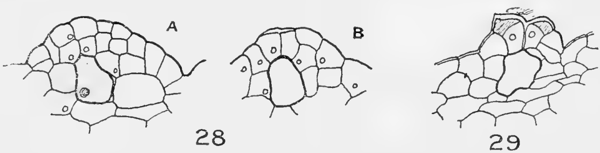
It may be as well to state at once the most prominent features in the embryo of *Tmesipteris*. These are, firstly, the basal wall, which can clearly be traced throughout the whole development until the young sporophyte becomes detached (the plantlet usually detaching itself here, leaving its foot embedded in the prothallial tissues); secondly, the superficial swelling of the prothallial tissues around the embryo, together with the repeated transverse divisions of the large prothallus-cells lying immediately interior to the foot (the browned "cup" being an outstanding feature on the prothallus-surface at an old point of attachment of a plantlet); thirdly, the haustorial protuberances from the foot into the tissues of the prothallus; fourthly, the presence of a single large apical cell in the outer, or shoot, region, in some cases a second apical cell being set apart in the other outer quadrant; and, lastly, the *Tmesipteris* embryo, when compared with those of other Pteridophytes, shows the important feature of the absence of suspensor, cotyledon, and root organs.

The hypobasal region of the very young embryo curves somewhat as it develops, so that frequently a single longitudinal section does not show both foot and shoot cut truly medianly. On this account, in illustrating some of the embryos on which my description is based, I have thought it advisable to show a series of several consecutive sections. Unless otherwise indicated, a series so illustrated always consists of consecutive sections. Again, in the epibasal region the apical cell never seems to be in the line of the archegonium-axis, so that the young shoot-apex bursts out from the tissues of the prothallus inclined at a greater or less angle, which, moreover, is not infrequently out of the plane in which the prothallus-limb lies. Hence in longitudinal section the apical cell is sometimes cut slightly obliquely.

In several cases developing embryos were seen on sectioning to be browned, the nuclei being small and the cell-walls more or less distorted. This would seem to have been due not to anything in the preparation of the material for embedding in paraffin, but to the previous death of the embryo.

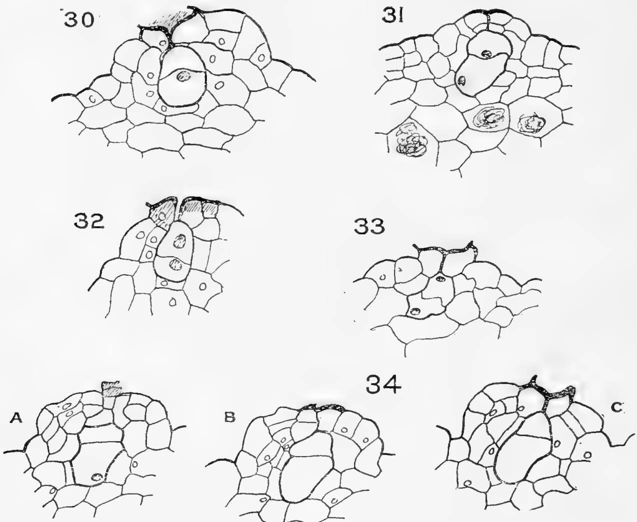
B. *First Segmentations.*

In my earlier paper I described and figured several very young embryos (7, figs. 52 to 57), noting (p. 22) that the first wall to be formed divides the embryo into lower and upper regions, and that the next division is in the hypobasal cell by a wall leading at an angle from the basal wall into the lower end. The exact sequence of the subsequent segmentations was not demonstrated, although from the figures and from the further study of the same embryos it would appear that an inclined wall is formed also in the epibasal cell, the embryo thus attaining a quadrant stage. From the present study, also, this seems to be the normal sequence of segmentation, although several abnormal cases will be described.



FIGS. 28A, 28B, 29.—Two fertilized egg-cells in longitudinal section. × 100.

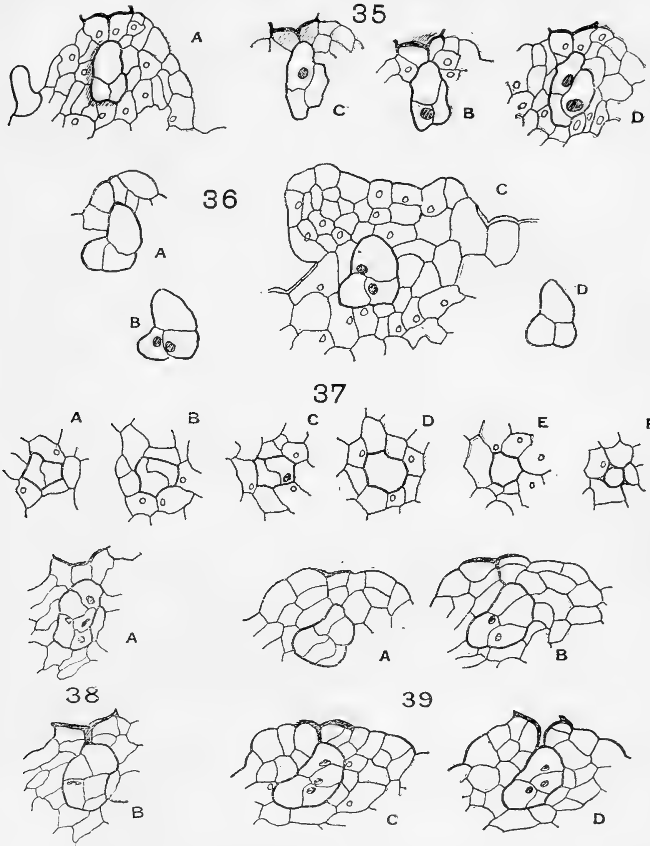
The fertilized egg-cell at once grows considerably in size. A good many instances of this condition were observed, two of which are shown in longitudinal section in figs. 28A, 28B, and 29. The former of these was cut a little obliquely, but from fig. 28A it is apparent that cell-divisions in the surrounding prothallial tissue begin immediately. A considerable number of embryos showing the first segmentation only were found (figs. 30 to 34 A–C. The basal wall is always transverse, and divides the fertilized egg into two more or less equal portions. I have never found any variation from this. The surrounding prothallial tissue at this stage projects considerably (fig. 34), so that it is possible sometimes to detect these young stages in an external examination of the prothallus (see Plate LXIII, fig. 1). Following this, there is formed in the inner or hypobasal cell an inclined wall leading from the basal wall down towards the lower end of the embryo and dividing the hypobasal portion into two somewhat unequal quadrants. This stage is shown in longitudinal section in the series given in figs. 35A to 35D and figs. 36A to 36D, and in transverse section in the series figs. 37A to 37F. Next, a similarly inclined wall leads off from the basal wall towards the upper end of the epibasal cell, though not into



FIGS. 30–34.—Five young embryos in longitudinal section, showing first division-wall only. The series 34A to 34C consists of consecutive sections, as in all series of sections illustrated in this paper unless otherwise stated. × 100.

the actual "beak," the embryo thus attaining the complete quadrant stage. This is shown in longitudinal section in the two series figs. 38A and 38B, and figs. 39A to 39D, and in obliquely transverse section in the series figs. 40A to 40G. This sequence in segmentation seems to be the normal rule, so that before referring to the abnormal cases met with I will describe the subsequent cell-divisions which lead up to the setting apart of an apical cell in the epibasal region.

I have not found a sufficient number of young embryos cut transversely to determine whether or not there is normally a regular octant formation, but judging from the embryo cut obliquely transverse and illustrated in the series figs. 41A to 41G, and from others also, I should say not. In this case in the lower portion of the hypobasal region the first inclined wall is alone present (figs. 41A to 41C). The section marked D probably also represents the embryo in section below the basal wall, showing a wall in each of the hypobasal quadrants which has led off from

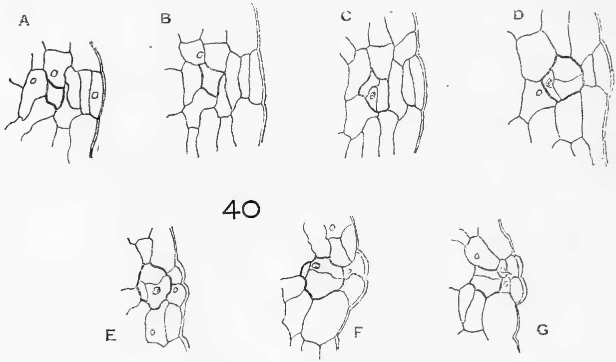


FIGS. 35A–35D, 36A–36D.—Two young embryos in longitudinal section, showing basal wall and also first hypobasal wall. × 100.

FIGS. 37A–37F.—A young embryo in transverse section from below upwards, showing first hypobasal wall. × 100.

FIGS. 38A, 38B, 39A–39D.—Two young embryos in longitudinal section, showing basal wall and also first epibasal and hypobasal walls. × 100.

the first inclined wall. In the epibasal region also (figs. 41E, 41F) the segmentation is not octant-wise. Figs. 42A and 42B show a slightly older embryo in longitudinal section, in which a regular segmentation of the quadrants in both epibasal and hypobasal regions has proceeded. Those illustrated in figs. 54 to 57 of my previous paper correspond fairly closely with this. The first inclined walls in both main regions of the embryo shown longitudinally in figs. 43A to 43E are apparent, but the subsequent segmentation has followed a somewhat unusual course.



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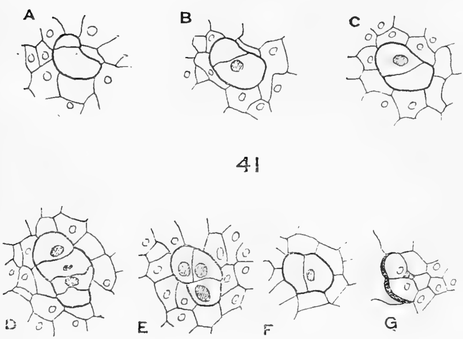

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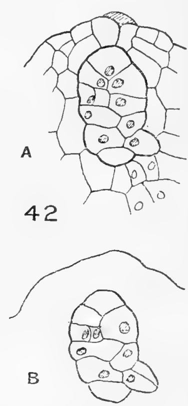

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FIGS. 40A–40G.—Young embryo in oblique transverse section from below upwards at a similar stage of development to those shown in figs. 38 and 39. × 100.

FIGS. 41A–41G.—Young embryo in oblique transverse section, illustrating absence of octant walls. × 100.

FIGS. 42A, 42B.—Young embryo in longitudinal section, showing first segmentations of the epibasal and hypobasal quadrants. × 100.

Abnormally segmented embryos are set forth in figs. 44A to 44C, 45A to 45F, and 46A to 46D. In each of these the basal wall is clearly to be distinguished, and also the first inclined wall in the hypobasal half, but in the two last-mentioned embryos the segmentation in the epibasal half is rather difficult to interpret. In that shown in figs. 44A to 44D a single

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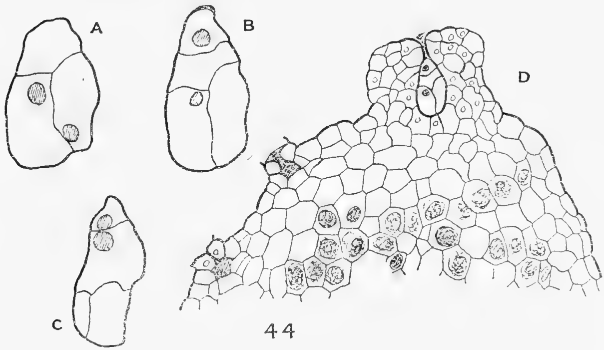

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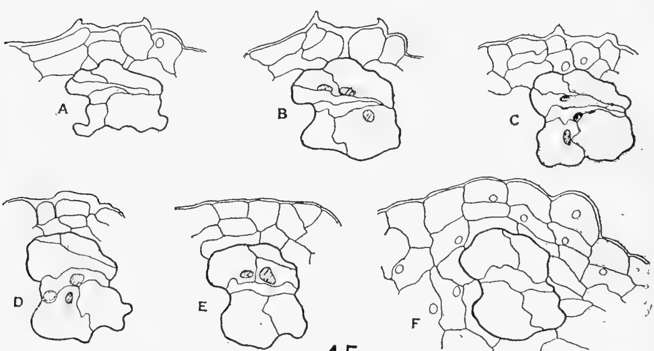

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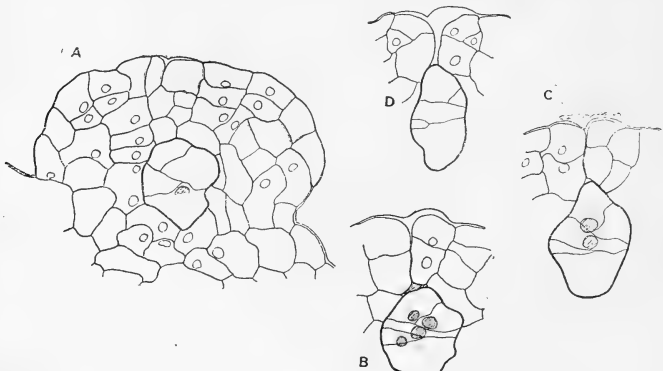
FIGS. 43A–43E.—Young embryo in longitudinal section, showing irregular segmentation of epibasal and hypobasal quadrants. × 135.

FIGS. 44A–44D.—Young embryo in longitudinal section, showing abnormal segmentation. In that marked D the transverse section of the prothallus is shown at the point where the embryo was borne. A to C × 180; D × 66.

FIGS. 45A–45F.—Young embryo in longitudinal section, showing abnormal segmentation. × 135.

division of the epibasal half has taken place by a wall which, instead of being inclined to the basal wall, is parallel to it. The uppermost cell thus has almost the appearance of a suspensor, but comparison with other embryos shows that this cannot be its nature. Fig. 44D represents a transverse section of the parent prothallus at the point at which this embryo was borne, and it will be seen that the prothallial tissues protrude here rather more than usual. Possibly the embryo has been stimulated by this to a rapid elongation. In the other two abnormal cases mentioned the archegonial neck appears towards the end of each series, so that the sections must be considered more or less obliquely longitudinal. In the case of that shown in figs. 45A to 45F there seem to be two inclined walls leading off at very slight angles from the basal wall into the epibasal region, and along with this it must be noticed that the embryo is squat in form. It was situated well up the prothallial protuberance which surrounded the foot of a well-grown plant, where the cells, although not compressed, were



FIGS. 46A–46D.—Young embryo in longitudinal section, showing abnormal segmentation. × 135.

yet all much extended in a horizontal direction. I would suggest that the extension of the young embryo in this direction had caused it to repeat the formation of the epibasal inclined wall. In the third of these abnormal cases (figs. 46A to 46D) it will be seen by reading the series from the last section backwards that the first-formed epibasal wall approaches the basal wall and presumably joins it before the section marked A is reached. Here too, then, it is apparent that this wall is inclined at an unusually slight angle, as is also that in the hypobasal region. These were the only abnormally segmented embryos observed.

C. *Initiation of the Shoot Apex.*

An apical cell is set apart comparatively early in one of the epibasal quadrants, and from this the shoot-apex is formed. In my earlier paper I noted that an apical cell was probably already present in the young embryo shown there in figs. 55 and 56, and a re-examination of these sections in the light of my subsequent studies confirms this belief. The

FIG. 1.

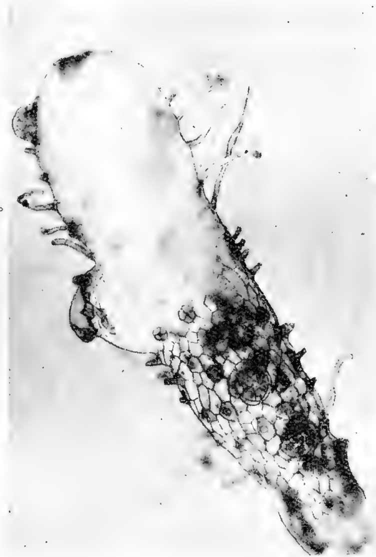


FIG. 2.

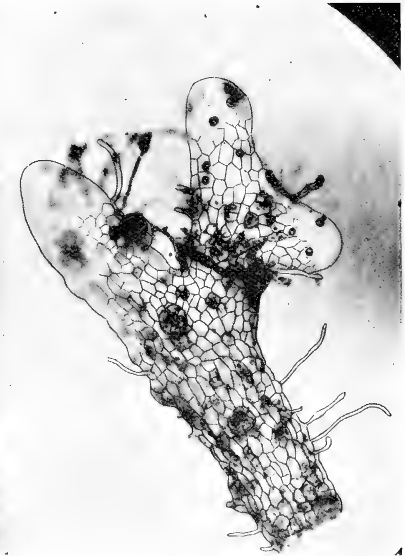


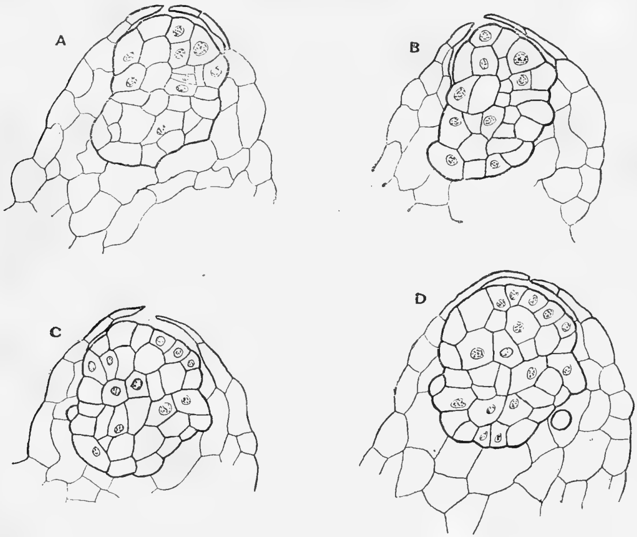
FIG. 3.

FIG. 1.—*Tmesipteris:* Photograph of a portion of a prothallus showing a protruding embryo and also two very young embryo protuberances at A and B. That at B contains two young embryos.

FIG. 2.—*Tmesipteris:* Photograph of the forward end of a prothallus, showing an embryo bursting through the prothallial tissues.

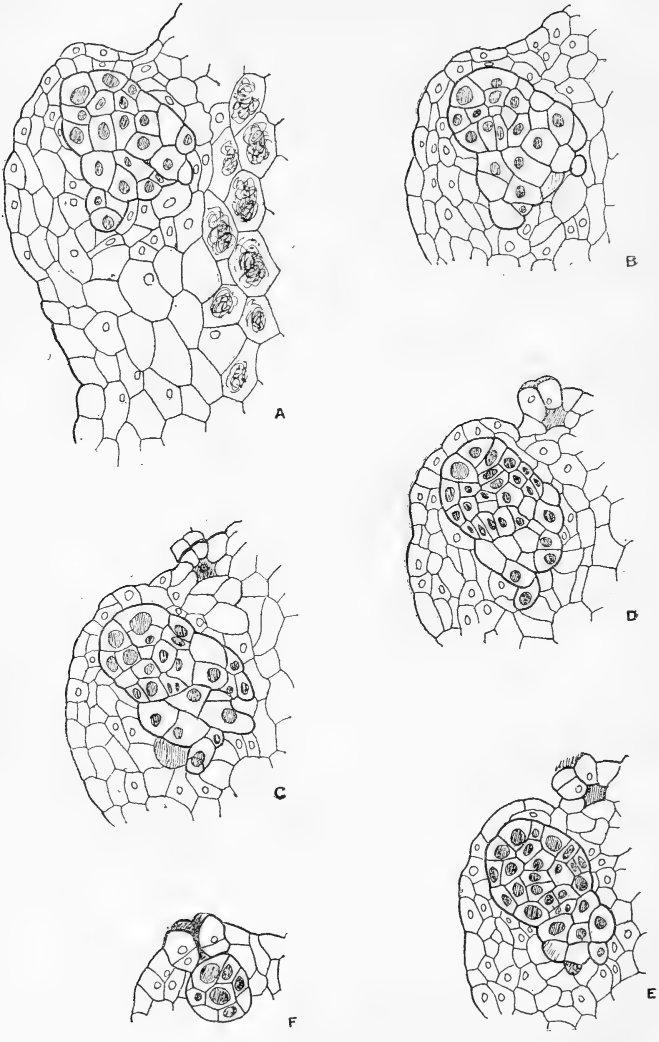
FIG. 3.—*Tmesipteris:* Photograph of the forward end of a prothallus, showing a young attached plantlet with two apices of growth.

young embryo figured in longitudinal section in the present paper in the series figs. 47A to 47D possesses an apical cell from which segments have apparently already been cut off. In the series figs. 48A to 48F another embryo, at a slightly older stage of development, is given in longitudinal section which apparently possesses two apical cells, one in each epibasal quadrant. In these early stages it is not clear whether or not the cells alongside the apicals have actually been cut off from them as segments or have arisen simply by the general segmentation of the quadrants. In those figured the former seems to be the case, and the apicals are strongly defined. Until the shoot has reached the size when the overlying prothallial tissues are ruptured, the apical cell usually cuts off more segments towards the base than towards the apex of the embryo. That illustrated



FIGS. 47A–47D.—Embryo in longitudinal section, showing initiation of the apical cell and also the main divisions. × 100.

in fig. 48 is not cut medianly for foot and shoot together. The full size of the former appears at the beginning of the series, but of the latter in the sections marked D and E. The section F, which shows the neck of the archegonium, lies five sections beyond that marked E. In fig. 49 another embryo is shown in which the single apical cell has been functioning for only a short time. The position of this embryo in the transverse section of its parent prothallus is shown in fig. 50. A median longitudinal section of another such embryo, with the foot rather more developed, is given in fig. 51. In all these the basal wall and the first inclined walls in both epibasal and hypobasal regions can be distinguished. They illustrate also the beginning of the outgrowth of the superficial cells of the foot, and in fig. 49 the cell-divisions in the prothallial tissue abutting on the foot can be well seen.



FIGS. 48A–48F.—Embryo in obliquely longitudinal section, showing two apical cells The section marked F is the fifth beyond that marked E. × 100.

Three obliquely transverse sections through the shoot region—the third, sixth, and ninth respectively from the one which first touches the top of the embryo—are shown in figs. 52A to 52C. The apical cell appears in

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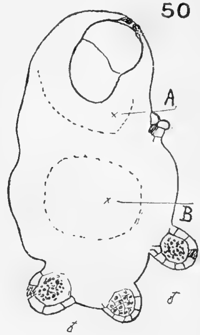

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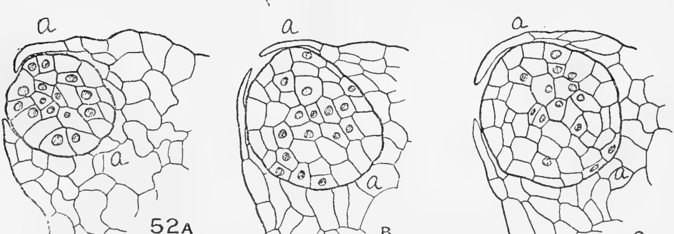

52A B C

FIG. 49.—Embryo in longitudinal section, showing the apical cell and the main divisions. × 100.

FIG. 50.—Transverse section of the prothallus, giving the position of the embryo shown in fig. 49. A is the area in which rapid cell-division is taking place, and B is the fungal area. × 40.

FIG. 51.—Embryo in longitudinal section, showing apical cell and main divisions. × 100.

FIGS. 52A–52C.—Three obliquely transverse sections from above downwards (Nos. 3, 6, and 9) through the epibasal region of an embryo. × 100.

that marked A. What is probably the first inclined division in the epibasal region appears in all three sections at *aa*, but an intersecting octant wall could not be traced throughout the series.

Two browned and probably dead embryos are illustrated in longitudinal section in figs. 53 and 54. In neither does the apical cell appear, but the main basal wall is obvious. The foot of that shown in fig. 54 had grown considerably.

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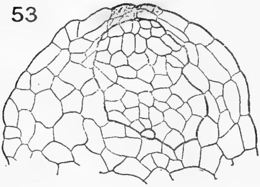

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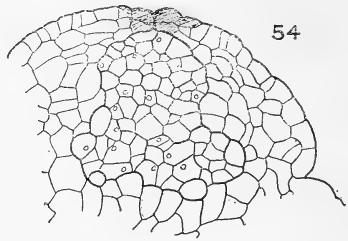

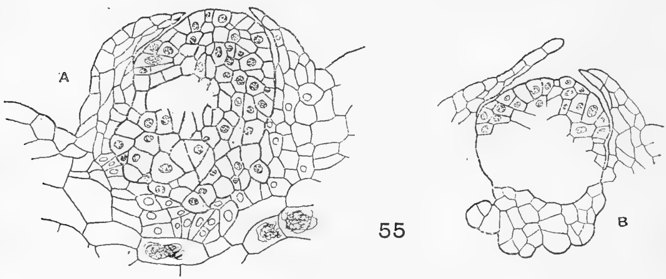

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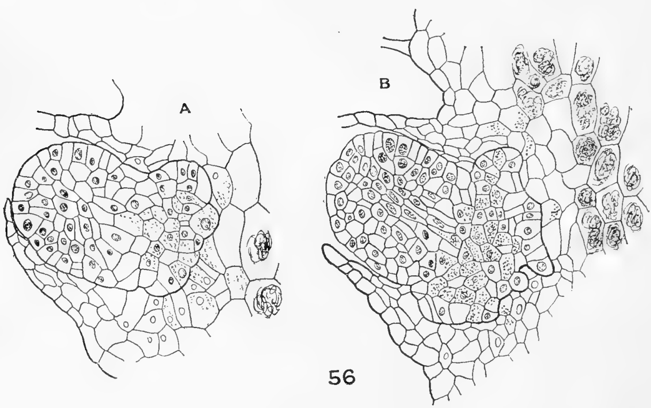

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Figs. 53, 54.—Two browned and dead embryos in longitudinal section, showing the main basal wall but not the apical cell. × 75.

Figs. 55a, 55b.—Embryo in longitudinal section, showing two apical cells in the shoot-region. A and B are not consecutive sections. × 75.

Figs. 56a, 56b.—Embryo in longitudinal section, showing two apical cells in the shoot-region. The sections A and B are not consecutive. × 75.

Not infrequently two apical cells, one in each epibasal quadrant, are set apart more or less simultaneously at an early stage. The youngest embryo which showed this feature is that in fig. 48, the apicals lying alongside one another at the apex of the shoot, separated only by the quadrant wall. Three other embryos, at rather older stages of development, which possess two apicals, are shown in figs. 55A and 55B, 56A and 56B, and 57A and 57B. While at first segments are cut off from the apicals rather towards the base of the embryo than outwards, all-round segmentation soon begins, and they become more widely separated, inclining from one another, as in the figures, at an obtuse angle, or even eventually in exactly opposite directions. In the *Tmesipteris* embryo the apical cells are always large and are readily observed, the regular arrangement of cells cut off from them being also a distinguishable feature. The growth of the young shoot from two similar apices will be dealt with in the next section of this paper, but the fact that the two apices are sometimes present together in the young embryo is noteworthy.

When only one shoot-apex is present a certain amount of cell-division takes place in the other quadrant until the young apex has actually burst through the prothallial tissue. The second quadrant thus forms a smooth rounded base to the shoot proper, consisting eventually of a uniform tissue of large-sized cells in which the symbiotic fungal coils early establish themselves. Before it emerges from the surface of the prothallus the shoot is more or less globular in shape, but the apex or apices soon become beak-like in form (Plate LXIII, fig. 2, and fig. 58A). A strand of elongated and narrow conducting-elements is early differentiated at the centre of the epibasal region by the longitudinal division of the cells there situated (figs. 56A, 56B, 57A, 57B). As the apex grows forward these narrow elements curve round and lead up behind it, extending back almost to the main basal wall. When there are two apices present the two strands both lead down in this way towards the foot. The haustorial protuberances early arise all over the foot-surface by the outward growth of its superficial cells, and the foot as a whole sometimes assumes a very irregular shape (figs. 54, 56A, 56B, 57A, 57B). The full development of these outgrowths is not attained until the young plantlet has become well advanced. Starch is often present in the foot and central cells of the embryo in large quantities, and in the cells of the prothallus also which lie adjacent to the foot (figs. 56A, 56B). On account of the rapid cell-divisions, and also of the large size of the nuclei in the upper region of the young embryo, mitotic figures can often be seen here to great advantage.

The Young Sporophyte.

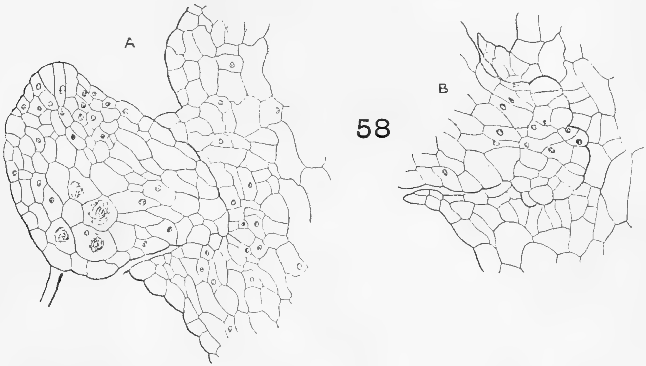
A. *The Rhizome.*

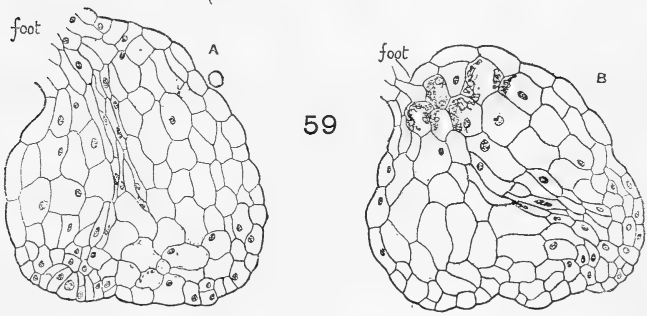
The forward growth of the young plantlet after it has emerged from the prothallial tissues is illustrated in figs. 58A, 59A, and 59B. In the former of these there is only one apex, and on account of its lower part not being cut medianly the conducting-strand does not appear. In the latter there are two equally-developed apices of growth, each with its conducting-strand. This plantlet had become detached from its prothallus. It may be compared with that shown in fig. 65 in my previous paper. Although for a considerable time the young plant is dependent upon its parent prothallus for the main food-supply, as evidenced by the continued extension of the haustorial outgrowths of the foot and the presence of

Figs. 57a, 57b.—Embryo in longitudinal section, showing two apical cells in the shoot-region. The sections A and B are not consecutive. × 100.

starch in and around them, it early forms rhizoids and shows the presence of the fungal coils in its cells. The largest of the embryos borne on the prothallus shown in Plate LXIII, fig. 1, may be compared with that in figs. 58A and 58B.

Young plants up to 4 mm. in length may frequently be found in which growth is taking place from only one apex. The base of the young stem is smooth and round, and in longitudinal section is seen to consist of

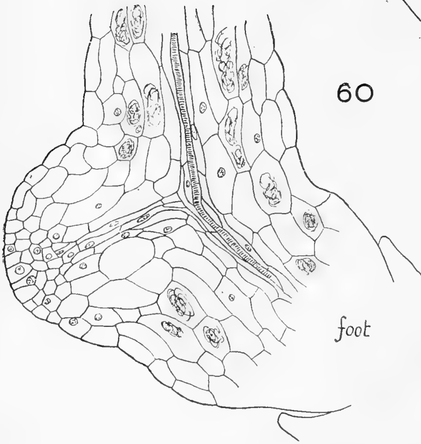


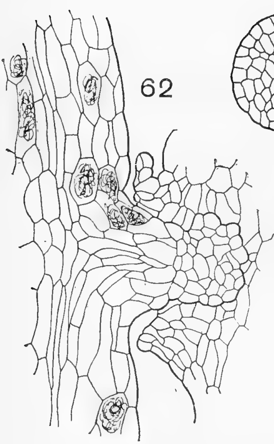


FIGS. 58A, 58B.—A protruding embryo in longitudinal section, showing the beak-like apex, and also the presence of the endophytic fungus. The sections A and B are not consecutive. × 75.

FIGS. 59A, 59B.—A very young detached prothallial plantlet in longitudinal section, showing two apices, each with its conducting-strand. The sections A and B are not consecutive. × 75.

a uniform tissue. There is no undeveloped apex present at this point. Two such plantlets are figured in my earlier paper (7, figs. 60, 67), and those shown at figs. 74 and 77 in the present paper will serve to illustrate the same point. In the majority of cases when the second apex of growth is formed in such plantlets it arises at the base of the first in just the position it would occupy if it had been initiated in the second epibasal quadrant of the young embryo. This second apex is inclined at a varying





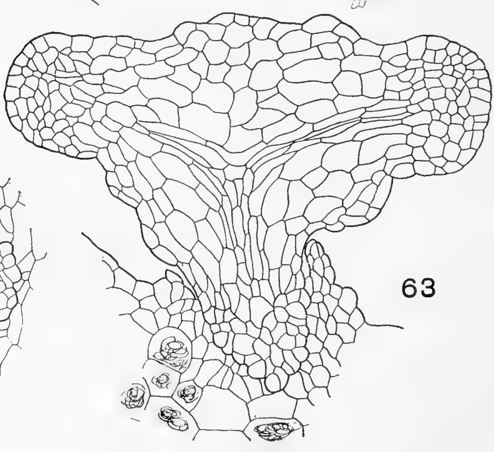


Fig. 60.—The base of a young prothallial plantlet in longitudinal section, showing an early stage in the development of a secondary apex. × 75.

Fig. 61.—A young prothallial plantlet in longitudinal section, showing the secondary apex in an unusual position. × 45.

Figs. 62, 63.—Two young prothallial plantlets in longitudinal section, showing two equally-developed shoot-regions. × 55.

angle to the primary shoot, being sometimes almost in a straight line with it (figs. 73, 76, 78, 81, 83). Comparison may be made with those illustrated in my other paper in figs. 68, 69, and 71. I have not observed the actual initiation of this secondary apex when thus late developed, but fig. 60 represents an early stage. It is, of course, adventitious in origin, and, judging from what takes place in the case of the origin of lateral adventitious shoots on both old and young rhizomes, an apical cell is cut out from one of the surface cells while at the same time the inner cells lying between this and the vascular strand of the primary shoot divide longitudinally to form conducting-elements. I have observed a few instances out of the large number of plantlets examined in which the

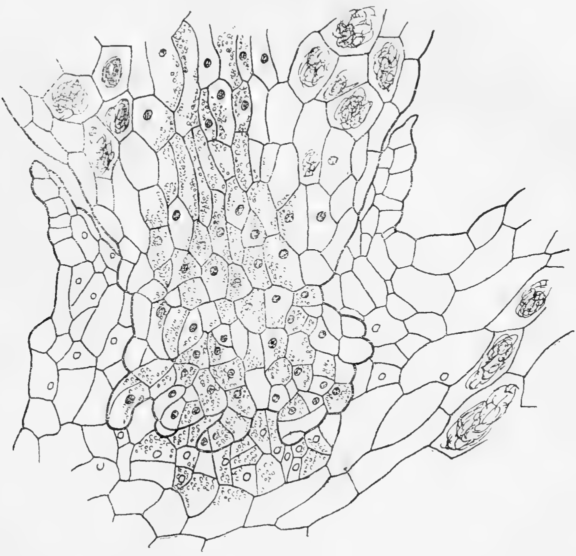
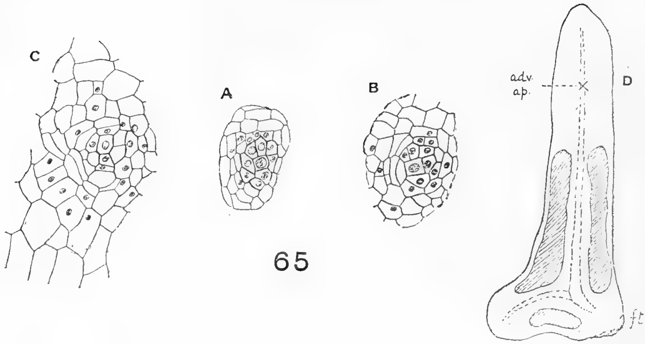
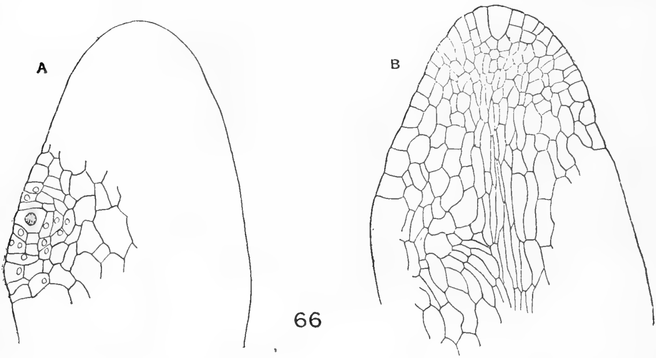
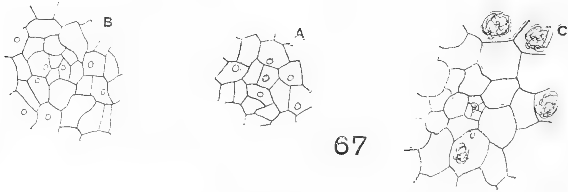


FIG. 64.—The point of attachment of the young prothallial plantlet shown in Plate LXIII, fig. 3, in longitudinal section, showing foot, basal wall, and accumulation of starch. × 100.

secondary apex was not situated at the base of the primary stem, but much higher up. One such plantlet is shown in fig. 61 in longitudinal section. In this the appearance is rather as if there had been a dichotomy of the apex. However, I have never come across an undoubted instance of such dichotomy in a young rhizome, although it may be seen in older rhizomes. Plantlets in which two primary apices of growth are present are shown in longitudinal section in figs. 62, and 63, and in general view in Plate LXIII, fig. 3, and in figs. 75 and 83. A corresponding instance was given in my previous paper (fig. 70). Fig. 64 is a longitudinal section of the point of attachment of the young plant shown in Plate LXIII, fig. 3.







FIGS. 65A–65C.—The young lateral adventitious apex shown in fig. 65D in three transverse sections from the apex downwards (Nos. 1, 2, and 5). × 75.

FIG. 65D.—Outline of a young prothallial plantlet in longitudinal section, showing the first and second apices of growth, foot, distribution of fungus, and the position of a lateral adventitious apex. × 20.

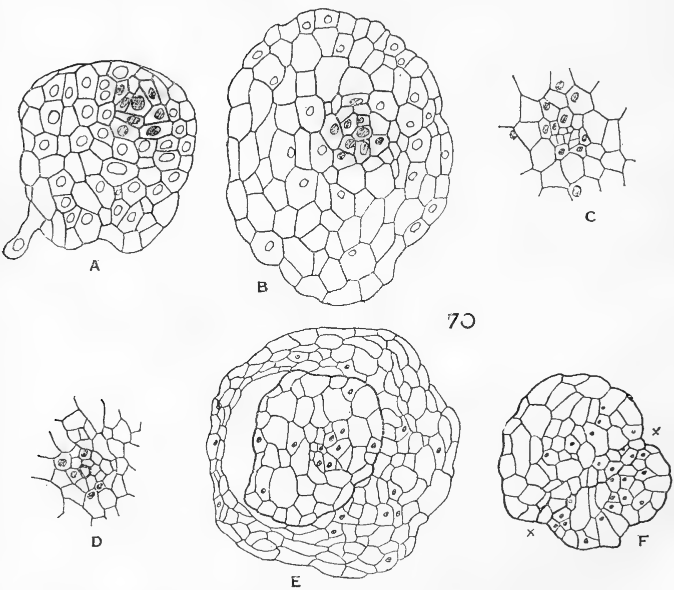
FIGS. 66A, 66B.—The apical region of a young prothallial plantlet in longitudinal section, showing a very young lateral apex cut obliquely. The sections A and B are not consecutive. × 75.

FIGS. 67A–67C.—A very young lateral adventitious apex in three transverse sections from the apex downwards (Nos. 1, 7, and 12). × 75.

Adventitious branches are a well-known feature in older rhizomes of *Tmesipteris*, where they sometimes apparently function as storage-tubers before developing further. Laterally-developed adventitious apices may be found also in quite young plantlets (figs. 74, 75, 81). One such was present at the point indicated on the plantlet shown in longitudinal section in fig. 65D. It projected very slightly above the surface of the main stem, and is shown in transverse section in figs. 65A, 65B, and 65C, which represent the first, second, and fifth sections passing through it. A slight strand of narrow elements led from behind it to join the strand of the main shoot. Another young adventitious apex occurring in a similar position is shown in figs. 66A and 66B. In the section marked B the apex and strand of the main shoot is cut longitudinally, but the adventitious apex and its strand does not lie quite in the same plane. The apical cell of the latter appears in the seventh section from B, and is shown cut obliquely at A. In figs. 67A and 67B a very young lateral apex is shown cut transversely. The section marked A passes through the apical cell. This has evidently been functioning for some time, judging by the arrangement of the cells in B, which lies six sections below A. Deeper down towards the main strand, however, the adventitious strand has the appearance, as seen in C, as if it had arisen not from the apical cell, but by the subdivision of an ordinary cortical cell of the main shoot. Sometimes a plantlet will show a third apex of growth at its base in close proximity to the second apex, as illustrated in longitudinal section in fig. 68. Here the main strand has been cut obliquely transverse, since the foot into which it leads lies in a plane at right angles to the direction of growth of the two young apices. The latter also are not cut medianly throughout their length, so that the course of their strands is not included in the figure. A plantlet in a similar condition is also shown in general view at fig. 79. One very young plantlet (figs. 69A, 69B, 69C) was found on sectioning to have three apices. Two of these—namely, B and C—had given rise to well-defined strands, and had probably been initiated in the embryo. The third, shown at A, had given rise as yet to no strand, and lay rather out of the plane of the other two, as can be seen from the fact that this section does not include the foot. It must probably be interpreted as an adventitiously-formed apex rather than as one which had arisen in the embryo.

FIG. 68.—A young prothallial plantlet in longitudinal section, showing the primary apex and also two apices at the base of the plantlet. × 45.

The apical cell of the main shoot in the young subterranean plantlet, and its manner of segmentation, is shown in longitudinal section at fig. 71. A series of transverse sections taken at intervals from apex to foot through a young plant of about the same age as that shown at Plate LXIII, fig. 3,



FIGS. 69A–69C.—A very young attached prothallial plantlet in longitudinal section, showing three apices of growth, two of which possessed conducting-strands. Sections B and C are respectively the tenth and fifteenth from A. × 47.

FIGS. 70A–70F.—A young prothallial plantlet in six transverse sections taken at different points from the apex downwards to the foot. A to D × 100; E and F × 80.

is given in figs. 70A to 70F. The section marked A passes through the apical cell of the shoot, and shows that it segments regularly from four sides. B, C, and D show the differentiation of the strand in progressively older regions of the shoot. Section E is taken at a point a little above the main basal wall, and shows the narrow conducting-elements which lead down

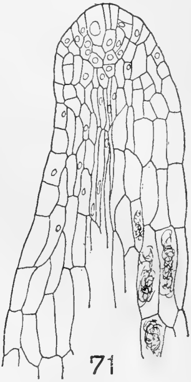


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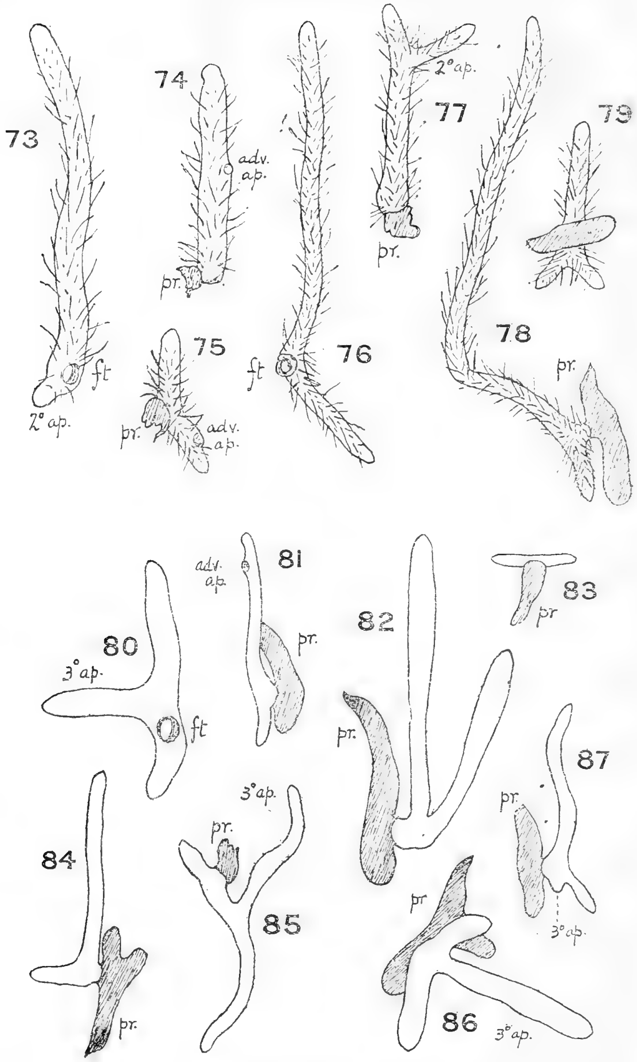
FIG. 71.—The apex of a young prothallial plantlet in longitudinal section, showing the apical cell and its segmentation. × 75.

FIG. 72.—The point of attachment of a young plantlet to the prothallus, showing unusually long intraprothallial shoot-region. The extra-prothallial shoot-region is cut obliquely. × 80.

to it from the shoot. Section F shows the foot in transverse section a little below the basal wall, the original first inclined wall in the hypobasal region of the embryo being still very evident. The haustorial outgrowths from the foot of a well-grown plantlet are illustrated in my previous paper at Plates II and III and figs. 58 and 59, the main basal wall appearing in the latter figure. In fig. 72 in the present paper is shown a young plantlet



Figs. 73–87.—Young subterranean plantlets in general view, showing variations in form. *pr.* = prothallus; *ft.* = foot; *adv. ap.* = lateral adventitious apex. All × 6.

in longitudinal section, in which that part of the epibasal region contained within the prothallial tissues was of unusual length. The extra-prothallial shoot-region is cut somewhat obliquely, so that the course of the strand becomes lost.

From the above account it will be seen that the young sporophyte of *Tmesipteris*, before the development of the aerial shoot, shows variations in form. A number are given in figs. 73 to 87, and with these can be compared others illustrated in my previous paper at figs. 66 to 72. The development of a third apex of growth has given an irregular form to those shown at figs. 80, 85, 86, and 87. In the plantlet at fig. 82 probably the longer of the two branches was the one secondarily developed, and it here occupies an unusual position. Some of these figures show that the plantlet may attain a considerable size while still attached to its prothallus. When detached they generally show a fragment of old prothallial tissue still attached to the foot, frequently in the form of a dark ring. The plantlet apparently becomes detached from the prothallus at the basal wall, and sections through a prothallus at an old point of attachment invariably show the whole foot of the plant still embedded in its tissues.

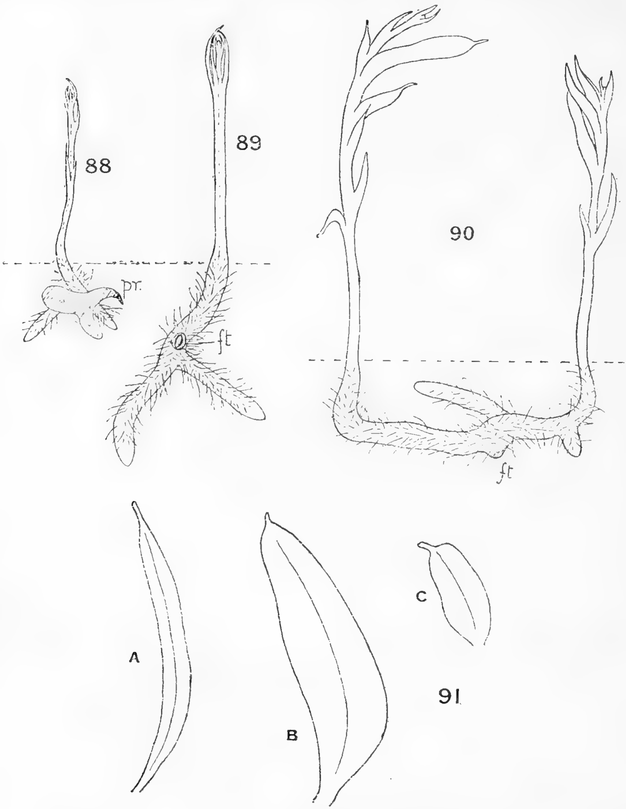
It may be stated here that throughout the life of the sporophyte no indications are to be met with of the adoption of any special root-like function on the part of any of the branches of the rhizome. These branches are all similar to one another in both external appearance and internal structure.

B. *The Aerial Shoot.*

The young wholly-subterranean plantlet frequently attains a length of $\frac{1}{2}$ in. to $\frac{3}{4}$ in. before forming an aerial branch. Generally one of the two main growing apices turns up out of the soil, the other continuing to extend in the humus (figs. 88, 89). In some cases both ends may grow out into aerial shoots (fig. 90, and 7, fig. 73), the rhizome-system then extending by the formation of lateral branches. Again, in other instances, the first aerial branch arises laterally, the main apices of the rhizome continuing underground (7, fig. 5).

The aerial shoot is much thinner than the rhizome, and is at first quite scaleless and leafless. Usually when the shoot is from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. high, leafy outgrowths are formed immediately behind the apex, but these form only scale leaves. The first aerial shoot generally does not grow more than 1 in. or 2 in. in height, and remains very slender and sterile, withering off when other shoots are formed. Frequently the second may do the same; but those next formed are much longer, although still slender. The mature well-grown shoots are to be found only when the rhizome-system has become strongly developed. In most cases aerial shoots remain unbranched, but a single forking sometimes takes place at or near the base, or occasionally, in well-grown pendulous branches, even higher up.

At the base of well-grown aerial shoots there is generally only a short region bearing the scattered scale leaves, the ordinary form of the leaf being fairly early and often suddenly attained, but the first shoots of the young plant frequently show a much longer scale-leaf region. In the latter the transition to the larger form may be either sudden or gradual. There is much variation in the size shown by the mature sterile leaf, this generally being longer, as might be expected, in pendulous branches than in those of more erect growth. The leaves of juvenile plants, also, are rather small in size. Sometimes however, elongated pendulous branches show a much shorter form of leaf than usual. Three examples of mature sterile leaves are given in figs. 91A to 91C, the first two coming from luxuriantly-growing pendulous plants, and the third from the lower part of a short, erect, but fully-grown shoot. The normal size is narrower and slightly longer than that shown in 91C. Individual branches may be met with showing marked



FIGS. 88, 89.—Young plantlets, showing first aerial shoot. × 3.
FIG. 90.—Young plantlet in which both main apices of rhizome have grown up into aerial shoots. × 3.
FIG. 91.—Three varieties of the mature sterile leaf taken from well-grown shoots. × 1·3.

variation in size of the leaves up and down the branch, a zone of quite stunted and almost scale-like leaves sometimes occurring in amongst those of the ordinary form. The leaves are sometimes in two orthostichies only, being then flattened in one plane, this being a common state in juvenile slender branches, but to be seen also in older ones. Again, they may be arranged in three or in four orthostichies, the stem in transverse section showing a corresponding number of ridges. These different leaf-arrangements may be found intermixed along the one branch. The leaves are never in whorls, but are scattered.

In pendulous branches the sporophylls are grouped in zones alternating with sterile zones. A characteristic very short and compact variety may sometimes be found on tree-ferns in which the whole of the upper two-thirds of the branch is fertile, there being no zoning. The two or three first-formed small aerial shoots in the young plant remain sterile. Sporophylls generally make their first appearance singly, juvenile shoots about 4 in. to 6 in. in height commonly showing one sporophyll situated about half-way along their length, and sometimes also another

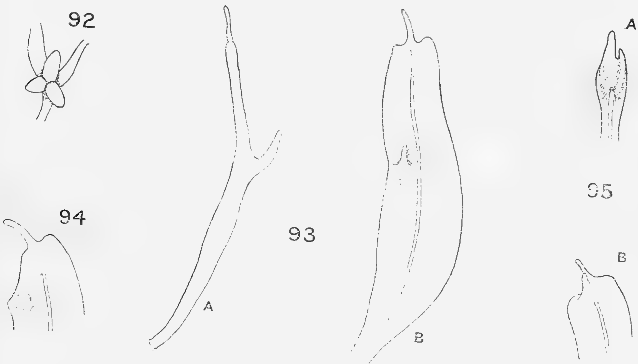


FIG. 92—Portion of sporophyll, showing abnormal number of loculi in the synangium. × 1·5.
FIGS. 93A, 93B.—A sterile leaf in side and face views, showing a lobe-like outgrowth from the lamina. × 3.
FIG. 94.—The upper portion of a sterile leaf showing a small marginal outgrowth and thickening. × 3.
FIGS. 95A, 95B.—The apex of a sterile leaf in side and face views, showing forking of the tip. × 3.

borne singly still nearer the apex. Well-grown shoots showing the usual alternate fertile and sterile zones may be found with these single sporophylls towards the base. Occasionally a juvenile shoot is found in which the sporophyll formation has been initiated not singly but in a normal zone. The lobes of the sporophyll are similar in form, and sometimes also almost in size, to the sterile leaf appendages, but generally they are narrower.

Abnormalities in the sporophylls have been described by A. P. W. Thomas (15). I have occasionally found synangia with three loculi instead of two (fig. 92), and not infrequently it happens that one of the lobes of the sporophyll is more or less reduced in size, or is even almost entirely absent. A sterile leaf in one instance bore about half-way down its flat surface a small lobular outgrowth (figs. 93A and 93B), the appearance being that of an abortive forking. Both sterile leaves and the lobes of the sporophyll sometimes show a slight projection at the margin with the tissues of the lamina thickened immediately behind it (fig. 94), suggesting a less-developed stage of the outgrowth shown in fig. 93. At the tip of another sterile leaf an outgrowth was present alongside the mucro, as if the tip was preparing to fork (figs. 95A and 95B). Such abnormalities may or may not have any significance in indicating that reduction has taken place in these leafy appendages, but they seem to show that the sporophyll and the sterile leaf are not in nature essentially different from one another, and that neither of them is altogether fixed in form. In fact, the sporophyte generation as a whole in *Tmesipteris* provides many details indicating, as might be expected in a plant showing undoubted primitive characters, a general lack of specialization.

General Considerations.

As has been noted above, there is a very striking similarity in form and general external appearance between the prothallus and the young subterranean sporophyte of *Tmesipteris.* It is evident that this similarity between the two generations holds for *Psilotum* also, judging from Lawson's description (12) of the prothallus and that of Solms Laubach (14) with respect to plantlets developed from buds on old rhizomes. Bearing in mind how plastic, generally speaking, the Pteridophyte gametophyte is known to be, and, moreover, how largely the distribution and persistence of these ancient families has probably been due to the ability of the gametophyte to adapt itself to new conditions, it would be, of course, unwise to conclude too hastily that the similarity between the two generations in the Psilotaceae is a primitive feature. On the other hand, a close correspondence of this nature is not found in the life-history of other modern Pteridophytes, even in those epiphytic forms of *Lycopodium* and *Ophioglossum* which possess a cylindrically-built, branched, and ramifying prothallus; nor can this be attributed altogether to the more complex organization of the young sporophyte in these families. Whatever view we take of this external similarity as it is to be seen in the Psilotaceae, the fact that it exists is at least worthy of attention, and becomes even more so when it is found to go hand in hand with certain important structural features in both generations which can with reason be claimed to be primitive.

The superficial position of the sexual organs on the prothallus of *Tmesipteris* and *Psilotum* can be regarded as a structural feature of the gametophyte which has not arisen by modification from a more deeply situated position. The adoption of the subterranean habit of growth in other pteridophytic families has not resulted in a similar simple organization and structure of the sexual organs as is to be found in the Psilotaceae, and it is therefore difficult to see why in the latter this simplicity should be regarded as the result of modification. The persistence of the single apical cell throughout the life of the prothallus, the dichotomous branching, the gradual extension in girth of the prothallus from an initial filament without the formation of such a primary tubercle as is found in some Lycopodiums, and the complete absence of any differentiation of tissues in the prothallus-body, may all be urged as more or less primitive features.

In correspondence with the superficial position of the sexual organs on the prothallus, the embryo also is shallowly seated, there being no suspensor organ to push it down into the food-supplying tissues of the prothallus such as has been developed in the Lycopodiaceae, and in certain also of the Ophioglossaceae. On the assumption that the suspensor is a primitive organ, it might be urged that it had become lost in *Tmesipteris* owing to the very early adoption of the fungal habit by the young sporophyte and its consequent ability to nourish itself. However, the dependence of the young sporophyte upon its prothallus is a protracted one, and the absence of the suspensor is compensated for by the development of haustorial protuberances from the foot, just as is found, only there not to so great an extent, in the sporogonium of the Anthoceroteae. The inference seems to be that the superficial position of the embryo and the absence of the suspensor is the more primitive condition.

There are only two main body-organs in the embryo and young sporophyte of *Tmesipteris*—namely, the shoot and the foot—there being no trace of root, cotyledon, or suspensor. Thus its embryogeny is the simplest among existing Pteridophytes. It would be difficult to conceive of a more simple organization for a vascular cryptogam, and in instituting comparisons we are forced to look to the young sporogonium of *Anthoceros* rather than to any Pteridophyte embryo. While not suggesting that *Tmesipteris* has been actually derived from the *Anthoceros* cycle of affinity, it is clear that the absence from the former of any such organs as root or cotyledon suggests that they approximate in so far as they both represent primitive lines of development. In his *Origin of a Land Flora* Bower contemplates the fundamental structure-plan of the various pteridophytic types of embryo as a spindle-shaped axis with the shoot-apex situated at the apex of the epibasal region. The embryo is primarily a shoot, and the other main body-organs are appendages developed secondarily upon it. Speaking of the light which it was hoped the embryogeny of the Psilotaceae would throw upon this matter, he says (*ibid.*, p. 421), " If the embryo develops without appendages directly into the rootless and leafless rhizome, then either reduction has been effective back to the earliest phases of the individual, or the sporophyte at first represents that primitive state of an axis without appendages which a strobiloid theory contemplates in the far-back ancestry." That the simplicity of *Tmesipteris* is not due to reduction is a belief which has been greatly strengthened by the discovery of the rootless and leafless Rhyniaceae. The embryogeny of *Tmesipteris* as described in the present paper makes more clear-cut the theory of the origin of the sporophyte of the Pteridophyta from an *Anthoceros*-like sporogonium.

Pursuing this theory further, it may be noted that two definite suggestions based on the embryogeny of existing Pteridophytes have been put forward as to how this origin could have taken place. Campbell (2, p. 210) would see in the young embryo of *Ophioglossum moluccanum* a primitive type of *Ophioglossum* which can be derived from an *Anthoceros*-like ancestor. In this species the lower portion of the embryo forms the large foot and the upper the cotyledon, the latter, however, not being sporogenous, as is the upper part of the sporogonium of *Anthoceros*. The new organ in *Ophioglossum* is the root which arises at the junction of the cotyledon and the foot. There is at first no stem-axis, this being developed late as a secondary structure upon the primary root. Campbell links up *Ophioglossum*, which he regards as " the most primitive type of the fern series " (*ibid.*, p. 42), with the Bryophytes in the suggestion that the Anthoceroteae progressed to the formation of a root from the basal meristem of the sporogonium, and that the " pro-*Ophioglossum* " produced spores upon the first leaf. Bower (1, p. 469) has criticized this theory by pointing out that for his primitive form Campbell has chosen the most abnormal of all the species of *Ophioglossum*, instead of starting with such a form as *O. vulgatum*, which approximates more to the usual pteridophytic type of embryo.

The presence of the "protocorm" in the embryo plant of certain species of *Lycopodium* has given rise to another suggestion with regard to the origin of the free-living sporophyte—namely, that the protocorm was the precursor of the leafy shoot. Against this it has been urged, especially by Bower (1), that the embryo of *Lycopodium* is prone to parenchymatous swellings, and that the protocorm is best regarded as a physiological specialization. My own study of the large development of this organ in the two New Zealand species *L. laterale* and *L. ramulosum* (4, 5) led me to conclude that its abnormal size in these two species could be put in connection with the fact that the young sporelings were required to tide over a summer season, during which their natural boggy habitat would be usually dried up, before they could establish themselves, and that the manner of development of their protocormous rhizome was capable of a physiological explanation. I concluded that this lent weight to the theory that the *Lycopodium* protocorm in general may best be interpreted in this way (4, p. 289). I was careful, however, to add that the fact that this organ is characteristic of two out of the five sections of the genus *Lycopodium*, and is also present in a specialized form in *Phylloglossum*, indicates "a considerable degree of antiquity for the protocorm within the genus *Lycopodium*." Vegetatively-produced plantlets of these New Zealand species possess a basal protocorm (5), as Osborn also (13) has shown in plantlets of *Phylloglossum* produced on detached leaves. This author inclines to regard the tuber of *Phylloglossum* as of physiological importance only. Since writing my first accounts of the *Lycopodium* protocorm I have found at the close of a dry summer season a colony of young sporelings of *L. cernuum* growing upon a roadside clay cutting in which this organ was as largely developed through the formation of a rhizomatous extension as in the other two New Zealand species mentioned (6, p. 189). This is unusual, for in *L. cernuum* the stem-axis is generally initiated early on the protocorm, and it indicates that the unusual conditions were the cause of this extra development. Recently Kidston and Lang (9) have described under the name *Hornea Lignieri* a rootless protocormous plant from the Early Devonian of Scotland which "retains in the adult condition an organization comparable to the protocorm stage in the species of *Lycopodium*. The relation of the aerial stems of *Hornea* to the rhizome is similar to that of the protophylls to the protocorm in *Lycopodium*" (9, p. 620). It is, of course, a perfectly legitimate criticism to make that even in this archaic plant the protocorm is merely a physiological specialization called forth by precisely the same conditions as govern the life of the modern swamp-growing species of *Lycopodium*, and the fact that the authors have indicated (9, note, p. 612) that an intercellular fungus is present in the rhizome is of considerable significance in this respect. However, the plant in its general organization is obviously primitive, and is associated with other types of plants of very simple structure, and, belonging as it does to a group which comprises the earliest known land-plants, can be considered as lending great weight to Treub's theory of the protocorm. If the protocorm can be regarded as primitive, it is, of course, open to be interpreted either as an organ by which the supposed sporogonium-like ancestor of the Lycopods first attained independence of the gametophyte, or as a more or less modified representative of a possible thalloid ancestor.

A third definite suggestion with regard to the origin of the leafy axis of existing Pteridophytes from a strobiloid ancestor arises out of the facts of the simply organized embryo of *Tmesipteris*. The only new feature to be postulated here is the extension in length of the shoot from an apical meristem instead of, as in *Anthoceros*, from an indefinite basal meristem, and the initial cause of the continued shoot-elongation might be set down as being the adoption of a subterranean mode of life by the gametophyte. The differences between the ancestral strobilus and the derived rootless shoot would then be referred largely to their different modes of life. Further development in complexity of the sporophyte of this "pro-*Tmesipteris*" would take place by the continued growth of the shoot and by its dichotomous and lateral branching. On this view, the subterranean habit of the gametophyte would be regarded as of very early origin in at least one line of descent of the higher plants, although in other phyla, as, for example, that of *Lycopodium*, and possibly also that of the Ophioglossaceae, it is probably a very much later development. Bower in a general way regards the subterranean habit of the gametophyte as being modified from the subaerial habit. He says (1, p. 710), "It may accordingly be concluded as probable that the prothallus of early Pteridophytes at large was a relatively massive green structure with deeply-sunk sexual organs." If, as suggested above, the superficial position of the sexual organs in the Psilotaceae is not a modified feature, the gametophyte of this class stands apart from that of other Pteridophytes. From Kidston and Lang's description of the asexual generation in the Rhyniaceae one is tempted to conclude that the gametophyte of these plants was subterranean rather than subaerial. The presence in the gametophyte of an endophytic fungus is a widespread feature of existing Pteridophyte prothalli, and I suggest that it may with as much reason be considered to have played a part in leading to the development of the rootless and leafless shoot of the Psilotaceae as to have been the cause of reduction taking place in a more complex plant-body. Modern Pteridophytes are so far removed in point of time from the hypothetical primitive form or forms that deductions based on comparative embryology, lacking as they do any support which might have been afforded by a knowledge of the embryogeny of archaic vascular plants, might be considered as altogether undependable. On the other hand, the extreme simplicity of the *Tmesipteris* embryo, wholly devoid as this is of appendicular organs, is full of significance, and the demonstration of a rootless and leafless condition in the earliest known land-plants strengthens the belief that the Psilotaceae have preserved in the first stages of their development primitive features.

The lateral origin of branches in the young rhizome of *Tmesipteris* would seem to be a more specialized character than branching by dichotomy of the apex, and it is curious to find that the latter does not apparently take place in the youngest rhizomes, whereas in those of a somewhat older age it is present along with lateral branching. The initiation of the second apex of growth may take place in the young embryo or be postponed till the shoot is well advanced, and even then varies in its position. This is just such a generalized character as might be expected in a primitive type of plant-body. The distinction also between the subterranean and the subaerial parts of the sporophyte would seem to be very indefinite, one or both of the first apices of growth emerging and becoming leafy according as the needs of the young plant direct. Sometimes the first-formed aerial shoot is still more unspecialized in its origin, arising as a lateral branch from the rhizome just as do the aerial shoots in the older state. The alternation of fertile with sterile zones on the aerial branch is not a fixed character, a branch being zoned or practically altogether fertile according to its habit of growth. Neither the sporophyll nor the sterile leaf is fixed in form. Thus the *Tmesipteris* sporophyte is a peculiarly unspecialized plant-body not only in the absence of cotyledon and root organs from the embryo, but also in the general organization of the rhizome and of the aerial shoot.

In their description of the rootless and leafless Rhyniaceae, Kidston and Lang express the opinion that this simple plant-body "might as well be termed a cylindrical branched vascular thallus as a stem" (9, p. 619). They are more inclined to interpret it in the light of the theory that the sporophyte of the higher plants has arisen by modification and by specialization in the time of appearance of the asexual stage of an algal ancestor, rather than as the result of the adoption of an independent existence by a sporogonium-like ancestor with the consequence of a progression in sterilization of its parts. The simple organization of the Psilotaceae is, of course, susceptible of the same interpretation—but this has not been the one followed in the above remarks.

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ART. XLV.—*New Species of Flowering-plants.*

By T. F. CHEESEMAN, F.L.S., F.Z.S., F.N.Z.Inst., Curator of the Auckland Museum.

[*Read before the Auckland Institute, 15th December, 1920; received by Editor, 31st December, 1920; issued separately, 12th August, 1921.*]

1. Agrostis pallescens Cheesm. n. sp.

Affinis *A. subulatae* Hook. f. (*A. Muelleri* Benth.) sed tenuior, culmis 3-nodis, nodo superiore supra culmi medium disposito, spiculis stramineis.

Annual, densely tufted and often forming a close sward, pale straw-coloured. Culms 3–6 in. high, slender, smooth, erect, 3-noded, the uppermost node high up the culm. Leaves numerous at the base of the culms and shorter than them, very narrow, almost filiform, smooth or very minutely scabrid, erect or somewhat spreading; sheaths long, deeply grooved; ligules thin, scarious. Panicle narrow, but not so much so as in *A. subulata*, lanceolate or ovate-lanceolate, $\frac{1}{2}$–1 in. long, straw-coloured; branches in fascicles of 2–4, unequal in length, somewhat spreading, finely scabrid. Spikelets $\frac{1}{12}-\frac{1}{10}$ in. long. Two outer glumes slightly unequal, oblong-lanceolate, subacute, membranous, scabrid on the keel; margins thin; third or flowering glume about $\frac{1}{3}$ shorter, thin and membranous, hyaline, truncate, faintly 5-nerved; awn wanting. Palea not developed. Grain oblong.—*A. Muelleri* var. *paludosa* Hack. in Cheesem. *Man. N.Z. Fl.* (1906), 864.

Hab.—South Island: Swamps near the Broken River; *T. Kirk!* Swamps in the Tasman Valley, not uncommon; *T. F. C.* 1,500–2,500 ft.

Near to *A. subulata*, but amply distinct in its 3-noded culms, the upper node of which is sometimes situated quite $\frac{2}{3}$ of the way up the culm, in the straw-coloured spikelets, and in the broader and more open panicles. In *A. subulata* the culms are seldom more than 1-noded, the node being placed near the base of the culm, the panicles are narrow and spike-like, and usually purplish in colour. In addition to the above, *A. subulata* is always limited to the steep rocky slopes of high mountains, and never occurs in swamps.

2. Atropis chathamica Cheesem. n. sp.

Affinis *A. Walkeri* Cheesem. a qua differt culmis multo robustioribus et laxe caespitosis, paniculis longioribus, spiculis 4–6 floribus.

Tall, stout, loosely tufted, perfectly smooth and glabrous, 9–18 in. high. Culms erect or decumbent at the base, 4-noded, the upper node placed above the middle; innovation shoots intravaginal. Leaves numerous, those at the base short and scale-like, membranous, without any lamina; cauline leaves sheathing the whole culm and the greater part of the panicle, perfectly smooth and glabrous, pale whitish-green, folded, grooved, tip cartilaginous, subobtuse; sheaths very large and broad, longer than the blades, split to the base, compressed, deeply striate; ligules broad, transversely oblong, membranous. Panicle narrow-linear, 2–6 in. long, rigid, erect, glabrous; branches few, unequal, solitary or 2-nate, more rarely 3-nate, erect, often almost appressed to the rhachis. Spikelets $\frac{1}{3}$–$\frac{1}{4}$ in. long, narrow lanceolate, 4–6-flowered. Two outer glumes unequal, the longer one about $\frac{1}{3}$ the length of the spikelet, lanceolate, 3-nerved; the shorter one broader, 1-nerved. Flowering-glume oblong-ovate, subacute, faintly 3-nerved, glabrous, or a tuft of fine silky hairs on the callus. Palea nearly as long as the glume, margins ciliate.

Hab.—Chatham Islands: Exact locality not stated; *F. A. D. Cox!*

This appears to be a distinct species, easily recognized by the stout loosely-tufted habit, long narrow panicle, and narrow many-flowered spikelets.

3. **Plantago Masonae** Cheesm. n. sp.

Affinis *P. triandrae* Berggren, sed differt foliis crassis et carnosis, spathulatis lanceolatisve, integerrimis vel dentatis vel pinnatifidis, lobis callosis, floribus minoribus, pedunculis brevissimis.

Rootstock short, stout, putting down numerous thick and fleshy rootlets. Leaves many, all radical, spreading, the outer closely appressed to the surface of the ground, thus forming rosettes $\frac{1}{2}$–$2\frac{1}{2}$ in. diam., very thick and fleshy, greenish blotched with purple, $\frac{1}{2}$–$1\frac{1}{2}$ in. long, rarely more, ovate- or oblong-spathulate to lanceolate-spathulate, suddenly narrowed into a broad flat petiole of variable length, towards the apex gradually narrowed into a blunt fleshy or almost callous point; margins, with the exception of the triangular tip, regularly and almost pinnatifidly divided into numerous shallow blunt fleshy or callous lobes; upper surface furnished with short whitish jointed hairs that are usually arranged in transverse bands; under-surface glabrous or nearly so; base of the leaf usually furnished with longer brownish tortuous hairs, but sometimes almost glabrous. Flowers minute, solitary in the axils of the leaves; peduncles wanting or nearly so, apparently not elongating in fruit. Bract ovate, minute. Calyx-segments 4, ovate, obtuse. Corolla-tube three times the length of the calyx in the flowering period; limb 4-lobed, lobes oblong, obtuse. Stamens invariably 4 in all the numerous flowers examined. Capsule globose; seeds numerous, 10–20.

Hab.—North Island: Sea-cliffs at Manaia, Taranaki, often in localities well washed with sea-spray; *Mrs. F. Mason!*

This is evidently a close ally of *P. triandra* Berggren, but differs in the more robust habit, very fleshy and proportionately much broader leaves with obtuse callous tips, more minute sessile flowers the peduncles of which apparently do not lengthen in fruit, in the stamens being always 4, and in the smaller capsules. I have pleasure in associating the plant with the name of its discoverer, to whom I am much indebted for information respecting the vegetation of south-western Taranaki.

4. **Colobanthus strictus** Cheesm. n. sp.

Dense pulvinatus glaberrimus, foliis arcte imbricatis, strictis, erectis, rigidis, lineari-subulatis, supra canaliculatis, apicibus piliferis; sepalis 5, basi late ovatis, incrassatis, supra longe attenuatis.

A perfectly glabrous densely-tufted rigid plant, forming hemispherical cushions 1–3 in. diam. Leaves numerous, densely imbricated all round the branches, straight or slightly curved, strict, erect, broad and membranous and sheathing the branch at the base, above rigid and coriaceous and gradually narrowed into a straight acicular apex, channelled above, convex beneath, $\frac{1}{3}$–$\frac{2}{3}$ in. long. Peduncles terminating the branchlets, stout, shorter than the leaves, stiffly erect. Sepals 5, broadly ovate at the base, suddenly narrowed into long acicular points half as long again as the capsule.—*C. Muelleri* var. *strictus* Cheesem., *Man. N.Z. Fl.* (1906), 68.

Hab.—South Island: Upper Clarence Valley, near Lake Tennyson; *T. F. C.* Shingly flats in the Tasman and Hooker Valleys; *T. F. C.* Dunstan Mountains; *Petrie!* Altitudinal range, 2,500–3,500 ft.

In the first edition of the *Manual* I treated this as a variety of *C. Muelleri;* but since then I have had opportunities of studying it in the Mount Cook district, where it is not uncommon, and have now no hesitation in constituting it a distinct species. It is mainly distinguished by the short, strict, erect leaves, and broad calyx-lobes which are suddenly narrowed into long acicular points much exceeding the capsules.

5. **Colobanthus Hookeri** Cheesm. new comb.

A small densely tufted moss-like plant, forming small rounded patches 1–1$\frac{1}{2}$ in. across, smooth and glabrous in all its parts. Leaves closely imbricate, $\frac{1}{6}$–$\frac{1}{4}$ in. long, strict and rigid, subulate, tapering from the base to a short acicular apex, channelled above, convex below, sometimes with a groove between the midrib and the margin. Flowers terminal, solitary; peduncles short, the flowers slightly exceeding the uppermost leaves. Sepals 5, ovate-subulate, thickened at the base, acute or very shortly mucronate, equalling or very slightly exceeding the capsule. Stamens always 5.—*C. subulatus* Hook. f., *Fl. Antarct.*, i (1844), 13, but not *Sagina subulata* D'Urv., *Fl. Ins. Mal.* (1826), 617, or *Fl. Antarct.*, ii (1847), 247, t. 93. *C. subulatus* Hook. f., *Handb. N.Z. Fl.* (1864), 25. *C. Benthamianus* Cheesem., *Man. N.Z. Fl.* (1906), 68, but not of Fenzl.

Hab.—Auckland and Campbell Island: *Hooker, Kirk! Aston!*

This is the plant long known to New Zealand botanists as *Colobanthus subulatus.* But in the *Subantarctic Islands of New Zealand* (ii, p. 402) I have pointed out that the plate of *C. subulatus* given in the *Flora Antarctica* (ii, t. 93) under the name of *Sagina subulata* represents a plant with a much more lax habit than the Auckland and Campbell Islands species; and that the sepals are only 4 in number, instead of 5. I think that it is quite clear that the New Zealand plant differs in several important characters from the Fuegan and Falkland Island species, and, as the name *subulata* must remain with the South American plant, I have applied the name *Colobanthus Hookeri* (in memory of its original discoverer) to the species found within the New Zealand area.

I have not seen any South Island specimens that I can refer to the species, although three localities are quoted by Hooker. Possibly they represent small states of *C. acicularis.*

Art. XLVI.—*New Plant-stations.*

By A. Wall, M.A., Professor of English, Canterbury College.

[*Read before the Philosophical Institute of Canterbury, 6th October, 1920; received by Editor, 21st October, 1920; issued separately, 12th August, 1921.*]

(The initials in square brackets are those of the person by whom the species or variety has been identified: B. C. A. for Mr. B. C. Aston; T. F. C. for Mr. T. F. Cheeseman; L. C. for Dr. L. Cockayne; D. P. for Mr. D. Petrie; A. W. for the author.)

Ranunculus sericophyllus Hook. f. Mount Rolleston; mountains at the head of the Waimakariri, 6,000 ft. [A. W.].

Ranunculus gracilipes Hook. f. Two Thumb Range, near Lake Tekapo, 6,500 ft. [D. P.].

Ranunculus foliosus T. Kirk. Walker's Pass, head of the Hawdon River [D. P.].

Ranunculus Cheesemanii T. Kirk. Mount White district, 2,500 ft. [D. P.].

Ranunculus depressus T. Kirk. Two Thumb Range, 6,500 ft. [D. P.].

Cardamine depressa Hook. f. Old Man Range, 5,000 ft. [D. P.].

Cardamine fastigiata Hook. f. Mount Skedaddle, Mandamus River, North Canterbury, 5,000 ft. [L. C.]. Formerly only in Nelson, Marlborough, the Macaulay River, and Otago.

Cardamine Enysii Cheesem. Puketeraki Range, 6,000 ft.; mountains flanking Hawdon River, 6,000 ft. [A. W.].

Lepidium sisymbrioides Hook. f. Maniototo Plains, near Waipiata [A. W.]. Not recorded previously south of the Waitaki and Lake Wanaka.

Hectorella caespitosa Hook. f. Old Man Range, 5,000 ft. [L. C.].

Aristotelia Colensoi Hook. f. Mount Hutt, in *Fagus* forest, 2,000 ft. [L. C.].

Carmichaelia gracilis Armstr. Poulter River, 2,000 ft. [A. W.]. Recorded only to 1,500 ft. in *Manual*, and not before in the south alpine region.

Carmichaelia prona T. Kirk. Lake Mary Mere, Craigieburn [A. W.].

Geum parviflorum Sm. Mount Herbert, Banks Peninsula, 2,800 ft. [A. W.].

Acaena inermis var. *breviscapa* Bittr. Mandamus River, North Canterbury [L. C.].

Epilobium brevipes Hook. f. Mouth of Mandamus River, tributary of the Hurunui River, North Canterbury [L. C.].

Epilobium gracilipes T. Kirk. Esk River and Iron Creek (Upper Waimakariri), on sandstone cliffs [A. W.].

Hydrocotyle dissecta Hook. f. Waikawa, Southland [D. P.].

Eryngium vesiculosum Lab. Balmoral scrub, North Canterbury, about twenty-four miles from sea-coast [L. C.].

Aciphylla Cuthbertiana Petrie. Takitimu Mountains, 4,500 ft. [D. P.].

Ligusticum piliferum var. *pinnatifidum* T. Kirk. Macaulay River, 4,000 ft. [D. P.].

Pseudopanax ferox T. Kirk. Camp Bay, Lyttelton Harbour [A. W.].

Coprosma grandifolia Hook. f. Mount Grey, near Amberley, North Canterbury [L. C.].

Coprosma virescens Petrie. Port Hills and Banks Peninsula [A. W.]. "Lake Forsyth" was the only Canterbury station for this recorded by Kirk.

Olearia lacunosa Hook. f. Crawford Range, Lake Sumner, 4,000–5,000 ft. [L. C.].

Olearia moschata Hook. f. Takitimu Mountains, 4,000–5,000 ft. [A. W.].

Celmisia ramulosa Hook. f. Rock and Pillar Range, 5,000 ft. [D. P.].

Celmisia densiflora Hook. f. Takitimu Mountains, 4,000 ft. [A. W.].

Celmisia Armstrongii Petrie. Crawford Range, Lake Sumner, 5,000 ft. [L. C.].

Celmisia Petriei Cheesem. Takitimu Mountains, 4,000–5,000 ft. [D. P.].

Celmisia linearis Armstr. Mount Miromiro, Hanmer, 6,000 ft. [L. C.]; mountains flanking the Hawdon River, 6,000 ft. [L. C.]. Not previously recorded in Canterbury except in Mount Cook district by Cheeseman.

Celmisia Hectori Hook. f. Takitimu Mountains, 5,000 ft. [D. P.].

Celmisia argentea T. Kirk. Old Man Range, 5,000 ft. [D. P.].

Raoulia Haastii Hook. f. Hurunui River [A. W.].

Raoulia Parkii Buch. Two Thumb Range, 3,000–6,000 ft. [D. P.].

Raoulia Hectori Hook. f. Two Thumb Range, 5,000 ft. [D. P.].

Raoulia Petriensis T. Kirk. Two Thumb Range, 4,000–6,500 ft. [D. P.].

Cotula filiformis Hook. f. Balmoral scrub, North Canterbury [L. C.]. Also found by Mr. Christensen, Hanmer Plains.

Senecio revolutus T. Kirk. Takitimu Mountains, 4,000–5,000 ft. [A. W.]. Previously recorded from more western localities only.

Phyllachne rubra Cheesem. Rock and Pillar Range, 5,000 ft. [D. P.].

Selliera radicans Cav. Saline patches by Taieri River, near Waipiata [A. W.]. Recorded inland on margins of the larger lakes only.

Lobelia Roughii Hook. f. Two Thumb Range, 5,000–6,000 ft. [A. W.].

Pernettya nana Col. Base of Two Thumb Range, Lake Tekapo [A. W.].

Dracophyllum prostratum T. Kirk. Takitimu Mountains, 5,000 ft. [D. P.].

Dracophyllum muscoides Hook. f. Benger Range, near Roxburgh [D. P.].

Samolus repens Pers. Saline patches near Taieri River, Waipiata [A. W.]. Not recorded in the *Manual* from any inland station.

Gentiana tenuifolia Petrie. Lake Pearson, North Canterbury, 2,000 ft. [D. P.].

Myosotis pulvinaris Hook. f. Old Man Range, 5,000 ft. [D. P.].

Gratiola peruviana Linn. Wycliffe Bay, Otago Peninsula [B. C. A.].

Veronica amabilis var. *blanda* Cheesem. Bluff Hill [D. P.].

Veronica Buchanani Hook. f. Rock and Pillar Range, 5,000 ft. [D. P.].

Veronica pimeleoides var. *glauco-caerulea* Cheesem. Base of Two Thumb Range to 4,000 ft. [D. P.]. Apparently no definite locality for this has been recorded.

Veronica Gilliesiana T. Kirk. Crawford Range, Lake Sumner, 5,000 ft. [L. C.].

Veronica quadrifaria T. Kirk. Mount Skedaddle, Mandamus River, 4,000 ft. [L. C.]; Two Thumb Range, 6,000 ft. [D. P.]. The only Canterbury station previously recorded is Mount Dobson. Occurs also on Mount Peel and in its vicinity.

Veronica Hectori Hook. f. Takitimu Mountains, 3,000–5,000 ft. [D. P.]; Old Man Range, 5,000 ft.

Veronica propinqua Cheesem. Mount Benger, near Roxburgh, 3,000 ft. [D. P.].

Veronica Thomsoni Cheesem. Old Man Range, 5,000 ft. [D. P.].

Ourisia glandulosa Hook. f. Old Man Range, 5,000 ft. [D. P.].

Plantago lanigera Hook. f. Upper Hurunui River [L. C.]. No definite Canterbury station has been recorded.

Muehlenbeckia ephedrioides Hook. f. Hurunui River, *c.* 2,500 ft. [A. W.]. The only Canterbury locality recorded is the Waipara River. This is the first record for the Canterbury alpine region.

Pimelea sericeo-villosa Hook. f. Mount White, Upper Waimakariri [D. P.]. Not previously recorded in North Canterbury.

Luzula Cheesemanii Buchen. Mount St. Bernard, Craigieburn, 5,000 ft. [D. P.]; Rock and Pillar Range, 5,000 ft. [A. W.].

Luzula leptophylla Buchen. Old Man Range, 5,000 ft. [A. W.]; Rock and Pillar Range, 5,000 ft. [A. W.].
Luzula racemosa var. *Traversii* Buchen. Mount St. Bernard, 4,000 ft. [A. W.]; Mount Hutt, 5,000 ft. [A. W.]; and many other localities in Canterbury and Otago. Hitherto recorded from very few stations in Canterbury.
Triglochin palustre Linn. Taieri River, Waipiata [A. W.]. The only Otago station hitherto recorded is Ophir.
Scirpus basilaris C. B. Clarke. Castle Hill, Waimakariri Basin [A. W.].
Gahnia pauciflora T. Kirk. Mount Grey, near Amberley [L. C.]; apparently first record in Canterbury. Also at Glentui, near Oxford [R. M. Laing].
Uncinia purpurata Petrie. Hanmer Mountains, to 5,000 ft. [D. P.].
Carex pyrenaica Wahl. Mount Miromiro, Hanmer, 6,000 ft. [L. C.].
Carex appressa R. Br. Near Godley Head, Port Hills, Christchurch [D. P.]. First record north of Otago.
Carex resectans Cheesem. Port Hills, Christchurch, and Banks Peninsula [D. P.]. Was no doubt formerly also on Canterbury Plains, and has been found by myself in lawn near Christchurch and in the New Brighton dunes.
Carex Raoulii Boott. Mount Hutt, Pudding Hill Stream, 3,000 ft. [A. W.].
Carex rubicunda Petrie. Richmond Station, Lake Tekapo, margins of ponds [D. P.]. First record for Canterbury. Previously only at Lake Te Anau and one station in the North Island.
Carex Berggreni Petrie. Hawdon River, north branch of Waimakariri [D. P.]; also at Arthur's Pass [W. Martin].
Deyeuxia Petriei Hack. Mount Herbert, Banks Peninsula, 2,500–2,800 ft. [D. P.]. First record for Canterbury. The flowering-glume has no awn. Mr. Petrie informs me that this species must be reduced to a variety of *D. Youngii.*
Deschampsia Chapmani Petrie. Jollie's Pass, Hanmer [D. P.]. Not before recorded outside Canterbury and Otago.
Trisetum subspicatum Beauv. A small form of this species grows at 7,000 ft., or just below that, on the Two Thumb Range [A. W.]. "Usually to 5,500 ft." in *Manual.*
Danthonia crassiuscula T. Kirk. Takitimu Mountains, 4,000 ft. [D. P.]. Hitherto chiefly recorded much farther west.
Triodia exigua T. Kirk. In the Waimakariri River bed, close to Christchurch, at sea-level [A. W.]. From 500 ft. to 3,000 ft. in *Manual.*
Poa Cheesemanii Hack. Hawdon River (north branch of Waimakariri), 2,000–2,500 ft. [D. P.]. First record for Canterbury.
Poa pygmaea Buch. Old Man Range, 5,000 ft. [D. P.]; Mount Benger, 3,000 ft. [D. P.]. Both these are referred to this species by Mr. Petrie with some reservation.
Poa Cockayniana Petrie. Mount St. Bernard, Craigieburn, 5,000 ft. [D. P.].
Asperella gracilis T. Kirk. Mount Herbert, 2,800 ft., Banks Peninsula (first record since Raoul's at Akaroa); Five Rivers Plains, Otago; Lake Tekapo [A. W.; D. P.].
Gymnogramme leptophylla Desv. Akaroa Harbour [A. W.].

Introduced Plants.

Glyceria procumbens. Tomahawk Lagoon, Dunedin [D. P.; T. F. C.]. A new record for the Dominion.
Alisma Plantago. Lower Avon, Christchurch [A. W.].

Art. XLVII.—*On Growth-periods of New Zealand Trees, especially* Nothofagus fusca *and the Totara* (Podocarpus totara).

By H. B. Kirk, M.A., F.N.Z.Inst., Professor of Biology, Victoria University College.

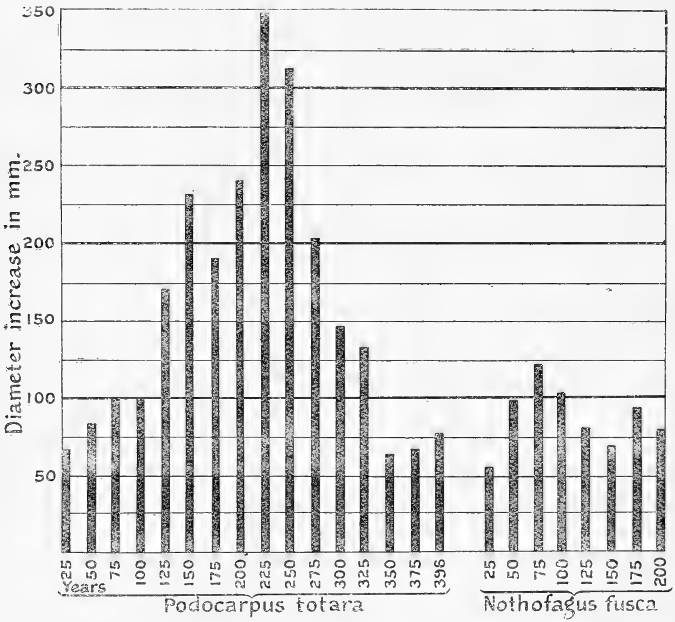
[*Read before the New Zealand Science Congress, Palmerston North, 29th January, 1921; received by Editor, 14th February, 1921; issued separately, 12th August, 1921.*]

Most of the information available as to the diameter-increase in New Zealand trees is expressed in terms of the diameter achieved by a tree during its whole life, little regard being paid to its growth at different periods of its life. Examination of several of our trees, however, shows that there is a well-marked period of youth, during which growth is slow; a prime, during which growth is, relatively at all events (and often absolutely), rapid; and a period of senescence, during which growth is slower than in youth. I was much impressed by this when marking the section of a big totara (*Podocarpus totara*) in the Biology Museum of Victoria University College. The Forestry Commission of 1913 published a photograph of this section in its report, together with a diagram showing the relative position of the twenty-five-year points marked on the radius, but did not otherwise call attention to the widely varying rate of growth at different periods. This varying rate is shown by the figures in Table A of this article, and by the graphic representation which shows the increase in diameter for each period of twenty-five years. It will be seen that in the first 100 years—the youth of the tree—a diameter of only 350 mm. (13·8 in.) was achieved. At 200 years the diameter had reached 1,180 mm. (46·49 in.). The period of most rapid growth (of the arbitrary periods marked) was that from 200 years to 225 years, bringing the diameter up to 1,528 mm. (5 ft.). From this time growth became slower until it was less than during the youth of the tree. At the age of 396 years, when the tree was felled, its diameter was 2,528 mm. (8·3 ft.). It has been assumed that only one growth-ring was formed in each year, and I believe the assumption is justified.

I have not examined other totara-trunks with the same attention, but have found that the slow early growth, the rapid growth of the prime, and the slower growth of age are constant features. The bearing of this upon the conservation of totara that have passed their first hundred years is obvious.

In February, 1920, I was for a few days at Paradise, at the head of Lake Wakatipu, where milling was being carried on in the beech forest, and trees were being felled to supply material for the bridge over the Reece. A number of trees of *Nothofagus fusca* had been felled, and examination of these showed a well-marked youth and prime, and that later growth had been at a slower rate, though the rate did not decline uniformly. The oldest of these trees showed 213 rings, but it is probable that none had reached full age. Standing trees of much greater diameter were probably older, but they were generally hollow. I counted carefully the rings on four of the sound trees, and measured the diameter-growth for each period of five years. In Table A these results are shown for periods of twenty-five years, to correspond with those chosen for the totara. These figures, with the graphic representation, show the slowest growth during the first twenty-five years, relatively rapid growth during the next seventy-five, followed by a growth-rate slower than the maximum, but never coming to be so slow as that of the youth period. I do not suppose that the period of old age had been entered upon by any of these trees. The average for these four shows the greatest growth in the third of the twenty-five-year periods. The tree C made its greatest growth in the second period. Although I was able to count with sufficient exactness for tabulation the rings on only four trees, I was able to count those on seven other trees with sufficient approximation to exactness to show that the averages of the different periods as ascertained for the four could not be far wrong, if wrong at all, for the whole number.

In order to see whether the growth of younger trees was proceeding at the same rate I examined a number of saplings that had been felled. The figures obtained are given in Table B, II. They are given for ten-year periods, as the life of none of these saplings covered two full periods of twenty-five years. Also, the figures are given for the longest radius only,



not for the diameter. The reason for this is that growth in nearly every young tree of *N. fusca* is eccentric, and sometimes the amount of eccentricity is great. The total length of the opposite radius, usually the shortest, is noted. After from fifty to seventy-five years the eccentricity becomes corrected by the unequal later growth.

In Table B, I, the radial growth of the four big trees A, B, C, and D is given for the first four periods of ten years. A comparison of the Tables B, I, and B, II, shows that the growth of the forest saplings is very much slower than was that of the big trees. It seems likely that these old trees were among the original members of the forest, and had a much more abundant supply of light than they permitted their descendants to have.

The view expressed at the conclusion of the preceding paragraph gains support from examination of saplings grown without the competition of older trees. Beside the road, and on the original road-clearing near the head of Diamond Lake, are closely-crowded young trees, often with only a few square inches of soil-surface for each tree. In many cases they are drawn up to a height of from 20 ft. to 30 ft. Table B, III, shows the radial increase for six of these plants. For the first of the ten-year periods these made nearly three times the radial growth made by the forest saplings, and a greater growth than that made by the four big trees in their first ten years. Those that had completed a second period showed greater growth than the forest saplings in the corresponding period, but less than the big trees had made. On the whole, they tend to show that competition with trees of their own age has been less retarding of diameter-increase than competition with older trees would have been.

No record was made in the case of any tree of which the foliage was not available to make certain identification possible.

So far as I could learn, the road was made about twenty-two years ago. As beech-seedlings lose little time in starting, it is probable that some of those that I examined were among the first competitors on the newly cleared site. If so, there is no reason to suppose that two growth-rings have been formed in any one year.

The data here given are recognized as inadequate for the foundation of a theory, but are, I think, adequate to show that in measurements of our trees we should have regard to growth-periods, and should not be content with a statement that a tree of a given age has a stated diameter.

TABLE A.

Nothofagus fusca, Paradise, 17th February, 1920.

—	Example.	Age, in Years.								
		25.	50.	75.	100.	125.	150.	175.	200.	Over 200.
		Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
Diameter	A	54	142	246	336	402	438	610	700	742 (213 yrs.)
	B	32	102	218	368	462	562	628	696	710 (206 yrs.)
	C	68	190	280	340	390	468	486 (158 yrs.)		
	D	64	176	356	486	576	636	694 (174 yrs.)		
Average diameter ..		54·5	152·5	275·0	377·5	457·5	526·0	619·0	698·0	
Average increase in diameter		54·5	98·0	122·5	102·0	80·0	68·5	93·0	79·0	

Totara (*Podocarpus totara*) in Biology Museum of Victoria University College.

—	Age, in Years.							
	25.	50.	75.	100.	125.	150.	175.	200.
	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
Diameter ..	68	150	250	350	520	750	940	1,180
Increase in diameter	68	82	100	100	170	230	190	240

—	Age, in Years.							
	225.	250.	275.	300.	325.	350.	375.	396.
	Mm.	Mm.	Mm.	Mm	Mm.	Mm.	Mm.	Mm.
Diameter ..	1,528	1,838	2,042	2,188	2,320	2,384	2,452	2,528
Increase in diameter	348	310	204	146	132	64	68	76

Table B.

Nothofagus fusca: *Increase in Radius shown for Periods of Ten Years.*

I. Trees A, B, C, D, First Forty Years.

—	Example.	Age, in Years. 10.	20.	30.	40.
		Mm.	Mm.	Mm.	Mm.
Radius	A	11	21	33	53
	B	8	13	19	34
	C	9	23	44	75
	D	6	23	41	67
Average radius		8·5	20	34·2	57·3
Average increase in radius		8·5	11·5	14·3	23·0

II. Saplings in the Forest.

—	Example.	Age, in Years. 10.	20.	30.	40	—	Opposite Radius.
		Mm.	Mm.	Mm.	Mm.	Mm.	Mm.
Radius	E	5	11	18	31	41 (47 yrs.)	30
	F	4	14	22	35 (39 yrs.)	..	30
	G	4	9	15	34 (40 yrs.)	..	27
	H	4	9	22	27 (35 yrs.)	..	27
	J	4	10	23	27 (37 yrs.)	..	25
Average radius		4·2	10·6	20·0			
Increase in radius ..		4·2	6·4	9·4			

III. Saplings grown in Road-clearing.

—	Example.	Age, in Years. 10.	20.	30.	Opposite Radius.
		Mm.	Mm.	Mm.	Mm.
Radius ..	K	10	18	19 (21 yrs.)	11
	L	13	19 (12 yrs.)	..	12
	M	16	18 (11 yrs.)	..	5
	N	14	19 (16 yrs.)	..	9
	O	9	16	17 (21 yrs.)	10
	P	5	7 (14 yrs.)	..	5
Average radius		11·2			

Art. XLVIII.—*Maori Food-supplies of Lake Rotorua, with Methods of obtaining them, and Usages and Customs appertaining thereto.*

By Te Rangi Hiroa (P. H. Buck), D.S.O., M.D.

[*Read before the Auckland Institute, 15th December, 1920; received by Editor, 31st December, 1920; issued separately, 12th August, 1921.*]

Plates LXIV, LXV.

Discovery and Settlement of the Rotorua District.

Ngatoroirangi, the *tohunga* and navigator of the "Arawa" canoe, was the first from that canoe to explore the Taupo district. Kahumata-momoe, the younger son of Tama-te-kapua, also journeyed to Taupo. On his return to Maketu he saw Lake Rotorua and named it Te Moana-nui-a-Kahu (the Great Lake of Kahu). The real settlers were Ika, one of the crew of the "Arawa," and his son Maru-punga-nui, who came via Lake Rotoiti, and who lived at Okapua, where there is a pool named Te Korokoro o Maru-punga-nui. The following genealogy will help us to follow matters:—

Tama-te-kapua
- Tuhoro-mata-kaka
  - Ihenga.
- Kahu-mata-momoe
  - Tawake-moe-tahanga
    - Uenuku
      - Rangitihi
        - Tuhourangi
          - Uenuku-kopako
            - Whakaue.

Ika
- Maru-punga-nui
  - Tua-rotorua.

Ihenga, the grandson of Tama-te-kapua, to whom is given the credit of the discovery, did not come to the lake until Maru-punga-nui and his son Tua-rotorua were firmly established there. Ihenga had been away with his father and grandfather at Moehau, Cape Colville, and came on to Maketu after the death of Tama-te-kapua. There he married Kakara, the daughter of his uncle Kahu. According to Grey's narrative, he went out hunting in the direction of Lake Rotoiti. His dog went farther on and reached the lake, where it had a meal of fresh-water fish. On its return to Maketu, fish were seen in its vomit, and hence Ihenga surmised an inland lake or sea. It is curious, if his father-in-law Kahu had seen the lake, that a dog should be the first to inform Ihenga of its existence. Another version states that Tama-te-kapua, without seeing it, named it after his son. However, Ihenga set off and came upon Lake Rotoiti at a beach called Paripari-te-tai, where he saw the footprints of his dog. He returned to Maketu, organized a party, and came on past Rotoiti to Lake Rotorua, where he built a *pa* at Whakarongo-patete. His pool for viewing himself, known as Te Wai Whakaata o Ihenga, is still to be seen. He came across the altar-place of Tua-rotorua at Utuhina, the stream by Ohinemutu. This he interfered with, and then ensued the bluff between himself and Tua-rotorua. He pointed out the cliffs in the direction of Te Ngae as his fishing-nets, hanging up in the sun to dry. To this Tua-rotorua seems to have tamely submitted, in spite of the fact that he must have seen those self-same cliffs daily for some considerable time. Probably Tua-rotorua, not knowing how many men Ihenga had behind him, deemed it advisable to acquiesce; at all events, he withdrew with his people. Some time after, Kakara, wife of Ihenga, was killed at Owhata, and her entrails were caught on a post, or *tumu*, near Waiteti. This rendered the lake *tapu* to Ihenga, and he left the district. The lake is alluded to in song as Te Roto Kite a Ihenga (the lake discovered by Ihenga).

Taipari, of Ngati-Kea, composed the following lament for his child, who was fatally burned through accident:—

Te kiri o te tau e . . .
Ka ka i te ahi na Whanui na Raumati
I tahuna ai Te Arawa e . . .
Patua te kakara ki runga o Titi-raupenga kia Maka e . . .
Koia te hamama o Tia ki runga o Maketu,
Tika mai i kona e . . .
Na Owhakamiti mai te ara,
Ko Paripari-te-tai,
Ko *te roto kite a Ihenga,*
I ariki ai Kahu.
Taku totara whakarangiura e . . .
Tena ka tere ki roto o Aorangi e . . .

[Translation.]

The skin of my loved one, alas!
Scorched by the flame,
Lighted by Whanui and Raumati,
Through which the Arawa canoe was destroyed. Ah me!
Send forth a sweet-scented savour to Maka at Titi-raupenga.
This was the call of Tia to Maketu:
"Come hither from there."
The path led through Owhakamiti to Paripari-te-tai,
To *the lake discovered by Ihenga,*
Through which Kahu became high chief.
My *totara* that brightened the heavens
Has drifted away to Aorangi. Alas! Ah me!

The descendants of Tama-te-kapua now lived on at Maketu, until the time of Rangitihi, when they reinvaded the lake district. Some fierce battles were fought with the Kawaarero, descendants of Tua-rotorua, who inhabited the island of Mokoia. Finally the Kawaarero were defeated and driven out of the district. The island was then divided up between Uenuku-kopako (see genealogy) and Taketake-hikuroa. Uenuku-kopako held the Rotoiti side of the island, where there were no hot springs. Taoi, his wife, after childbirth, desired to bathe in a hot spring known as Waitapu, but Taketake-hikuroa objected to the trespass on his part of the island. Rangi-te-aorere, a noted warrior, who had taken chief part in the subjugation of the Kawaarero, took Taoi to the bath. Taketake-hikuroa, owing to this affront, left the island, thus abandoning his share, when the island was divided up among the three wives of Uenuku-kapako—namely, Rangi-whakapiri, Hine-poto, and Taoi. Through the descendants of these wives the threefold division was maintained to modern times.

With regard to Taoi, who came from Ngati-Maru, an interesting tale is told. There is a long shoal stretching from Owhata to Kawaha. The Maori have an idea that above this shoal there is a distinct ridge in the water, which is called Te Hiwi o te Toroa (the Ridge of the Albatross). Taoi was well tattooed on the buttocks and thighs (*rape* and *puhoro*). Uenuku, paddling over the ridge with his three wives, was desirous of letting his other two wives see Taoi's tattooing. He could hardly ask Taoi to expose herself to satisfy the curiosity of the others, so he arranged a diving match to see which of them could bring up a fresh-water mussel from the sandbank below. Taoi had ornaments of albatross-feathers in her ears. She stripped, uttered an incantation, and dived. First an albatross-feather floated up from below, and then Taoi broke the surface with a handful of sand. The purpose had been accomplished—the other wives had seen Taoi's tattooing. In memory of her deep dive the ridge was named, after the albatross-feather that had floated up, Te Hiwi o te Toroa (the Ridge of the Albatross).

Food-varieties.

In pre-trout days the lake teemed with food which to the Maori palate was far more appetizing than the introduced trout which has displaced so much of it. The varieties consisted of a shell-fish, a crustacean, and three kinds of fish: *kakahi*, the fresh-water mussel (*Unio*); *koura*, the fresh-water crayfish (*Paranephrops*); *inanga* (*Retropinna richardsoni*); *toitoi* (*Gobiomorphus gobioides*); *kokopu* (*Galaxias fasciatus*). Of these the most famous to outside tribes was the *koura*, which, though found in nearly all fresh-water streams, could nowhere be found in such quantities as at Rotorua. The *kakahi* had the greatest reputation locally.

The *koura* came in in October, and lasted from November to March. They ceased to be fat in April. *Inanga* and *kokopu* were in season from December to February, and perhaps to March; *toitoi*, from May to September. *Kakahi* were obtained throughout the year, but were best in the winter.

In the case of these food-supplies there was no significance in the days of the month, but they were affected by the winds. Certain fishing-grounds were good during certain winds, whilst others were useless. A good wind was that known as Hau-a-uru Tipoki, which lasted about three weeks. Then the Rauporua ground teemed with fish, and the netting could go on for the whole time without the supply becoming exhausted. The moment the wind changed the fish sought other grounds. It would be fitting, perhaps, to give the nights of the month according to the Arawa for the purpose of record:—

1st—Whiro. The moon is not seen.
2nd—Hohoata or Tirao.
3rd—Oue.
4th—Okoro.
5th—Tamatea-tutahi.
6th—Tamatea-turua.
7th—Tamatea-tutoro.
8th—Tamatea-tuwha.
9th—Huna.
10th—Ari.
11th—Mawharu or Maurea.
12th—Hotu.
13th—Ohua.
14th—Atua. Moon rises at sunset, and hence has a red appearance.
15th—Rakaunui.
16th—Rakau-matohe.
17th—Takirau.
18th—Oika.
19th—Korekore.
20th—Pirikorekore.
21st—Tangaroa-a-mua.
22nd—Tangaroa-a-roto.
23rd—Kiokio.
24th—Otane.
25th—Orongonui.
26th—Mauri.
27th—Mutu.
28th—Mutuwhenua.

Fishing-grounds.

The old-time Maori, a careful and observant student of nature and all matters connected with food-supplies, soon ascertained the parts of the lake where the various foods were most plentiful and most easily procured. These spots became the fishing-grounds, carefully marked and jealously guarded by the various subtribes and families. They were given names, and the most famous were alluded to in song and story. Such were Kaiore, *te whare o te koura, o te toitoi* (the home of the *koura* and the *toitoi*), and Te Taramoa, where nets were drawn and *tau* were set. Patua-i-te-rangi, in a lament for Te Ao Karewa, who was drowned in the lake, sang as follows :—

E hine e Pare, e Pare kinokino kia au ki to kuia,
E kore korua ko to tungane e puta i Te Ponui-a-Rerenga.
E kukume ana te au o te taua ki o papa.
Na Ngati-Whakaue te riri i tuku atu kia hoki,
Kia ata noho e te tangata,
Kauaka e rere ki te tau poito.
Ki ta ia tangata kupenga ra.
Piki ake ra e hine
Ki o taumata e rua ki Taupiri ki Te Rewarewa,
Kia marama koe te titiro
Ki te moana ki o whaea,
E moe ake ra Te Ao i tona whare kinokino,
I te whare kai a te tangata, ko Kaiore,
Ko Kaiore tukunga porohe ki te parenga ki Te Taramoa.
Puruatia o mawhiti, he puru whare no Te Whakaruru e . . .

From the fourth line this may be translated roughly as follows :—

It was Ngati-Whakaue who turned back those seeking strife,
And (advised) that man should live in peace—
Not to meddle with the *tau* kept up by floats
Or with the nets of other men.
Ascend, O little maid,
The two summits, Taupiri and Te Rewarewa,
That thou mayest clearly view
The lake and your elders,
Where Te Ao sleeps in her house of death,
The house of the food of man, Kaiore—
Kaiore, where the *toitoi* traps are set in the direction of the shore, towards
Te Taramoa.

Te Moari was famous as Te Moenga o te Kokopu (where the *kokopu* sleeps). The big drag-nets were used on this ground. Of the *kakahi* grounds the most famous of all was Tahunaroa, another famous one being Te Rau Tawa.

Landmarks.—Some of the grounds were located by sighting conspicuous objects ashore and getting a cross-bearing between two sets. The Tahunaroa ground, for instance, was picked up as follows : A line was taken from a large cabbage-tree on the lake-shore near Owhatiura to a small clump of trees known as Te-Rau-o-te-Huia, situated on the hills at the back of Owhata. Keeping on this line, the canoe paddled forward or back until a certain conspicuous slip in the Arikikapakapa Reserve, near Whakarewarewa, was in line over the top of some small islands, known as Motutere, n the lake-arm at the back of the present Sanatorium. The canoe was now on Tahunaroa, and down went the pole with the absolute certainty of striking bottom.

Other marks were the natural objects in the water, such as rocks. Such a one was Pātuwhare, a rock off the shore of Mokoia, out from the bath of Hinemoa. It is said to have split before the fall of Mokoia to the Ngapuhi under Hongi, thus giving ominous warning of impending disaster.

Tumu.—As, however, the grounds were not too deep, the commonest marks were posts called *tumu.* They served the double purpose of marking the ground and for the fastening of one end of the *tau* of *aka* vine which carried the fern bundles intended to trap the shelter-seeking *koura* and *toitoi.* They also marked ownership, and hence were often named after ancestors. The best woods to withstand the water were *rewarewa* (*Knightia excelsa*) and *kaponga* (*Cyathea dealbata*). As most of the grounds were marked in this manner, the number of *tumu* in the lake was very considerable, and served to mark the boundaries of the various subtribes and families. They were especially numerous around Mokoia. The launches and punts used for carrying sulphur up from Lake Rotoiti were responsible for the disappearance of many. Such a plebeian fate befell Hinewhata, famed for having given breathing-time to Hinemoa in her famous swim to Mokoia, whither she was lured by her love for Tutanekai and guided by the music of his *koauau.*

Hinearanga marked the famous Kaiore ground already alluded to. Te Taramoa was also the name of the *tumu* which marked the Taramoa ground. Others were named Morewhati, Te Kopua-a-Tamakari, Te Moari (still standing), and Hinerimu.

Many *tumu* were carved, such as Te Roro o te Rangi, carved on the top to represent a human figure. It may still be seen. Tu te Whaiwha is still standing, but the part above water-level was knocked off. It is about 6 in. in diameter, and is surmounted by a modern sign. Rongomai was carved, and originally stood near Mokoia, but it developed wandering propensities (*he tumu haere*), and is looked upon as a *taniwha.*

Between Waimihia and Ngongotaha once stood four *tumu,* named Irohanga, Te Huka, Potangotango, and Te Kaea. The origin of these names is interesting. In the genealogy given below the descendants of Tamarangi went to Waikato, whilst those of Kaimataia remained at Rotorua.

- Tamarangi
  - Pukauae
    - Irohanga
    - Te Huka
    - Potangotango
    - Te Kaea.
- Kaimataia
  - Te Roro-o-te-Rangi
    - Te Waha-o-Poroaki
      - Manawa.

Te Kaea made an eel-weir in Waikato and named the *paepae* (one of the beams) after Manawa. The news reached Manawa, and, not to be outdone, he immediately named four *tumu* in the lake after Te Kaea and his three brothers.

The *tumu* against which the entrails of Kakara, wife of Ihenga, were caught was called Hakaipuku. Some *tumu* were forked, to distinguish them from others: such were Tapaeo and Nga-kuha-o-te-Hauwhenua.

From the above it will be seen that the *tumu* in the lake were used like surveyors' pegs in modern times: they marked off the parts of the lake that belonged to the various families and subtribes. Undoubtedly more of the lake was pegged off than the part in the immediate neighbourhood of the shore, which proves how valuable it was considered as a source of food-supply. It was far more valuable to the old-time Maori than any equal area of land.

Ropes.

For use in the dredging operations to be described a special kind of rope was manufactured by which to draw the canoes carrying dredge-rakes or dredge-nets towards a driven-in pole to which an end of the rope had been attached. This special rope was made from the leaves of the cabbage-tree, or *whanake.* It was plaited in the ordinary three-ply plait, usually by old men sitting in the hot pools (*waiariki*). The hot water softened the leaves and rendered the work easier. The butts of the leaves were allowed to project slightly. In hauling on such ropes they were softer to the hands than the usual ropes, and the projecting butts gave a securer hold.

Methods of procuring Supplies.

There were four main methods of procuring supplies. There were probably minor methods by means of small traps and hand-nets, but the following were the methods of procuring in quantity: (1) *Tau koura,* for obtaining *koura* and also *toitoi ;* (2) *kupenga,* or nets, for *inanga and kokopu ;* (3) *paepae,* or dredge-nets, for *koura ;* (4) *kapu* or *mangakino,* or dredge-rakes, for *kakahi.*

1. *Tau Koura.*

The *tau* was, and is still, the favourite method of obtaining *koura.* The process depends on the fact that if bundles of fern are allowed to rest on the lake-bottom the *koura* swarm in between the leaves and rest there. Best* quotes the Rotoiti people as stating that the *koura* feeds on the *nehu,* or pollen, of the fern. The Rotorua people say that when the *nehu* is on the fern the *koura* are fat.

The fern (*Pteridium esculentum*) is carefully selected, being taken from certain grounds near the cliffs and high lands, never from the flats. There are famous fern-grounds, such as Kawarua, Te Tiepa, and Hauroro. Battles have been fought in ancient times for the possession of such grounds, thus proving the importance attached to the right kind of fern. As the Maoris said, the characteristics of such fern were *he kakara, he ngawari, kaore e whati* (it was sweet-scented, it was pliable, and would not break or snap). The fern was carefully pulled from the ground and left near the shores of the lake to dry—*ki tatahi tahua ai*—the drying process lasting about a week.

For each bundle about twenty stalks, with leaves intact, were selected. The stalks were all placed in the same direction, and after a long strand of the stem of a climbing-plant (*aka*) had been run down the middle of the bundle of stalks a finer piece of *aka* was bound round and round the stalks near the butts to keep the bundle firmly together. The *aka,* or climbing-plants, used were *aka turihanga, aka puha, aka kiore* (*Parsonsia rosea*), *aka pohue* (*Metrosideros florida*). The *aka* used to bind the stalks together was called, no matter what its botanical name, the *aka tahua,* from its function. The length of thicker and stronger *aka* was to form the line by which the bundle was to be fished up from the lake-bottom. It was called

* Elsdon Best, *Trans. N.Z. Inst.,* vol. 35, p. 77, 1903.

the *pekapeka*, and was of sufficient length to reach from the lake-bottom to the surface, where it was fastened to the *aka tauhu*, or simply *tauhu*.

The *tauhu*, or ridgepole, consisted of a stronger length of *aka*, about 2 in. thick. One end was usually attached to a *tumu*, or post, marking the crayfish-ground, the other being fastened to a *poito*, or float. The *pekapeka* were attached along it at intervals of 10 ft. To prevent the line of the *tauhu* being altered by winds or currents, a *punga* (anchor) was often attached by a line to the *tauhu*.

The complete *tau* is shown in the diagram (fig. 1). When set on the *koura* ground the *tauhu* line is fastened at one end to the *tumu* at the water-level, and kept on the surface, like the top rope of a net, by floats. Every 10 ft. along its length a *pekapeka* line hangs down to the bottom of the lake, with a fern bundle attached to its end by an *aka tahua*. Into these bundles the *koura* make their way and await their fate.

Before, however, the owner of the *tau* can secure the trapped *koura* he must be provided with a *korapa*, or hand-net. The *korapa* is shaped somewhat like a tennis-racquet on a large scale, without a handle. The frame is made of *toatoa* wood (*Phyllocladus trichomanoides*), which has a springy, elastic fibre. The two ends are brought round in an oval, lashed together, and strengthened by a cross-piece a few inches above this binding. A flax net, with very little bag in it, is stretched across the frame.

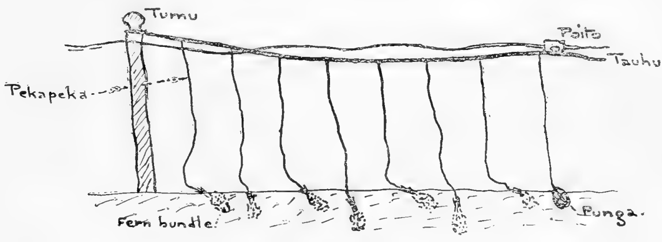


Fig. 1.—The *tau koura*.

The process of securing *koura* by means of the *tau* is known as *tătă koura*. If the owner of a *tau* invited you to accompany him to secure his catch he would say, *Ka haere taua ki te tătă koura* (Let us go and *tătă koura*). This is an idiomatic phrase that applies only to the *tau*. Having embarked on his canoe, he made his way to the ground and picked up the *tauhu* at the *tumu*, or post. He then hauled along the *tauhu*, hand over hand, until he reached the first vertical line, or *pekapeka*. He then drew up the *pekapeka*, evenly and smoothly. The *koura* lay in the leaves of the fern, and the movement, if not too sudden, had no disturbing effect upon them whilst the bundle was still in the water. Exposure to the air, however, was a different matter—as probably many of us will remember from our juvenile experiences in attempting to lure a fresh-water crayfish ashore on a bent pin baited with a worm: it will come to the surface clinging on tenaciously, but immediately it breaks the surface it lets go and kicks for the bottom again. The old-time Maori was acquainted with this characteristic of the *koura*, and hence the invention of the *korapa*. Up came the *pekapeka*, hand over hand, until the butts of the stalks of the fern bundle appeared above the surface. Then the *korapa* was gently inserted between the fern bundle and the canoe. The butts of the stalks rested against the lashed end of the *korapa* just out of water, whilst the mass of the leaves of the fern bundle, still under water, rested against the submerged broad face of the *korapa*. The two were drawn up together, and just as the leaves of the fern were about to reach the surface there was a quick pull, with leverage against the canoe-side. In the latter stage of this pull the arms were assisted by the naked foot treading on the cross-bar of the *korapa*. The fern bundle left the water in a horizontal position with the *korapa* beneath it. The *koura*, kicking backwards for home, were intercepted by the net of the *korapa*, and shared the fate of those that the inner recesses of the fern bundle had lulled into false security. The *korapa* and fern bundle having been brought into the canoe, the leafy end of each stalk was carefully shaken until all the contents rested in the bottom of the canoe. The bundle was then returned to the water, and the canoe drawn hand over hand along the *tauhu* to the next *pekapeka*. In this manner the process was repeated to the end of the *tau*. By this time, if the season were good, the canoe would be laden to the gunwales.

In ancient times there were thieves, as now, and a good *tau* was liable to be raided. A thief was known as a *korara*, and, as he was generally in a hurry, he did not use a *korapa*, or net. In some cases the owner of a *tau*, to save himself from the depredations of these fresh-water pirates, would do without a *tumu* and floats, and thus allow the *tauhu* line to sink to the bottom. This procedure left no surface marks to serve as a guide for thieves. The owner, to ensure his picking up his *tauhu*, would mark the line of his *tau* by selecting landmarks ashore which would lie across this line. When he went to collect his catch he would paddle out till he picked up his landmarks, and then dredge across the line of his *tau*. This necessitated a dredge-hook, or *marau*, as part of his equipment.

The *marau* consisted of a three-pronged piece of wood, made from the part of a tree where two branches on the same level forked out from the trunk. A stone was lashed between two prongs, and a rope tied to the third or upper prong. With this dragged along the bottom, across the line of the *tau*, the *tauhu* was picked up, and the usual procedure carried out.

That the *marau* was necessary as a protection against thieves is proved by the song alluding to the Kaiore and Taramoa grounds. In it the poet states that men should live without creating trouble, and not meddle with the *tau poito*, or *tau* kept up by floats.

On some grounds, and in the appropriate season, the *tau* was also used to snare the *toitoi*, which took refuge in the fern bundles like the *koura*. When used in this way the *tau* was also called a *porohe*. In the song quoted above, the famous fishing-ground of Kaiore is alluded to as *Kaiore tukunga porohe* (Kaiore, where the *toitoi* traps are set). The Rev. Fletcher* records that at Taupo the *tau* was used for catching *kokopu* as well as *koura*.

Best mentions the fern bundle as being called a *taruke* at Lake Rotoiti. As he states, the *taruke* is a trap used for catching sea-crayfish. Probably the Rotoiti people have adopted this word from their coastal relatives.

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* Rev. H. J. Fletcher, *Trans. N.Z. Inst.*, vol. 51, p. 260, 1919.

FIG. 1.—*Tau koura.* The *korapa* being slipped down between the canoe and the fern bundle, still submerged.

FIG. 2.—*Tau koura.* The *pekapeka*, with the stalk end of the fern bundle, being drawn up against the *korapa*.

Face p. 440.]

Fig. 1.—*Tau koura.* Completely out of water by leverage against side. Note attitude of right foot, which is pressed on bar of *korapa.*

Fig. 2.—*Tau koura.* The catch from one fern bundle. Note the *marau*, or grappling-hook, held by one of the men.

(2.) *Kupenga* (Nets).

Nets were used for *inanga* and *kokopu*, but *toitoi* were also caught in them. The same kind of net did for all. My notes are somewhat meagre, as these old flax nets have long since passed out of date, and no sample survives to enable a more minute description being given. The nets were several chains long, and some are reported to have taken as long as three years to complete. They were made in parts, different parts being often allocated to various subtribes. When these parts or sections were completed they were assembled and joined together.

The most important section was named the *konae*. This formed the middle section of the net, and when the ends were hauled in it formed the belly, which held the fish. It was the first section to be made, and was started by two or three skilled men. They worked on through the night and never slept on their work. In the dark the width of the mesh was measured by the finger-nail. Blind men have been skilled *konae* weavers. After some progress had been made, others joined in and the work went on quickly. My informants stated that an unskilled man could not get a strip of flax in, as the net was constantly moving.

On either side of the *konae* there was a section called the *whakahihi*. This had a coarser mesh, and served to drive the fish back into the *konae*. Anaha, the famous old carver at Rotorua, who was alive when these notes were taken, gave different divisions to the nets. He maintained that the sections next to the *konae* on either side were the *upoko roto*, then came the *whakahihi*, and lastly the *matatu*. Probably this applied to the very large nets, which would thus be made in seven sections. The number of sections led to the following classification:—

(1.) *Kupenga nui*, with all the sections described by Anaha.

(2.) *Koroherohe*, a smaller net used at Mokoia Island for *koura*, *toitoi*, and *inanga*. This consisted of three sections, the *konae* and two *whakahihi*.

(3.) *Pahikohiko*, used near the shore, as at Rauporoa. In this net there was no *matatu* section at either end. A pole was fixed at each end and the net drawn without canoes, the *inanga* being driven into the net, or various shoals cut out.

The nets were, of course, furnished with *poito*, or floats, made from the *whau* (*Entelea arborescens*), and attached to the *kaha runga*, or top rope. The *poito* over the middle of the *konae* was of larger size, and was usually carved. In the large nets there were two additional carved *poito*, one on either side, situated at the junction of the *whakahihi* and the *matatu*. These carved *poito* often had names given to them. The central one was famous enough to pass into a saying—*Te poito whakarewa i te kupenga* (The float that lifts the net). Great chiefs were alluded to in these terms, for as the carved float of the *konae* lifts or supports the net, so the tattooed chieftain of old uplifted his tribe.

Karihi, or sinkers of stone, were attached to the *kaha raro*, or bottom line of the net. They were tied to the back of the line so as not to be worn by the sand.

The famous nets were named. Such a one was Tipiwhenua, which belonged to the Ngati-Pehi Hapu. It was 300 yards long without the end ropes. Another famous net was Te Whenuataua, belonging to Ngati-Tunohopu.

When the canoes came ashore with a good catch of *inanga* the women-folk would be waiting with their baskets to obtain their share. In those communistic days nobody went empty away, but, at the same time, a distinction was made in favour of the workers. One man usually doled out the fish in double handfuls. He had to be a just man who would not unduly favour his own relatives. More was given to the women of those who had got wet skins through working. The phase used was, *Engari tena; he kiri maku* (That one is right; a wet skin). On the other hand, when the womenfolk of a non-worker approached with their baskets the cry was, *Hirangi, hirangi; he kiri maroke. Hirangi* means "not deep," hence the significance of the phrase is easily understood: "Not deep, not deep; a dry skin."

In netting *inanga* the large canoe which carried the net was called *waka uta kupenga* (the canoe which carries the net). This phrase was used for people of some importance. On the other hand, there were often small canoes towed along, into which the fish were emptied from the net. These canoes were used for fish alone, and were called *waka kaitiiti*. The name was often applied to persons of no importance.

Uhu and Waro, chiefs of the Ngati-Whakaue, were one day looking at a good catch of *inanga* where the few live fish on the surface were jumping about on the mass of dead ones below. One of them observed to the other, *Kia pena pea taua mo te riri* (Would that we were like that in battle). Their warlike spirit aspired to be leaping hither and thither over the heap of dead, slain by their prowess.

(3.) *Paepae*, or Dredge-net.

The *paepae* is a net that is dredged along the bottom to catch *koura*. In *Bulletin No. 2* of the Dominion Museum there is one shown in fig. 64 and fig. 78. In fig. 78 Hamilton calls it a "*roukoura*, or dredge-net, from Rotorua." The Arawa people of Rotorua call this net a *paepae*, never a *roukoura*. *Rou* means "to reach or procure by means of a stick or pole": there is no pole used with this net, hence the name is inapplicable.

The *paepae* derives its name from the lower beam of the frame which carries the bag net. The one I saw in use was 10 ft. long and 4 in. wide by 1½ in. thick. The upper edges were rounded off. The timber used is *manuka* or *maire*. Holes are bored through to support the uprights, to be described later. Good *paepae* are carved at either end and midway, and sometimes half-way between these points.

The *whitiwhiti* is an arched rod of *manuka* inserted at each end into holes in the ends of the *paepae* beam. The *paepae* and *whitiwhiti* frame the opening of the net. To strenghten the *whitiwhiti* a number of uprights are let into the holes bored in the *paepae* and, passing behind the *whitiwhiti*, are firmly lashed to it. The *pouwaenga*, as its name implies, is the middle upright. It is stouter and stronger than the others, as the main rope is fastened to it when the net is being hauled. It is also grasped when lifting the net into the canoe. The measurements of these uprights are shown in the diagram. About 2 ft. 3½ in. on either side of the *pouwaenga* are the uprights named *tangitangi*. They are fixed in the same way as the *pouwaenga*, but are not so stout. In the angle between them and the lower beam, on the outer side, stone *punga*, or sinkers, are attached to the *tangitangi*. Six inches from either end of the lower beam are short uprights slanting outwards but fixed in the same manner as the preceding. They are named *punga*, because stone *punga* are attached to them, as shown in the diagram. Side ropes are also attached to them and led to the main rope, to which they are tied.

Ropes.—The main drag-rope is tied to the *pouwaenga.* The side ropes tied to the *punga* uprights are called *tangitangi,* the same name as the second set of uprights. They join the main rope about 4 ft. from the *pouwaenga.*

The net of the *paepae* has no special name. The one I saw had a $2\frac{1}{4}$ in. mesh. The opening of the net was fitted to the framework of the *paepae* and *whitiwhiti.* From this opening the net gradually narrowed down to a point about 10 ft. 10 in. away. To this point was attached a piece of rope 7 ft. long, which carried the *punga,* or *koremu* (the stone sinker).

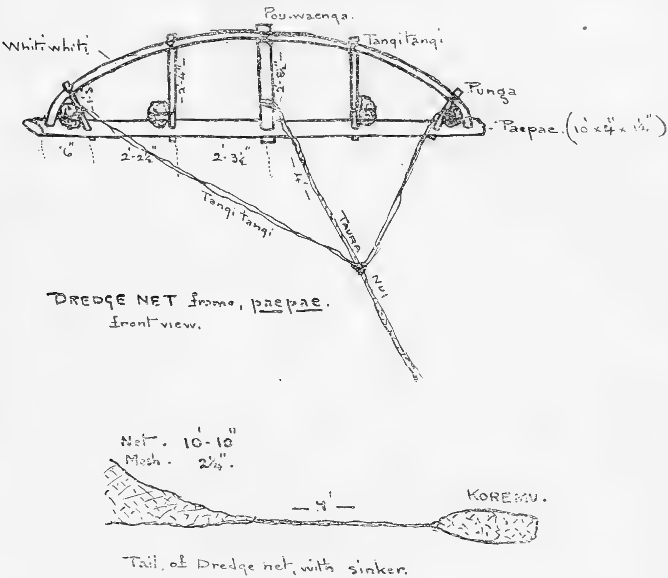

Fig. 2.—*Paepae,* or dredge-net.

I saw Ngati-Uenuku-Kopako at Mokoia Island with a *paepae* of which the arch, or *whitiwhiti,* was composed of thick, plain wire. The *paepae* bar was 10 ft. 8 in. long, and extra uprights were inserted between the *punga* and *tangitangi* uprights These were called *whitiwhiti,* the same name as the arch.

Naming.—As in the case of other nets, good *paepae,* which caught large catches, were named after ancestors or near relatives.

Method of Dredging.—When collecting these notes we went hauling on the Moari grounds off Mokoia. The first procedure was to plant a long pole, called a *turuturu,* firmly into the bottom of the lake, on one edge of the rather shallow fishing-ground. A fairly long rope of *whanake* leaves was tied near the bottom of the *turuturu* before it was thrust down. It takes a skilled man to plant the *turuturu.* On touching bottom it is gently twirled with one hand, and gradually insinuated more and more deeply until it is considered that it can stand the strain of having the canoe drawn towards it from the end of the rope. It will be noticed that the rope is tied to the bottom of the *turuturu* so as to take the strain and prevent leverage. If not skilfully and firmly planted, when a strain is put on it the *turuturu* comes up. This was considered an ill omen, and was called *he take maunu* (a loosened support), and in olden days the man who planted such a *turuturu* would promptly be struck with a *taiaha* or club. If he were man enough he would guard the stroke, leap overboard, and swim ashore, no matter how far.

The *turuturu* having been securely planted, the canoe paddled away from it. The *whanake* rope was paid out until the end was reached. As the canoe paddled towards the end of the rope a landmark was taken to keep the line of the canoe. The net was now put over the side. The sinker was lowered first and allowed to tighten up before the net left the hand. If this were not done the net would be liable to get twisted and the arch go under, causing the *paepae* to be dragged along upside down. This accident was called *karitutu,* and resulted in no fish being caught. On hauling up an empty net the disappointed fishermen would say, *E, i karitutu ta taua kupenga* (Alas, our net was upside down).

Enough rope was paid out to ensure the *paepae* resting on the bottom. The drag-rope of the net was then tied to the canoe. The canoe was hauled by the *whanake* rope towards the *turuturu,* and the dredge-net, tied by its rope to the canoe, was dragged along the bottom. The man hauling on the rope had the opportunity of " putting on side " by stretching out with full-arm reaches to grasp the rope and then straightening his back in a spectacular manner. This was the correct thing to do : *Kia maro te tuara* (Straighten the back). Either hand was used alternately, and the bight of the rope as it came in was dropped in a figure-of-eight coil—not in a single coil, as with Europeans. The canoe was not hauled too close to the *turuturu,* lest it should be loosened. When near enough, the rope was tied to the canoe and attention directed to the net. The experts could always tell as they hauled in whether there was a good catch. The weight of the crayfish caused the *paepae* to lift and the net to roll about. *Ka tahurihuri te kupenga, he tohu kua mou te koura* (When the net rolled about it was a sign that *koura* had been caught). As the net came up, the *pouwaenga* was grasped and the framework lifted clear of the sides of the canoe ; the other parts were then drawn in.

If the net was filled with *koura* more than the span of the two arms it was an evil sign—*he iro tangata.* The tale would be whispered round the village, *Ko te kupenga a mea, na te waha o te paepae i whakahoki te koura* (The net of So-and-so, it was the mouth of the net that stopped the *koura*). This was a sign of death—an *aitua,* an *inati.*

The crayfish having been emptied out of the net, the canoe was paddled back to the end of the rope ; but by carefully observing their landmark a spot was made for a few yards to the right or left of the last drag. This was done on each drag, so as to ensure the same ground not being gone over twice. In the old days a couple of drags would secure a quantity equal to the contents of a sack or two. Often there would be a dozen canoes on the same ground competing one against another.

Sometimes a canoe was tied to the *turuturu* and remained stationary whilst another canoe worked backwards and forwards to it with the drag-net. In this case there were two ropes tied to the base of the *turuturu.* One was drawn taut and tied to the bow of the stationary canoe, and the other to the stern. The hauling-rope of the drag canoe was paid out from the stationary canoe. This brings up an incident that occured after the fall of Mokoia to the Ngapuhi under Hongi. The Ngapuhi, anxious to sample the famous *koura* of Rotorua, ordered some of their prisoners to accompany them to the fishing-grounds and drag for *koura*. A fishing-ground near the mainland by Te Ngae was selected by the prisoners. A large canoe containing the captors was fastened to the *turuturu*. One can imagine, in the light of what subsequently occurred, how carefully and firmly that *turuturu* was thrust in by the prisoners. The prisoners entered a small canoe with a dredge-net, and, paying off the rope, paddled off towards a point on the mainland. There were no Ngapuhi on this canoe, as, being unskilled, they did not wish to be in the way of the workers. As the canoe paddled away, its speed gradually increased, and on the end of the rope being reached, instead of pulling up, the rope was cast overboard and the canoe driven for shore at full speed. The Ngapuhi, with yells and threats, started to uproot the *turuturu*, but before they could get going properly the fugitives had landed and made their escape.

Dr. Newman, in his article " On Maori Dredges,"* quotes Mr. L. Grace as stating that at Lake Taupo, when using the *hao*, or toothless dredge, the rope was tied to a tree on the bank and the canoe then rowed out to the full length of a many-fathomed rope. In Lake Rotorua, where the fishing-grounds were some distance from the shore, the *turuturu* took the place of the tree.

Best mentions the *paepae* as being used to catch *koura* in the lakes by being dragged along the bottom. But though his article deals with the food-supplies of Tuhoeland, this remark follows after mention of fern being used to catch *koura* at Lake Rotoiti, and I take it to apply to the Lakes District and not to Tuhoeland.

(4.) *Kapu, Mangakino*, or Dredge-rakes.

It is curious that the *kakahi*, or fresh-water mussel, whilst the least appetizing of the lake food-supplies, is the most important in story, song, and proverb. For instance, there is an old saying—*Tane moe whare, kurua te takataka ; tane rou kakahi, aitia te ure* (Man drowsing in the house, smack his head ; man skilled in dredging *kakahi*, marry him). There is no exhortation of a similar nature applied to men skilled in netting *koura*, *toitoi*, *inanga*, or *kokopu*, and we must conclude that the prize for relish was awarded to the *kakahi*.

The dredge-rake may be described in three parts—the wooden frame, the net, and the pole or handle.

(*a*.) *Kapu, Mangakino*, or Wooden Frame.—The wooden frame carries the teeth of the dredge-rake, and to it are attached the net and the handle. It is called *kapu* or *mangakino*, and gives its name to the whole apparatus. Both Hamilton and Newman call it a *roukakahi*. This is a misnomer, as I shall point out later. The *kapu*, or *mangakino*, is always made of *manuka* wood, so as to stand the strain. By consulting the diagram it will be seen that it is made in two pieces and then lashed together above and below in the mesial line. Each part consists of a horizontal bottom beam, a bend, and an ascending upper arm.

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* *Trans. N.Z. Inst*, vol. 37, p. 138, 1905.

The horizontal bottom beam is called the *paetara* (lower beam with points). It carries the wooden teeth, or *tara*, which are about 6 in. long. They are lashed to the under-surface of the beam with fine *aka* or with fibre of the *Phormium tenax*, and then a thicker piece of *aka* is woven in and out in figure-of-eight turns to finish off. The number of teeth are usually about two dozen. The two halves of the *paetara* are joined on a slant, and *aka* or fibre lashings passed through holes drilled on either side. The overlap in the *paetara* I saw in use was 17 in., and its total length 44 in.

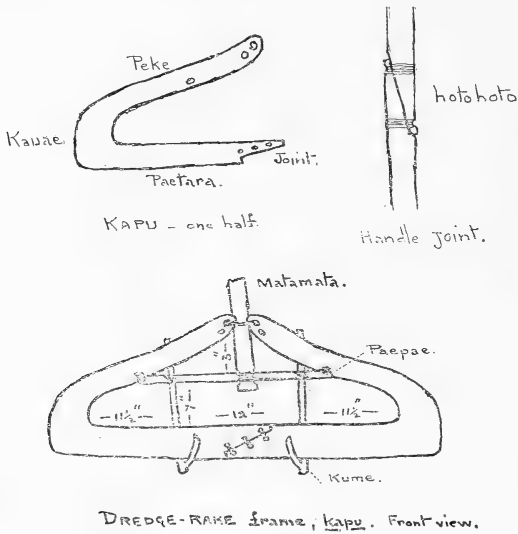

Fig. 3.—Dredge-rake frame.

The bend at the sides is called the *kauae* (jaw). Besides bending upwards, the *kauae* bends forwards and is continued on into the upper limb, or *peke*. The two *peke* do not come close together in the middle line, but are separated by a gap of from 1 in. to 1½ in. This point is about 10 in. above the bottom beam. These ends of the *peke* have holes through them for lashing purposes. From the front, the plane of the *kauae* and *peke* forms an angle of about 45° with the plane of the *paetara* and teeth.

About 7 in. above the lower beam a horizontal rod, called the *paepae*, is securely lashed at either end to a hole in the ascending limbs. As further support there are two vertical rods, called *kume*, about 1 ft. to the inner side of the bends. They are made of *manuka*, with a fork at the lower end. The fork embraces the lower beam from behind, and the rod passes behind the *paepae* and ascending arms, to each of which they are securely lashed. The two *kume* and the *paepae* rods thus brace and strengthen the wooden framework, or *kapu*.

(*b.*) *Heheki*, or Net.—The net is a bag net with a $1\frac{3}{4}$ in. mesh and about 34 in. long. At the end away from the frame it is wider, if anything, than at its attachment. It is attached to the *paetara* below, and the upper edge comes up as high as the *paepae* above, but is not fastened to it. It has a string attached to this upper edge, which is drawn taut and tied to the lower end of the pole or handle. The net has a special name, the *heheki*. In *Museum Bulletin No. 2* Hamilton quotes Best as giving the name of the dredge-rake used at Rotoiti as *heki*. The Rotorua people were very clear that it is the actual net that is the *heheki*. In fig. 76 of the above publication a dredge-rake is shown with a *punga*, or sinker, attached to the end of the net. This is incorrect, as there was no necessity for it in this position, the *kakahi* weighting the net back as they were dredged up.

(*c.*) *Rou*, or Handle.—The handle was called the *rou*. In order to drag the rake along the bottom the handle had to be from 28 ft. to 30 ft. long. It was not a simple case of getting the longest pole from the adjacent forest, as Newman* states in his article on Maori dredges. To get a pole of the right length without being too heavy or unwieldy, and yet with sufficient slimness and spring without being too weak, was the problem that faced the neolithic Maori. He solved it by joining four pieces together, thus obtaining length without excessive thickness. Of these four pieces the most important was the lowest, called the *matamata*. This was carefully sought for in the bush. It had to be a straight piece of *toro* (*Myrsine salicina*) or *mapou* (*Myrsine Urvellei*) of the right thickness. These woods are very springy, and will not break or snap. In the *rou* I saw in use the *matamata* was 12 ft. 4 in. in length and $3\frac{1}{2}$ in. in circumference. The thin end was downwards, and near this end a groove was cut round, for a purpose to be detailed later.

The other three pieces were not so important, and the wood was not so carefully selected. The ones I saw were of *tawa* (*Beilschmiedia tawa*). The piece next to the *matamata* was named the *whakatakapu*. It was spliced to the *matamata* with an overlap of 11 in. and had the thick end down, and was 4 ft. 7 in. in length. The third piece was of the same length, and was called the *whakangawari*, and had an overlap of 11 in. The last piece was the one which was grasped by the hand, and hence was called the *tango-tango* (what one lays hold of). It was 9 ft. $6\frac{1}{2}$ in. in length, and had the thin end uppermost, being here about 1 in. in diameter. The overlap with the *whakangawari* was $9\frac{3}{4}$ in.

The various parts of the *rou* were joined together as shown in the diagram, with a 9 in. to 11 in. overlap, by a double tie. These ties at the joints are called *hotohoto*.

When the dredge-rake was not in use the handle was untied, taken to pieces, and put in water to preserve it until the next season. In northern France the French farmers, after the pea crop is gathered, place the wooden stakes or pea-props in ponds for a similar reason.

Joining the Rou *to the Framework.*—The *rou*, or handle, having been completed, the lower end of the *matamata* is fastened to the *kapu*. It is passed down at the back of the two ascending arms (*peke*), and the groove already mentioned at the lower end is fitted on to the cross-rod (*paepae*) and securely lashed to it and the *peke*. The handle, *peke*, and *kauae* are now in the same

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* A. K. Newman, On Maori Dredges, *Trans. N.Z. Inst.*, vol. 37, p. 141, 1905.

plane, and, as before mentioned, form an angle of 45° with the plane of the teeth of the rake. This insures the teeth gripping the sand or mud at the bottom when the rake is dragged.

The *punga*, or sinker, is then attached, not to the end of the net, but to the back of the *matamata*, between the cross-rod (*paepae*) and the ascending arms (*peke*), where in fact it is fastened to all three. Some fern is wrapped round the *punga*, before fastening, to save the woodwork. Its weight is about 6 lb. Should the weight of the sinker be insufficient, smaller sinkers, called *potiki*, are attached on either side of the main *punga*. It will be observed that the function of the *punga* has nothing to do with the net, but from its position at the lower end of the handle and directly over the middle of the frame it weights down the lower beam and causes the teeth to sink into the soft sand to scrape up the *kakahi*. The sinker described by Dr. Newman, in his article already quoted, as being flat at the base whilst the other side is rounded, was not so made that the broad flat surface should lie in the lake-mud, but that the flat surface might rest evenly against the back of the framework in the position described above.

Method of Dredging.—As foreshadowed in the proverb already quoted, *kakahi* dredging required great skill, or, as the Maoris say, *He tino mahi tohunga*. It was very difficult to get a good quantity, and the *kuare*, or unskilled dredger, was useless. It is said that skill descended in or was inherited by certain families. The Ngati-Pukaki were a skilled tribe. As there was so much talk about dredging, it is natural that a good deal of show was indulged in. The fisherman going out to the *kakahi* ground put on his best dress-cloak of dogskin or fine flax. The *turuturu* was driven in, and the canoe paddled off to the end of the attached rope. The dredge-rake was lowered over the left side of the canoe, and the end of the handle (*tangotango*) held in the left hand. After feeling that the rake was on the bottom and that the teeth had gripped, the dredger would work towards the *turuturu* by successive pulls on the rope with the right hand. In olden days, when conscientious objectors were not even dreamt of, if a Maori held a stick in his hand and started moving it about his fighting-blood was speedily aroused. It is known of many a Maori of the old school, peacefully walking along with a walking-stick in the degenerate post-fighting days, that if he struck once or twice at a tree-branch or a piece of bracken an association of ideas seemed to stir the blood, and it was no uncommon sight to see him leaping about from side to side and going through all the strokes and parries of the ancient pastime. This would happen even with men using the *ko* in digging. So with the *kakahi* dredger: as he dredged along he had to move the handle from side to side; gradually the movement would excite him so that anon he was guarding and parrying with the handle of the dredge-rake, quite oblivious of the *kakahi* below. It was considered good training for war: hence my informants said, *He karo rakau tonu te mahi* (The method was just like guarding against a weapon). Probably some excitable warrior created a precedent and it became the fashion.

When a larger canoe was used there might be three or four dredgers all facing the same way, and were the angles of the handles of the rakes the same all would be well; but if one were different all would be wrong, and the rake that was out of line would immediately be drawn up, so that the fault might be investigated. The fault might be (*a*) the tying at the joints (*hotohoto*) of the handle, (*b*) the teeth of the *kapu* loosened or set wrongly, (*c*) more weight (*potiki*) needed. When the net became full the weight caused the handle to assume a more vertical position—*ka tu te rou.*

Whakaangi.—When a special demonstration was desired the method of dredging known as *whakaangi* was indulged in. In this it was necessary that a breeze should be blowing across the dredging-ground. Big canoes, preferably war-canoes, were dragged out, and the crew of fishers dressed in their finest array. They paddled up against the wind to the edge of the ground, and with dredge-rakes over the side drifted across the ground with the wind. No *turuturu* was needed. It was here, with their numbers and brave cloaks, that the *tu karo,* or sparring with the handle of the rake, was especially indulged in. Old men say that with several canoes vying with one another on the same ground it was a sight to stir the blood. Kaiore was a good fishing-ground for the *whakaangi* method, as also was Puha te Reka, belonging to Ngati-Whakaue.

Carving.—Good dredge-rakes are carved at the *kauae* and at the upper ends of the ascending arms. In some the mid-part of the ascending arms, where the *paepae* is secured, is also carved. Such a rake is shown in *Museum Bulletin No. 1,* fig. Lc.

Name of Dredge-rake.—The name *roukakahi* that has been applied to the wooden frame of the dredge-rake is wrong. The word *rou* as a verb means "to reach or procure by means of a pole or stick." As a noun it means "a long stick used for the purpose of reaching anything." These are the meanings given in Williams's Dictionary, and these are the interpretations of the word as used with regard to the dredge-rake by the old men of Rotorua. *Rou,* as a noun, is the name of the handle of the rake. *Roukakahi,* as a verb, is the process of procuring *kakahi* by means of a pole, to which incidentally the rake and net are attached. Williams gives as a second meaning to the verb *rou,* "collect cockles or other shell-fish," and gives as his example, *kei te rou kakahi.* "Collect" is certainly the result obtained, but the true meaning of the example he gives is "procuring or collecting *kakahi* by means of something connected with a pole." Pole is involved in the word *rou.* The frame of the dredge-rake is not a *roukakahi,* but a *kapu* or *mangakino,* as the Maori manufacturers state, and the correction should be made in our records. From a consideration of the meaning of the word *rou* we see that the *paepae,* or dredge-net, could never be called a *roukoura.* There is not the excuse for making a mistake as in the case of the dredge-rake, because the *paepae* was dragged by a rope, and there was no pole, or *rou,* used in connection with it. The *hao,* or toothless dredge-net, that Newman mentions as used in Lake Taupo evidently had a handle. There might have been some ground for calling this a *roukoura,* but there certainly was not as regards the *paepae.*

Mauri-oho-rere is the name of a rock within which Hatupatu, of ancient fame, sought refuge. It is not now seen unless before some disaster, when it is an ill omen, or *aitua.* If, whilst dredging for *kakahi,* pumice (*pungapunga*) was displaced from the bottom and floated to the surface it was looked upon as an ill omen. This particular genus of ill omen was named after the rock of Hatupatu, *Mauri-oho-rere.*

Food.

The supplies having been secured by the methods described, a few remarks about them as foods are necessary.

To any one who enjoys the shell-fish of the salt water the *kakahi* is very tasteless and insipid. This opinion seems to be shared by the present generation of the Arawa people, for dredging is gradually being abandoned. In olden days, however, the *kakahi* was very important. It was used in the feeding of motherless infants where a wet-nurse could not be secured. The *kakahi* was cooked and the child fed with the soft *paru*, or visceral mass, which, further softened with the water retained in the shell, could be sucked like milk. Three or four *kakahi* formed a meal. Hence the Maori said, *Ko te kakahi te whaea o te tamaiti* (The *kakahi* is the mother of the child). *Ka whakangotea ki te wai o te kakahi* (It was suckled on the juice of the *kakahi*).

The *kakahi* was often greatly desired by patients. When the eyes took on a deathly, unnatural white appearance it was alluded to as *kua whakawai kakahi nga kanohi* (the eyes have taken on a *kakahi* white appearance). Then the appropriate treatment was to feed the patient with *wai-kakahi*—the juice of the *kakahi* after it had been cooked in a hot spring. Smith* mentions these uses of the *kakahi.* If the patient could take it the prognosis was considered good. If the patient had been very ill and asked for *kakahi* it was looked upon as a good sign.

Kakahi were sometimes eaten raw. The opening of a raw *kakahi* has a special word, *tioka.* If a person desired raw *kakahi* for a meal he said, *Tiokatia mai he kakahi* (Open me some raw *kakahi*). If the *kakahi* were cooked, the word for opening was *kowha.* They might also be eaten underdone—that is, they were dipped into a hot spring for a few seconds. This just warmed the *kakahi* and caused the shell to open very slightly. This process was called *whakakopupu.* Hence the phrase *Whakakopupututia mai he kakahi* means, literally, "Underdo me some *kakahi.*"

There was, of course, the ordinary cooking, though the Maori never cooked their shell-fish until the shell was wide open and the contents shrivelled to the consistency of leather, as the European seems fond of doing.

The proper *kinaki,* or relish, to go with *kakahi* was the *pohue,* a kind of convolvulus. The *kakahi* after being eaten as food was always alluded to in the plural as *nga kakahi.*

The shell of the *kakahi* was used for cutting the hair of adults, and also the umbilical cord of a newborn child.

In addition to the proverb already mentioned, there is another drawn from the fact that the *kakahi* in moving about on the bottom of the lake forms a trail of curves and spirals not unlike tattooing or carving: *Nga kakahi whakairo o Rotorua.* This was applied to *toa,* or warriors, who dashed in and out of the war-party.

The *kokopu* and *toitoi* were eaten locally, and not preserved. The *inanga* and *koura,* on the other hand, were preserved, and, besides providing for local needs, were sent as presents and exchanges to outside tribes.

The *inanga* were dried by being spread out on the *papa* or rocky slabs rendered hot by the natural hot steam below. When dried they were called *whakahunga,* and were packed in baskets lined and covered with fern-leaves, and were then ready for storing or export.

The *koura* makes delicious eating, the flavour resembling that of large prawns. It has survived the introduction of trout better than its finny comrades, and to this day the *tau koura* still obtains good catches, though not comparable to those of times gone by. Curried *koura* is often included in the menu of the dining-room run in connection with the dances in the carved meeting-house of Tama-te-kapua at Ohinemutu; and during the

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* T. H. SMITH, *Trans. N.Z. Inst,* vol. 26, p. 429, 1894.

visit of the Prince of Wales to Rotorua *koura*, though late in the season (April), were supplied in the Maori canteen, to the delight of the Maori visitors. They are cooked in baskets in the steam-holes, and it is interesting to see how neatly and quickly the local people get rid of the shell and expose the flesh. The abdomen, or tail, consists of seven segments, the hindmost, or seventh, being biologically called the "telson." In the large sea-crayfish it is usual to separate this abdominal part and remove the exoskeleton, or tergum, from each segment in turn. With the small fresh-water *koura*, however, the Maori removes the tergum in one piece, without detaching the fleshy mass from the anterior cephalothorax. Grasping the cephalothorax with the left hand, with the right hand he first squeezes the sides of the abdominal segments. This loosens matters up, and, grasping the telson, or end segment, above and below, he squeezes it firmly. This pushes the flesh forward out of the end segment, and by now pulling backwards and slightly upwards the whole exoskeleton comes away. The carapace, or covering of the anterior part, is then flicked forward and upward and detached. The tail part and the viscera of the anterior part are taken in a mouthful; whilst the head, legs, and under part of the cephalothorax are rejected. Care must, however, be taken to avoid the bile-ducts, which show up black just behind the head. They are usually pinched off beforehand. One has only to struggle with a *koura* himself to appreciate the quickness, neatness, and ease of the above method in the hands of the *cognoscenti*.

For preserving purposes the fleshy tail parts, after being cooked, were threaded on a string of flax-fibre and dried. They were thus stored in long strings, shell-fish being preserved in a similar manner; and in condition they would keep for a year. The strings were packed in baskets. Eight baskets were called a *rohe*, which was equivalent to a sack.

Feasts.—At a large *hui* at Awahou in 1899 there were six hundred people present from the Bay of Plenty and East Coast. The gathering lasted a week, and *koura* was the chief food. A great present of *koura* was sent to Kawana Paipai at Wanganui in 1859, but my informants had forgotten the quantities. At the opening of Tama-te-kapua at Ohinemutu, in 1873, it is said that at the feast there were five hundred *rohe* of dried *koura* and *inanga*. As this would mean four thousand baskets, some idea can be formed of how the lake must have teemed with food and what an invaluable asset it must have been to the tribes fortunate enough to possess it.

Conclusion.

The notes that form the basis of this paper were made at Rotorua some years before the war. I have to thank Mr. H. Tai Mitchell and his committee of old men who gave me the information for the purposes of record. A *tau* was visited and demonstrations given in the manner of using the dredge-net and the dredge-rake. My thanks are also due to Miss Preen for some of the photographs used to illustrate the text.

Art. XLIX.—*Maori Decorative Art: No. 1, House-panels* (Arapaki, Tuitui, *or* Tukutuku).

By Te Rangi Hiroa (P. H. Buck), D.S.O., M.D.

[*Read before the Auckland Institute, 20th December, 1920; received by Editor, 31st December, 1920; issued separately, 12th August, 1921.*]

Plates LXVI–LXIX.

Maori decorative art, as exemplified by definite patterns and designs, found expression in the following forms:—

(1.) Tattooing on the human figure (*moko*).
(2.) Carving on wood, bone, and stone (*whakairo*).
(3.) Painting on rafters of houses (*tuhi*).
(4.) Weaving of coloured threads in the borders of dress cloaks (*taniko*).
(5.) Plaiting of coloured elements into floor-mats and baskets (*raranga*).
(6.) Lattice-work in house-panels (*arapaki, tuitui,* or *tukutuku*).

The last division, house-panels, whilst frequently mentioned, has never received the detailed attention it deserves. Archdeacon H. W. Williams has given the best description of the patterns, but, as he dealt with them only as part of his article on "The Maori Whare,"* I venture to add a few details, in the hope that other observers may be induced to criticize and to add still further to the material contained in this paper.

Decorated panels formed an important finish to the large meeting-houses and the carved houses of chiefs of any standing. A carved house without lattice-work stitched in patterns, no matter how simple, had an air of incompleteness, or even poverty, that the old-time Maori felt was not in keeping with the prestige that a well-carved house should convey. In olden days, when the houses were lined with reeds, the art of panel-decoration was universal. With the change of building-material due to civilization the art began rapidly to disappear. In some districts, such as the East Coast and Hot Lakes, it survived even when wooden walls and corrugated-iron roofs replaced the thatch of the old days; the Maori *form* of the house remained. The carved woodwork and painted rafters demanded the retention of the appropriate lattice-work panels. Owing to European influence in providing motives, and colouring-matter in Judson's dyes, the panels, in many instances, became more complicated in design, and, owing to the introduction of greens, violets, and other colours unknown to the tattooed craftsman, more inartistic in effect. In other parts of the country, again, fluted boards and painting superseded the simple but more artistic panels of old. In the North Auckland Peninsula, where the European form of wooden hall with side windows entirely replaced the Maori type of building, the art disappeared completely.

The Panel-space.

Before going on to the panel-decorations it is necessary to describe how the panel-spaces are formed in the typical Maori house. To do this I cannot do better than quote from Archdeacon Williams's article already mentioned: "The framework of the sides, *pakitara*, consisted of upright slabs of wood set in the ground. These slabs, *poupou*, were from 1 ft. to

* Rev. H. W. Williams, *Jour. Pol. Soc.*, vol. 5, pp. 145–54, 1896.

3 ft. wide. In ordinary houses the height of the *poupou* above ground was somewhat under 6 ft. They were, of course, set opposite one another at even distances. The intervals were, as a rule, a little wider than the *poupou*. The upper ends of the *poupou* were secured to a batten, *kaho paetara*, placed behind the *poupou* and lashed to notches or holes in the corners of each. A skirting-board, *papaka*, was formed by slabs placed between the *poupou*. These slabs were rebated from the front at the ends to come flush with the faces of the *poupou*."

The panel-space is thus defined by the *poupou* on either side, by the *kaho paetara* above, and by the *papaka* below. This is the nomenclature of the East Coast. The Arawa people of the Hot Lakes district, and the Whanganui on the west, call the upper cross-piece the *kaho matapu*. The lower skirting-board is called the *paekakaho* by both tribes, whilst the Arawa gave it an additional name, *poitoito*. In the best houses both cross-pieces were often carved. In other good houses the upper piece was ornamented by bindings of flax or *kiekie*, and in more modern times by painting. The panel-space was called *moana* by the Whanganui people.

The Elements of the Panel.

The elements from which the decorative panel which fills up the panel-space (*moana*) is formed consist of three portions — two rigid and one flexible. These, which form the groundwork, may be called, in terms of wickerwork—(*a*) vertical stakes ; (*b*) horizontal rods ; (*c*) a flexible material, which, threaded through the above, forms the patterns and designs of the panel. External to the lattice-work panel is the ordinary thatching of the walls ; and in some of the common type of dwellinghouse even the vertical stakes of reeds may not be used. Hence we are justified in regarding all the elements used in the formation of the panels as not being essential to the construction of the wall, and thus being primarily decorative in origin.

(*a*.) *Vertical Stakes.*—The vertical elements formed the outer layer of the panel. They are composed of the flower-stalks (*kakaho*) of the *toetoe* (*Arundo conspicua*). A single layer of *kakaho* was placed close together vertically to fill up the panel-space. Hori Pukehika, of Whanganui, states that the flower-ends and the butts were placed alternately so that an even width might be maintained, and great care was exercised that an even number should fill the panel. In some of the Rotorua work this has not been followed out, and the number of stakes is often odd. Where the cross-rods were narrow each vertical reed formed an element for threading purposes; but where the former were wider than usual two reeds were included as a single element in threading. In the sleeping-houses (*wharepuni*) the vertical lining of *kakaho* was considered sufficient decoration. In later years Maori have in several instances had specially-cut fluted boards made at the sawmills for lining their more modern houses. This represents the *kakaho* stakes in more durable material. Hence the conservative Maori artistic sense of his old-time decoration is appeased, and at the same time deference is paid to the European desire for durability. Some say that it is a labour-saving device, due to laziness.

It is in connection with the parallel arrangement of the flower-stalks, as the sole lining of the house-walls or under the roof, that the following proverb is used : *He ta kakaho e kitea, he ta ngakau e kore e kitea* (A defect in the arrangement of *kakaho* is seen ; a defect of the heart is not seen). This means that deceitfulness is not apparent on the surface.

(*b.*) *Horizontal Rods.*—The horizontal elements form the inner layer of the panel. They were placed close together so as to cover completely the outer layer of *kakaho,* but leaving enough space between the rods to pass the flexible material through to form the patterns. In old houses the long straight stalks (*kakaka*) of the common fern (*Pteridium esculentum*) were used. In the better houses laths of *totara* (*Podocarpus totara*) or *rimu* (*Dacrydium cupressinum*) were adzed out for this purpose. Wood that had lain in water for some time was sought after, as it split much more easily. The laths were shaped to an even thickness and width. The Whanganui people say that *rimu* was preferable to *totara,* as it did not fracture so easily. The laths were often painted red with haematite, or blackened by exposing to fire or rubbing with *parapara,* a black mud obtained from peaty swamps. These two colours were used alternately on an even number of laths. This held good in the East Coast and Whanganui districts. In the beautiful carved house in the Auckland Museum, which is of Arawa design, the number of laths of one colour is generally odd. Colenso,* in his description of the panels of a house that was made for him by the Hawke's Bay people, states that the coloured rods of black and red were in threes. One cannot help thinking that the Maori, no matter how skilled, were careless about some details in building for Europeans, as they did not have to live in the houses themselves. In many of the good houses in existence at the present time white paint has been added to the red and black of old. Paint has, of course, been used for the red and black, as it is more durable than the original material.

The rods or laths are called *kaho tara* by the Arawa, and *kaho tarai* on the East Coast. The Whanganui called them *arapaki,* and also used the same word for the entire panel, including the panel-patterns to be described later.

In some of the very modern houses fluted boards have been placed horizontally across the panel-space to represent the transverse arrangement of rods. A variation in the arrangement of the rods is seen in some of the meeting-houses near Te Puke, in the Bay of Plenty. Here the rods, instead of being horizontal, run diagonally across the panel-space. This method is modern, and is used with some of the panels to lend variety.

(*c.*) The flexible material for stitching the design consisted of (1) flax (*harakeke, Phormium tenax*), (2) *kiekie* (*Freycinetia Banksii*), (3) *pingao* (*Scirpus frondosus*).

Kiekie was preferred to flax, as it had a whiter colour after preparation. *Pingao* was used for its orange colour, but was only procurable in certain localities on the sandhills near the coast. The long leaves of these plants were shredded with the thumb-nail into strips of from a tenth to an eighth of an inch in width. The strips were placed in hot water and then scraped (*kaku*) with a shell, to remove part of the outer epidermis covering the fibre. They were then doubled over, tied into hanks, and hung up to dry. When dry the *kiekie* and flax became white, whilst the *pingao* retained its rich orange colour. Some of the *kiekie* and flax strips were dyed black to add further colour-variety to the decoration. The method of dyeing was the same as in the preparation of flax-fibre (*muka*) for dress cloaks. The scraped material was soaked in an infusion of the bark of the *hinau* (*Elaeocarpus dentatus*), which acted as a mordant. It was then rubbed with, or steeped in, the black peaty mud (*parapara*) above referred to. On drying, the strips assumed a permanent black colour.

* W. Colenso, *Trans. N.Z. Inst.*, vol. 14, p. 50, 1882.

Tumatakahuki.—Archdeacon Williams points out that in all well-made panels a vertical stake, called a *tumatakahuki*, passed down the middle of the panel and was fixed to the face of the rods by a special stitch. The Whanganui people maintain that the purpose of the stake was to keep the transverse rods in position, the ends of the stake being fixed behind the upper and lower cross-pieces of the panel. The stake consisted of a rounded piece of wood, which was sometimes replaced by lengths of *aka* vine where the decorative effect of bulging out the stitching was all that was desired.

Method of Stitching.

The process of threading the strips of flexible material between and around the stakes and rods has been termed "stitching" by Archdeacon Williams. The Maori use the word *tui*, or *tuitui*, for the process; and, whilst this may mean either threading or stitching, it is now generally applied to the latter. The Whanganui call the decorative pattern a *tui*, as, *He aha te tui o te whare o mea?* (What is the stitching of the house of So-and-so?) The Arawa apply the term *tuitui* not only to the pattern but also to the entire panel.

The stakes and rods being in position, the *tohunga*, or skilled craftsman, took up his position inside the house, whilst an assistant stood outside with strips of material. The *tohunga* was responsible for the patterns, whilst the assistant might be entirely ignorant of them. A woman could act as an assistant outside, but she could on no account enter the house until after its completion, and after the ceremony for removing the *tapu* had been performed. The *tohunga* used a wooden implement, *rakau hei tui* (stick for stitching). One end was sharpened, whilst the other was rounded and had a loop of flax through it with which to hang it on the wrist. It was called a *huki*. The *tohunga*, having decided on his pattern, thrust the *huki* through one of the interspaces between the rods and stakes, and the assistant followed the *huki* with a strip of material. The *tohunga* returned it through the appropriate interspace, and so the process went on. In modern times the panels have been completed separately and then fitted into the panel-space.

Stitches or Strokes.

It will be evident from the arrangement of stakes and rods that the rods fill up the interior surface of the panel; enough of the stakes (*kakako*) can, however, be seen in the slight intervals between the rods to indicate the spaces between them. The whole panel-surface is therefore divided up into a number of small regular squares—or, strictly speaking, rectangles, as the stakes and rods are rarely exactly the same in width. The Maori craftsman had before him a series of squares upon which to stitch the patterns that the limitations of scope and experience allowed. It is interesting for the Maori to know that the pakeha, in the evolution of the individual, commenced the art of stitching at exactly this stage. Some few years ago the first lesson that pakeha girls received in sewing was upon a piece of canvas or material woven in a coarse plain check—that is, in small squares. Upon this material the white child sewed her first sampler. In Barrie's play "Peter Pan" the drop-scene was painted to represent the little heroine's first sampler. The white child,

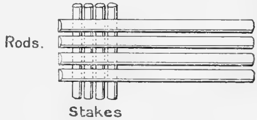


Fig. 1.

with steel needle, fine cotton thread, and a series of small squares composed of the warp and weft of some soft material, was faced with the same problems as the tattooed *tohunga*, with wooden *huki* and coarse strip of flax, standing before a panel of squares composed of rigid stakes and rods. In each case the needle could be passed only through the intervals between the two elements at the corners of the squares, and in each case the stitch had to pass diagonally across the square. Experience taught Maori and pakeha alike that the working of the crossed stitch into patterns was the simplest way of combining utility with decorative art. In the pursuance of art the two diverged. The white child, with the larger scope of more squares and the suggestions of teachers, went on to cross-stitching trees and animals. The brown adult, restricted by space and knowing no outside influence, never ventured beyond simple geometrical designs.

The actual stitches used in panel-work may be divided into three: (1) cross-stitch, (2) single stitch, and (3) overlapping wrapped stitch.

(1.) *Cross-stitch.*—This stitch is the one most commonly used. The strip, after passing diagonally across the front of the rod corresponding to a square space, was taken round the back of the stake horizontally and, emerging to the front, crossed over the first stroke, forming a cross-stitch as shown in the patterns. According to Williams, this stitch was called *pukanohi aua* (herring's eyes) on the East Coast. The Arawa called it *purapura whetu* (star-seeds). Both names seem to be derived from the fancied effect of the stitch and not from the technique. The Whanganui call it *kowhiti* (to cross). They also apply the term to a special pattern. The Whanganui say that the cross-stitches in a pattern should be of an even number, except, of course, where an angular pattern demands a single cross-stitch at the points of the angles. The East Coast people and the Arawa do not seem to be so wedded to even numbers. In Williams's diagram of the *poutama* pattern from the East Coast the cross-stitches form odd numbers. The same is true of some of the Arawa patterns in the carved house in the Auckland Museum.

(2.) *Single Stitch.*—In this stitch the strip crossed the squares once. With it, continuous rows of chevrons and lozenges were formed. Williams records that on the East Coast the zigzag lines formed by continuous rows of chevrons are termed *tapuae kautuku* (bittern's footprints) and *waewae pakura* (swamp-hen's feet) according as the lines were vertical or horizontal. The lozenges were termed *whakarua kopito*. The Arawa call the lozenges *waharua*. With this stitch the single lines are separate and distinct, no other stitch crossing them. So far as I know, not more than three squares were crossed by one stitch. This was probably the result of experience, as too long a stitch would prove an insecure binding, and where unsupported by other crossing stitches would be apt to loosen and be dragged or snapped by catching in other objects.

(3.) *Overlapping Wrapped Stitch.*—This stitch was primarily used to lash the vertical stake, *tumatakahuki*, to the middle of the panel. The stitch was made as follows, with the stake in position: Following the course of a single strip as shown in fig. 2, it will be seen that the strip, emerging from the interspace above rod 1, round which it has been wrapped, crosses the stake downwards and to the right. It is pushed through the interspace between rods 3 and 4, on the right of the stake, after having crossed three rods. It is wrapped round rod 3, and emerges to the front through the interspace between rods 2 and 3. It now passes obliquely down to the left, crossing itself and three rods, and passes back in the interspace between rods 5 and 6. It is wrapped round rod 5, reappears in the interspace between 4 and 5, and again, obliquely crossing three rods, disappears between 7 and 8. It is wrapped round rod 7, and continues in like manner to the bottom of the panel. If we term this strip "sinistral *a*," reference to the figure will show that it has secured, by wrapping, one side of the rods 1 and 5 on the left, and 3 and 7 on the right. A second strip, "dextral *a*," commencing at rod 1 on the right, will secure the opposite sides of the rod already wrapped—namely, 1 and 5 on the right, and 3 and 7 on the left. This will render rods 1, 3, 5, and 7 fully secured. A third strip, "sinistral *b*," commencing at rod 2 on the left, will wrap rods 2 and 6 on the left, and 4 and 8 on the right. A fourth strip, "dextral *b*," will wrap the opposite sides—namely, 2 and 6 on the right, and 4 and 8 on the left. Thus all eight will be fully secured. On completion, these overlapping wrapped stitches produce the effect shown in Plate LXIX. This detail would not have been entered into except for the Whanganui contention that originally the stitch was not decorative, but was a lashing of *aka* vine from the aerial roots of the *kiekie*—not to hold an ornamental stake in position, but to secure the horizontal rods in their place in the panel. Certainly the firm nature of the lashing would seem to prove that the contention is founded on fact.

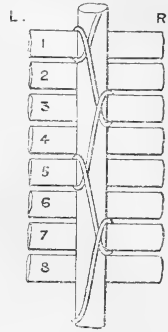


Fig. 2.

Patterns and Designs.

Patterns of the various stitches, in white, black, and yellow, were formed into pleasing designs, especially when the background of rods was spaced in red and black. Where every square was stitched a close design was formed. Variety was obtained by leaving some of the squares unstitched, thus forming an open design. There can be no doubt that the number of original Maori designs was comparatively few. This can readily be understood when to the limitation of scope is added the conservatism characteristic of Maori art. Some of the old men of Whanganui go so far as to say that in the days of their youth they saw only four designs in the old houses, and the majority of designs with which we are acquainted at the present day are due to European influence. The patterns and designs may therefore be divided into two classes—(1) Maori, and (2) post-European. These, again, may be described according to the stitches used.

Maori Designs.

(*a.*) Cross-stitch.

(1.) The simplest design, requiring no calculation, would be to fill up the entire panel-space with cross-stitches. This has been done, and the Whanganui maintain that it is one of the few original designs; but owing to its monotony it was abandoned, and its name is lost, and I was unable to procure it. The Arawa have a similar design, shown in Plate LXVI, fig. 1, but white and red stitches alternate. The red is modern, but the design and name are old. The name is *Te Mangoroa* (the Milky Way), from the massing of star-seeds (*purapura whetu*).

(2.) The Arawa pattern of alternate colours in a close design is resembled, in effect, by an open design where alternate stitches are left out. This is an old design, named *kowhiti* by the Whanganui. This is their name for the cross-stitch; but as applied to the design it conveys the idea of having crossed or leaped over spaces or squares. It is the commonest design in the meeting-houses of the Whanganui River. The Arawa have a more fanciful name—*roimata* (tears). In the example fig. 2, Plate LXVI, it will be seen that the general effect is a series of lozenges, but the lozenge name was never applied to it.

(3.) Another simple effect is vertical lines of ones or twos separated by blank spaces of a like number. The latter is seen in fig. 3, Plate LXVI. A variation of this is shown in fig. 4, Plate LXVI, where the lines, after crossing twelve rods, are continued down another twelve in the line of the blanks and then back to the original lines. These are Arawa designs, and are known by the poetic name *roimata toroa* (albatross-tears). The Whanganui have a similar design, which they call *tuturu* (leaking water).

(4.) The lowering or raising of the alternate vertical lines of "albatross-tears" and the introduction of short horizontal lines to connect the vertical ones led to an alteration of the pattern and resulted in the step-like design shown in fig. 1, Plate LXVII. This is a widely-distributed design, known as *poutama* both in the east and west. Of the meaning of the word I can get no satisfactory explanation. It is a very common pattern plaited in baskets and floor-mats, and also figures in the decorative borders of Rarotongan floor-mats (*moenga*). The motive was obtained from plaiting. In the example figured the design is closed by coloured stitches between the white, but in many cases the designs are left open. Pukehika, of Whanganui, maintained that it was not old as applied to panels.

(5.) From vertical and horizontal lines we pass to diagonal lines producing a continuous chevron or zigzag effect. The design might be closed or open, and the line of chevrons might run horizontally or vertically. In either case the design was called *kaokao* (side of the thorax) by the Arawa and East Coast people. The idea is derived from the bend of the ribs at the side. Fig. 2, Plate LXVII, shows a closed horizontal design, and fig. 3, Plate LXVII, an open vertical one. With reference to fig. 3, Plate LXVII, viewed from either side, it will be seen that it is a continuous line of chevrons running vertically and enchanced on either side by repetition of its generating-lines.

(6.) Reference to fig. 3, Plate LXVII, shows that the chevrons are enchanced on either side. The elimination of the enchancement on one side would result in the effect being a series of continuous triangles although the motive is chevron. Fig. 4, Plate LXVII, shows a horizontal series of continuous chevrons, the generating-lines of which are composed of lines of two white cross-stitches and enhanced on the lower side by lines of two coloured stitches. The height of the chevron permits of only one white cross-stitch to represent the second line of enhancement. The effect, as stated above, is a continuous series of triangles, but the motive is chevron. This design is named *niho taniwha* by the Arawa (*niho*, teeth; and *taniwha*, a fabulous reptile).

(7.) Further evolution of the chevron design is shown in fig. 4, Plate LXVIII. On a wider panel, by producing the lines of the chevrons or making the points of the second vertical row coincide with the points of the first, the effect produced is a series of lozenges running down the middle of the panel. Both the lozenges and the original chevron motive forming the sides of the lozenges are enhanced internally by repetition of their generating-lines. The example figured is a closed design except for the small

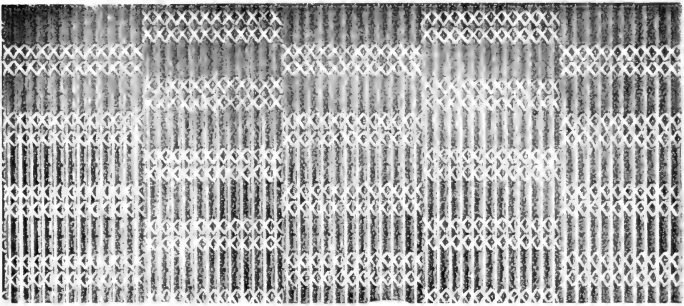


FIG. 4. *Roimata toroa* (albatross-tears).

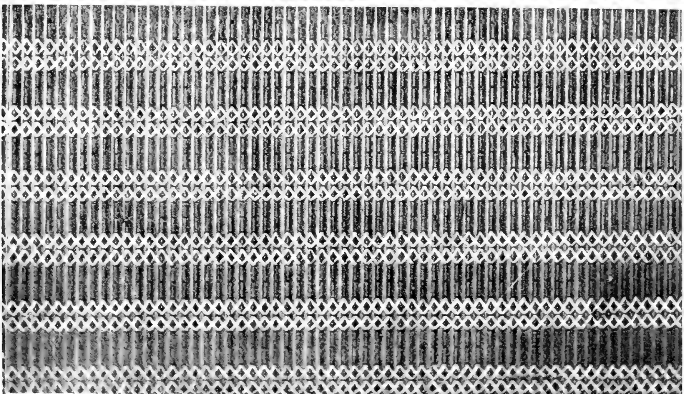


FIG. 3. *Roimata* (tears).

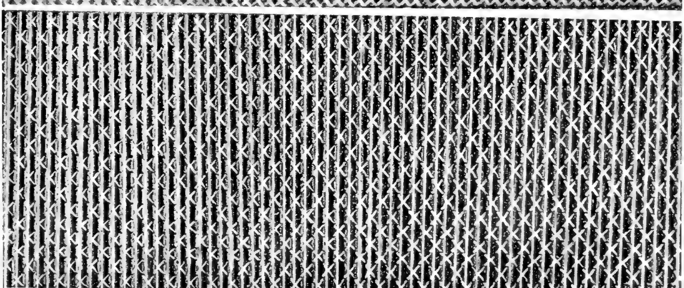


FIG. 2. Stars, or *roimata* (tears).

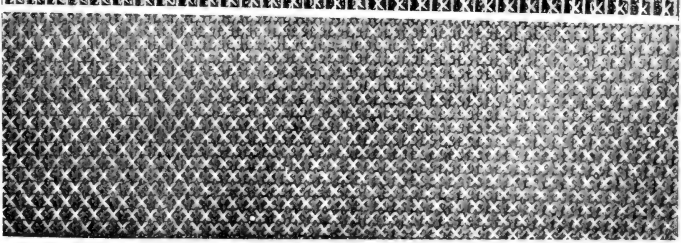


FIG. 1. *Te Mangoroa* (the Milky Way).

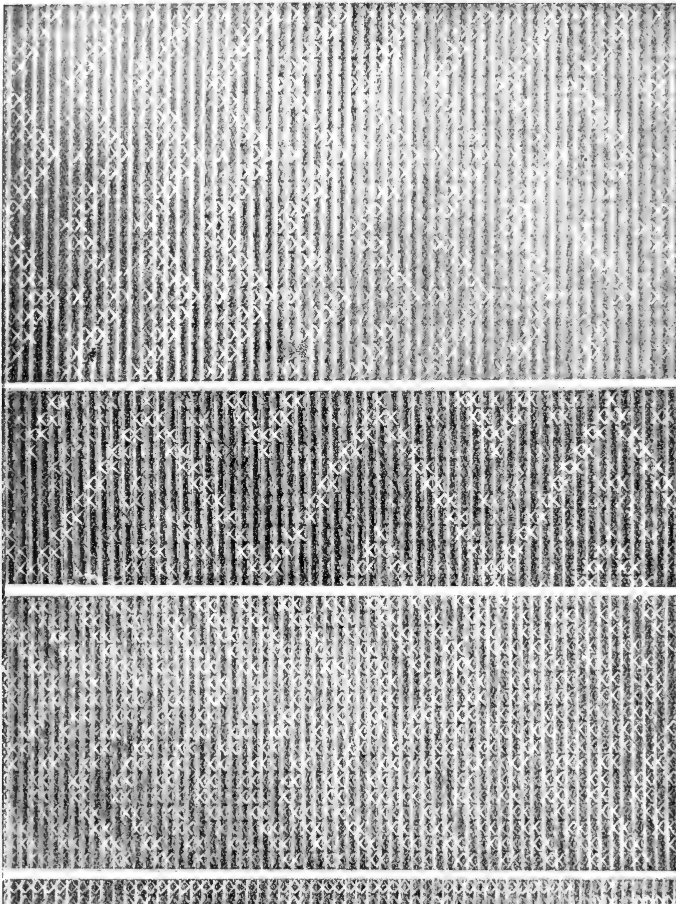


FIG. 1. *Poutama.*

FIG. 2. *Kaokao* (human ribs).

FIG. 3. *Kaokao* (ribs, armpits).

FIG. 4. *Niho taniwha* (dragon's teeth).

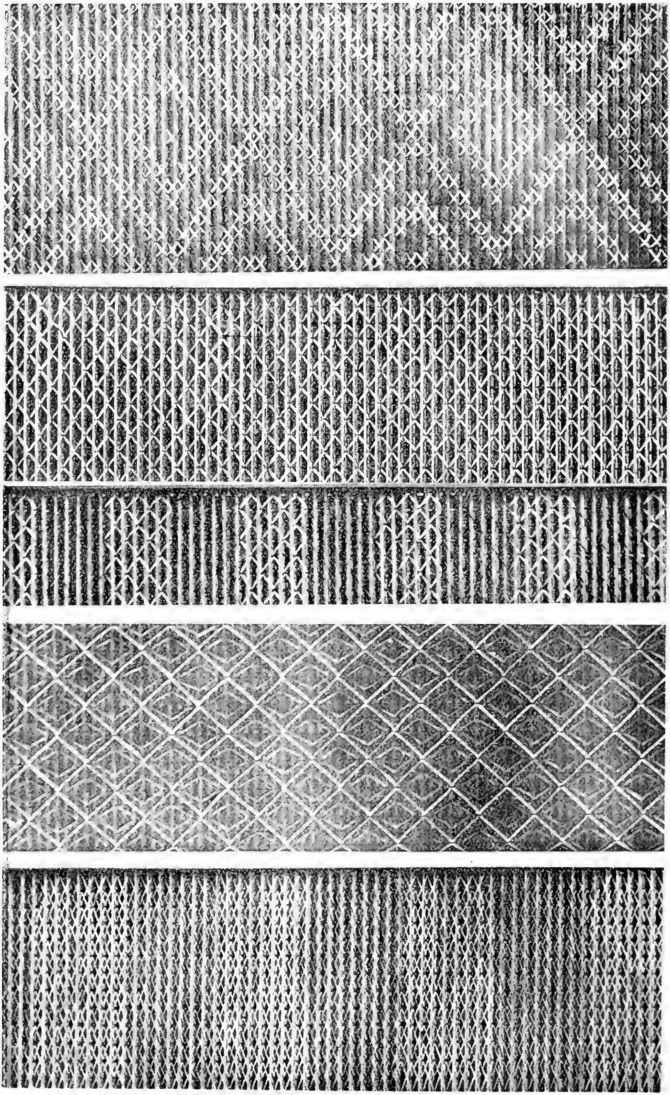
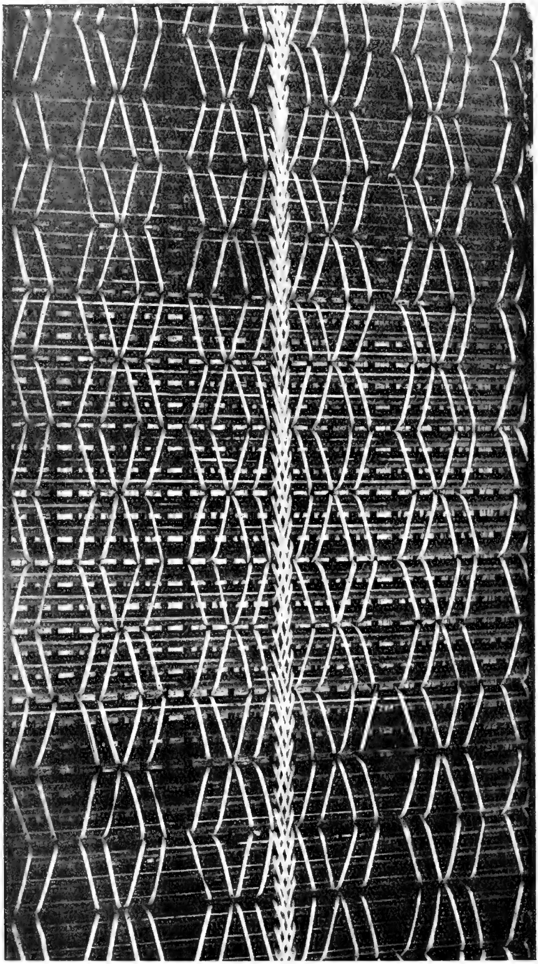


Fig. 1. *Konohi aua* (herring's eyes).

Fig. 2. *Waharua* (double mouth).

a Fig. 3. b *Waharua*, or *waharua kopito*.

Fig. 4. *Patiki* (flounder).



Overlapping wrapped stitch. In this example, from the English Church at Ohinemutu, the stitch has become purely ornamental, there being no vertical rod beneath.

enhancing lozenges, which are open. The Arawa call this design *patiki* (flounder). It is probably of more recent origin ; or, supposing it to be old, I think that it was the last of the simple combinations that the ancient Maori produced in geometrical designs. Other geometrical forms and combinations of greater complexity bear the impress of European influence—unconscious it may be, but still present.

(*b.*) Single Stitch.

As already pointed out, single stitching results in lozenges or continuous chevrons as shown in fig. 3, copied from Williams. Whilst the lozenge pattern No. 2 is common, the continuous lines of chevrons Nos. 3 and 4 are now rare. The chevrons are, however, the more simple pattern, and it is easy to see that by moving a square to the right or left horizontally in each succeeding row the points of the chevrons would be brought together and a series of lozenges would result. This no doubt is the origin of the lozenge in the single-stitch patterns.

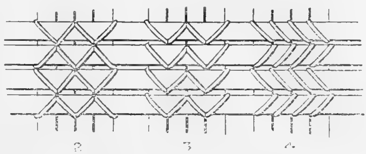


Fig. 3. (After Williams.)

(1.) Continuous rows of chevrons, horizontal or vertical, are named on the East Coast *tapuae kautuku* (bittern's footprints) or *waewae pakura* (swamp-hen's feet).

(2.) The lozenge pattern formed by single stitches crossing one square is named *whakarua kopito* on the East Coast and *waharua* by the Arawa (see fig. 3, Plate LXVIII). If this simple *waharua* design is compared with the *roimata* design in fig. 2, Plate LXVI, it will be seen that the effect is the same—namely, rows of continuous lozenges. The motive is, however, different. In the former it is rows of continuous chevrons produced by single stitch with each succeeding row arranged to produce the lozenge effect ; in the latter it is rows of alternate crosses produced by cross-stitches, and the lozenge effect is incidental.

Whilst the simple lozenge, with the sides occupying one square, may have been incidental in origin, it no doubt supplied the motive which led to lozenges of larger size being attempted. Fig. 2, Plate LXVIII, shows a design of larger lozenges which are enhanced internally by smaller ones. In the outer lozenge the stitch crosses three squares, and the inner lozenge two. It will be noticed that lozenges formed by the single stitch and the cross-stitch have their distinct names. This design is called *waharua* by the Arawa, there being no distinction between it and the previous design. There is a possibility of the enhanced *waharua* being of recent origin.

(*c.*) Overlapping Wrapped Stitch.

(1.) The pattern produced by this stitch over the *tamatakahuki* was named *pihapiha mango* (shark's gills) on the East Coast In addition to this name the Arawa called it *whakaiwi tuna* (to make like an eel's bones or eel's backbone). The Whanganui named it *tukutuku*, which is the name applied to the whole panel by the East Coast tribes. In well-panelled houses this pattern passed down the middle of the panel; and, though subsequently mainly decorative, the vertical stake was retained to throw the pattern out in relief. In some panels of the older houses this pattern, with the coloured rods, formed the only decoration. It was usual, however, for the full design to be the middle vertical line of *pihapiha mango*, with one or other of the patterns already described filling up the panel-space on either side. The panelling of the house Tama-te-kapua at Ohinemutu, Rotorua, consists of the *poutama* design with the *pihapiha mango* down the middle of each panel. Te Paku-o-te-rangi, a house belonging to the Takarangi Mete Kingi family at Putiki, Whanganui, has two lines of *tukutuku* or *pihapiha mango*, dividing each panel into three parts, in which the *tuturu* and *kowhiti* designs alternate. A further variation, shown in Plate LXIX, was the discarding of the stake and the use of the stitch alone for purely decorative purposes. The resulting pattern was exactly the same, except that it was flat. Such a design of five lines is shown in fig. 5 from the carved house Rangitihi in the Auckland Museum.

(2.) Fig. 1, Plate LXVIII, shows an Arawa design where the stitches cross two rods and overlap over the whole surface of the panel. It is called *kanohi aua* (herring's eyes) and is probably recent.

Post-European Designs.

It is extremely difficult to draw the line of demarcation between original Maori patterns and those of post-European date. The Maori patterns already described are very simple, and the same motive is used in regular sequence throughout the field of the panel. In the case of the house Te Paku-o-te-rangi at Whanganui, already mentioned, though there are two motives on the one panel, they are separated into definite areas by vertical stakes (*tumatakahuki*) and an arrangement of coloured rods. The post-European panels are more complicated, have more than one motive, and are combined less uniformly, though they may be symmetrical in one or more directions. From these distinctions it will be seen that the two classes conform to J. L. Myres's * definition of patterns and designs: "If a motive, or any combination of motives, is used in regular sequence it forms a *pattern*. Motives combined less uniformly compose a *design*, which may be *symmetrical* in one or more directions, or otherwise adapted by the balance, rhythm, or porportion of its parts to decorate a given *field*, more or less spacious, but of definite shape." Though the terms may have been used somewhat loosely in this article, for practical purposes we may say that the old Maori work consists of patterns, and the post-European of designs.

The second distinguishing feature of post-European work, in many panels, is the introduction of non-Maori motives. By the arrangement of lines and spaces the Maori geometric combinations went as far as chevrons, triangles, and lozenges. The conservatism of his art prevented him from going farther, though other geometric figures could easily have been produced. With the advent of the European other motives were introduced, such as squares and octagons. Once the old patterns were departed from, lines and spaces were combined in various ways and obeyed only one rule, that of symmetrical balance in a horizontal direction. In some panels we can see where the craftsman, through a miscalculation, did not get his design quite

* *Notes and Queries on Anthropology*, p. 203. Royal Anthropological Institute, 1912.

symmetrical laterally. Many of the post-European designs are rendered still harder to distinguish by the fact that in some of our best existing carved houses the panels were stitched by skilled Maoris, who gave them old names and maintained that they were original Maori designs. Some of them have old Maori patterns included in part of the panel. The application, however, of the above two points of distinction, and careful cross-examination, shows that the Maori craftsmen were probably unconsciously influenced by modern conditions. Their idea of good work was to make the designs as complicated as possible. The retention of some original Maori motives as part of the design, and the application of some old Maori name, made the new design an original Maori one in their minds.

There are several of these designs amongst the Arawa and East Coast people, but they are absent from the conservative Whanganui. A few have been selected to illustrate this class, and the names given are translated from the original manuscript written by one of the old men who assisted in making the designs. They may be roughly classified into—

(1.) Designs with an original Maori motive forming part :—

Fig. 4, *kotoretore makamaka.* This is an alternative Arawa name for *waharua*, the single-stitch lozenge, which is shown in the lower third of the panel and gives its name to the whole design.

Fig. 5, *whakaiwituna* (eel's bones). This is seen in the upper third. It is the overlapping wrapped stitch without the vertical stake and with the original middle motive repeated twice on either side. The rest of the design is called *mangati* and *mangata*, from a fancied resemblance to a figure in the game of cat's cradle (*whai*).

(2.) Designs with non-Maori geometrical figures :—

Fig. 6, *mumu.* This takes its name from the squares or chequers in the upper or lower thirds of the panel, and will be dealt with later.

Fig. 7, *pekapeka.* Amongst its many meanings, *pekapeka* means a flat plait of nine strands. As there are nine vertical lines in the top row of the panel, the design probably takes its name from that. In the middle third the octagon appears as a motive, but, though the outstanding feature of the design, there is no name for it.

Fig. 8. This design, for which I have not the name, shows the double triangle, which, though of widespread distribution, was unknown to the Maori.

(3.) Designs with Maori motives not hitherto used :—

Fig. 9, *patungarongaro* (fly-flap), from the large lozenge in the lower third. Fly-flaps were made of flax plaited in the form of a lozenge and fixed to a handle. They were used to keep the flies away from a corpse when it was lying in state.

Fig. 10, *hereweromanu* (bird-spear). The bone point of bird-spears were usually barbed on one side, at intervals, in threes. The motive for the name is shown in the lower third, where the three barbs appear on both sides for the sake of symmetry.

Fig. 11, *Rangitihi*, the name of the carved house in the Auckland Museum. This is shown in the middle third of the design. The lower third of the design is called *rapakaheru*, the blade of the old Maori wooden spade, and is taken from a figure in cat's cradle that bears the same name.

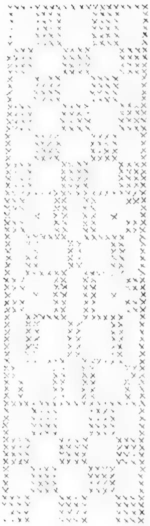


FIG. 4.
Kotoretore makamaka.

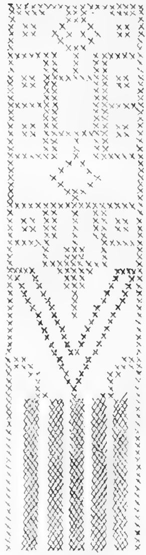


FIG. 5.
Whakaiwituna.

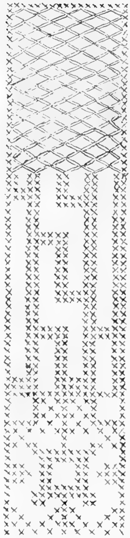


FIG. 6.
Mumu.

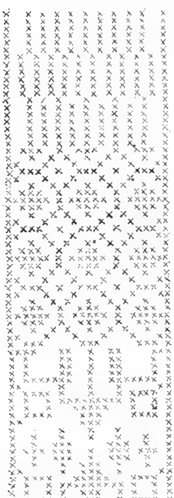


FIG. 7.
Pekapeka

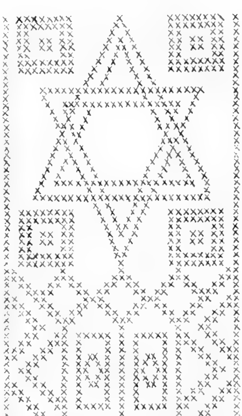


FIG. 8.

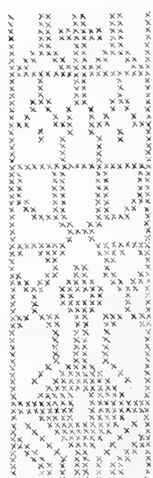


FIG. 9.
Patungarongaro.

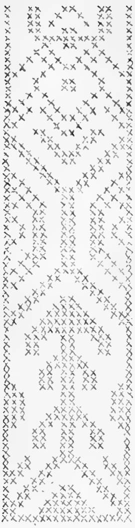


Fig. 10.
Hereweromanu.

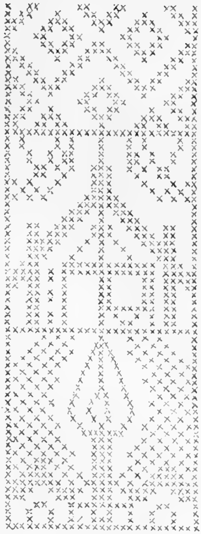


Fig. 11.
Rangitihi.

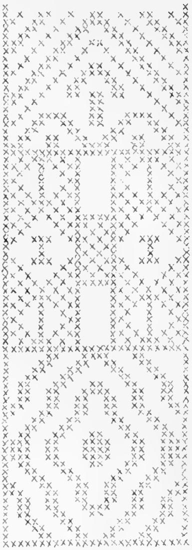


Fig. 12.
Mokoia.

Fig. 13.
The coil of the string of the kite of Whakatau.

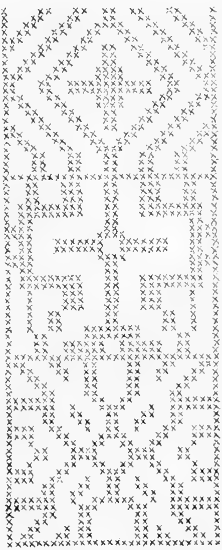


Fig. 14.
Aka matua.

Fig. 12, *Mokoia,* the island in Lake Rotorua. This is shown in the lower third, standing in Lake Rotorua. A similar figure can be produced in cat's cradle. The rest of the design is supposed to represent *Matariki* (the Pleiades).

(4.) Designs in which the names are purely fanciful.

Fig. 13, "The coil of the string of the kite of Whakatau, who flew his kite from a small hill at the time that Hine-te-iwaiwa went to search for Whakatau to avenge the death of Tuhuruhuru. The death was avenged. The motive of the name is seen in the middle third of the design." Whakatau-potoki was one of the great heroes of the race when they were in Polynesia. He is famous in song, story, and incantation.

Fig. 14: "*Aka matua* (the firm root) is the name of this design. It is the firm root by which Tawhaki climbed upwards to the heavens to get his daughter Arahuta, who was born of his heavenly wife."

Another design, with very slight modification, is described as follows: "*Aka taepa* (the loose root), is the name of this design. This is the way by which Karihi, younger brother of Tawhaki, attempted to climb to the heavens and nearly lost his life." The story of the two brothers is told in detail in Grey's *Polynesian Mythology.*

An excellent picture of post-European designs, taken from Porourangi, on the East Coast, is shown in Hamilton's *Maori Art,* part 2, plate xiii, fig. 2.

Decorative Transformation.

The decorative transformation of artificial and natural objects to wood, stone, and other material has led to a complete classification of patterns and designs according to what the craftsman tried to express. Although I hold that in the original Maori designs the patterns came first and the names after, it may be interesting to classify our panels according to the accepted system.

(1.) *Skeuomorphs.*

These have been defined as forms of ornament demonstrably due to structure. The markings on the handles of Tongan clubs have been shown to represent bindings of sinnet. Under this heading, the cross-stitch, no matter what the subsequent pattern developed, and the overlapping wrapped stitch are undoubtedly skeuomorphs. They were bindings originally to fasten the rods to the stakes and keep them in position. Even the single stitch in the simple chevron patterns comes under this heading. As they were named after various things, however, they will be classified accordingly.

(2). *Physicomorphs.*

Under this heading comes any representation of an object or operation in the physical world. Here we get the first three patterns done with the cross-stitch: *Purapura whetu* (star-seeds); *Mangoroa* (the Milky Way) (fig. 1, Plate LXVI); *tuturu* (leaking water) (fig. 3, Plate LXVI).

(3.) *Biomorphs.*

Biomorphs are divided into—

(*a.*) *Zoomorphs*—representations from the animal kingdom. The only example in this group that has the whole figure represented was the *patiki* (flounder) (fig. 4, Plate LXVIII). Some of the other designs represent part of the animal, as *waewae pakura* (swamp-hen's feet) (fig. 3 in text); *pihapiha mango* (shark's gills) (fig. 5 in text); *whakaiwi tuna* (eel's bones) (fig. 5 in text); *niho taniwha* (dragon's teeth) (fig. 4, Plate LXVII); *kanohi aua* (herring's eyes) (fig. 1, Plate LXVIII).

(*b.*) *Phyllomorphs*—representations from plant-life. In this group there are no examples. Doubtless owing to the impossibility of forming curves in the limited number of squares contained in a panel, that great motive in carving and rafter-painting, the curling shoot of the tree-fern, fails to appear.

(*c.*) *Anthropomorphs*, representing the human figure, should come under *zoomorphs;* but man, with his usual egotism, has placed himself in a class apart. In the old patterns the ribs are represented in the *kaokao* design (figs. 2 and 3, Plate LXVII).

The post-European designs I have left out of this classification. There are, however, most excellent examples of anthropomorphs in the great East Coast meeting-house, Porourangi, at Wai-o-mata-tini. Full-length portraits of ancestors are worked in the lattice-work of the panel, and duly labelled with the name neatly worked in cross-stitches.

THE EVOLUTION OF THE PANEL.

The evolution of the decorative patterns is so bound up with the construction of the panel that we must deal with all the elements that compose it. There can be no doubt that the first attempt at decoration was the vertical arrangement of the flower-stalks of the *kakaho* in the panel-space. The vertical thatched bundles of *raupo* (*Typha angustifolia*) as seen in the ordinary sleeping-houses (*wharepuni*) formed the basis of the house-wall and was complete in itself. In the Cook Islands, where the Maori ancestors sojourned ere embarking on the voyage to New Zealand, the house-walls are lined with thin vertical poles of the *purau* tree. These are peeled of their bark, and the thin white stakes lend a decorative effect to the walls. They are called *kaka'o* by the Rarotongans, who do not aspirate the *h*. The thin stakes of *purau* not being available in New Zealand, the Maori builder soon seized upon the long, thin, white flower-stalks of the *Arundo* as a substitute. or even improvement. Using them as a decorative lining, he applied to them the ancient name of *kakaho*. This type of decoration was carried on up under the sloping roof. Owing to the difficulty of working, it here remains stationary, whilst the easily accessible panel went on increasing in complexity of decoration. A few energetic spirits have, however, broken through the labour difficulty, for Te Wai Herehere, at Koriniti, on the Wanganui River, has cross-stitch decorations under the roof.

The next stage in evolution was the addition of horizontal rods. It seems probable that fern-stalks (*kakaka*), being easily procurable and requiring no special preparation, were the first material used. Variation of design seems to have demanded variation of material; and, whilst information can be obtained of house-panels decorated with *kakaka* rods with hardly any decorative stitching, I can gather no acccount of *kakaho* rods being used even as a foundation for elaborate stitching. To fix the rods to the stakes, ties or lashings were used. The lashings would natural y be of the same material as that used in the ordinary construction—namely, strips of flax. The simplest method would be to tie the ends of each rod to the stake behind. The simplest secure lashing would be a figure-of-eight turn round the rod and stake, and then tied. As the usual thing is to conceal knots, both from an artistic sense and to prevent their being rubbed loose, the knot in this case would be tied behind the stake and would result in the crossing of the figure-of-eight being in front of the rod. This is the origin of the cross-stitch in Maori panel-decoration. The cross-stitch—or, rather, the figure-of-eight lashing—is used by many people. The fishermen of the Murray Islands, in the Torres Straits, use it to lash the horizontal strips of cane and palm-leaf midribs to the cane rings in their *were*, or scoops used in *tup* fishing. A good illustration of this is seen in the *Report of the Cambridge Expedition to the Torres Straits,* vol. iv, fig. 170. The modern medical man uses a continuous overlapping form of this lashing to bandage a dressing to an arm or leg. The single stitch was also used as a lashing, and, whilst not so secure as the cross-lashing, when restricted to crossing one rod it served its purpose. A better class of rod was desired for the more elaborate houses, and the wood of the *rimu* and *totara* were split into laths, delicately adzed to even shape, these supplanting the more humble fern-stalk. The painting of these rods with the favourite red haematite of the Maori followed as a matter of course, and the artistic desire for contrast and variety demanded that others should be blackened. The law of even numbers that applies to rods and stitches in some districts may have followed from one of their systems of counting—the counting by twos. The value of the single and cross lashings of flax as a decoration did not long elude the keen eye of the old-time builder. In the many hours spent in the meeting-houses, with no books or other civilized methods of filling up the leisure hours, he had ample opportunity for studying the house-panels. Even whilst listening to speech, gossip, song, or story, his eyes could dwell on the stitches lashing the rods to the stakes. Irregular or sparsely scattered stitches offended his sense of symmetry and awoke the idea of more orderly arrangement. The surface of the rods became covered with ornamental stitches in addition to those necessary for binding. Lines, chevrons, and lozenges, that developed incidentally, were seized upon as motives and developed into definite patterns. These were named and handed on by the craftsman to his pupils.

The strip of flax, which at first was an ordinary binding, for decorative purposes was specially prepared to give it a whiter appearance. The *kiekie*, which is whiter than flax, was introduced. The contrast between the white stitched portions of the field and the darker unstitched portions in the open patterns suggested the possibilities of colour arrangement. Strips were dyed black, and the yellow of the *pingao* added to the scheme.

There must always have been some slight difficulty in keeping the cross-rods in position. The stakes at the back, in the course of time, are liable to slip down, perhaps at one side, and the rods become tilted. This is frequently seen in old houses. This led to the introduction of the vertical stake down the middle of the panel, and the overlapping wrapped stitch. In its useful stage the stake was braced against the upper and lower cross-boards, and, according to the Whanganui, entirely supported the rods. The stakes (*kakaho*), they held, were then of no functional use in supporting the rods, but were included in the decorative stitches to keep the lines of the patterns straight. This was followed by a stage where other arrangements, such as nailing, were made for fixing the panel; and the stake (*tumatakahuki*), now no longer braced above and below, became, with its lashing, purely decorative. A further recent development was the discarding of the stake and the retention of the lashing, either down the middle of another pattern or having the panel to itself with two or four repetitions. A very modern variation in the other direction is seen in the meeting-house Te Puru o Tuhua, at Taumarunui, on the upper Wanganui. There the stake is retained and the lashing represented by oblique bands of red, white, and black paint.

The further influence of European ideas and materials we have seen in the development of the post-European designs and the introduction of fluted boards to represent the *kakaho*. The limit is reached in the house at Taumarunui mentioned above. Fluted boards are run horizontally across the panel-spaces to represent the rods. They are painted red, whilst black and white cross-stitches are painted upon them in the form of designs.

A few years ago old houses in various parts of the country could be seen with panels completed in the various ways described. They served as links with the past, and marked the stages through which the house-panel had passed in the evolution of decorative art.

Names and Motives.

Professor Haddon* has pointed out that the investigations of Professors Ehrenreich and Karl von den Steinen in Brazil, and Mr. H. Vaughan Stevens in the Malay Peninsula, have, through oral information gathered from the natives, led to startling results as to the origin of simple geometrical figures in the decorative art of those regions. Links have been found establishing a connection between a recognizable though conventional representation of a motive and a geometrical figure that is unrecognizable. In these cases the geometrical figures were carved or painted. By these methods the craftsman had a wider scope for displaying his skill, and could produce a recognizable representation of his motive before the evolution into geometrical figures occurred. In Maori panel-decoration the craftsman was from the beginning confined by his field of small squares to geometrical figures. These, with the exception of the step and the large chevron, we have tried to argue were produced incidentally in the old patterns. The most important clue to the origin of the motives to be obtained by oral information is the name, with its meaning. Even with a good working knowledge of a language it is sometimes extremely difficult to say whether a geometrical figure developed incidentally and had a name applied to it subsequently, or whether the motive named really gave rise to the geometrical figure. In the old panel patterns, with the two exceptions named, the pattern came first and the name after.

The Maori has always been apt at naming places or objects from incidents that actually happened in his new home or were told of the old home in Polynesia, or from resemblances actually seen or attributed by his mythopoetic imagination. He could always find a name. According as the thought struck the tribal craftsman on the completion of his work, so he named his handiwork. The name was adopted by his assistants and became the tribal name. Thus we have a variety of names for the same motives amongst different tribes.

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* A. C. Haddon, *The Evolution of Art*, 1905.

The cross-stitch, used decoratively, remained simply *kowhiti* (crossed) with the Whanganui. Other tribes, if they had lashing names, abandoned them. The East Coast artist likened it to the eyes of a herring (*pukanohi aua*), whilst the Arawa, combining visional effect with imaginative speech, called it "the seed of a star" (*purapura whetu*). When the panel was completely covered without colour-patterns the Arawa saw a massing of star-seeds, and the pattern became the Milky Way (*Mangoroa*). With simple vertical lines, the Whanganui craftsman saw in each separate stitch a resemblance to the distinct drops of water falling from a leak in the roof, and the name *tuturu* (leaking water) was applied. A similar idea occurred to the Arawa, in that the leaking or dripping water of the Whanganui became, with them, falling tears, and, as metaphor and poetic simile were in everyday use, the pattern was named *roimata toroa* (the tears of the albatross).

With the two diagonal lines forming a chevron, the Maori had to seek for a name amongst the natural objects of his environment. For the smaller chevrons, formed by the single stitch, it was hard to find. However, the East Coast people found it in the feet or footprints of a bird. Any of the larger birds would have done, but the early artists settled on the bittern (*kautuku*) and the swamp-hen (*pakura*). The small-chevron effect became "bittern's footprints" (*tapuae kautuku*) and "swamp-hen's feet" (*waewae pakura*). With the larger-chevron pattern, made with the cross-stitch, the naming was much easier. The commonest name for this pattern is *kaokao* (side or bend of the ribs). Another common name is *maihi* (the facing-boards of the gable of a house). Both names convey the idea of an angle or chevron on a larger scale than the small single-stitch pattern mentioned above. Though attention has been drawn to the fact that this pattern could easily be evolved on the panel, many Maori say that the motive was derived from the similar pattern on floor-mats, belts, and baskets. The floor-mat must be given priority, for plaiting was brought from Polynesia, whereas the panel patterns developed in New Zealand. *Koki* means "an angle," and *whakakokikoki*, "to bend into angles," was the name applied to the large chevron pattern plaited in floor-mats and baskets. *Whakakaokao* is also applied to it. Both these names are used for the panel pattern. It seems probable, therefore, that this pattern was derived from an existing motive furnished by the sister art of plaiting. The other motive and name derived from a similar source, the *poutama*, or step pattern, has already been mentioned. Of the exact meaning of *poutama* and its bearing to this figure I can offer no suggestion.

The triangle required some triangular object to supply a name. This was found in the triangular tooth of the shark. Triangles in the carving of some of the New Guinea people are named after it. The ceremonial peace-axes of Mangaia, besides the K pattern, or *tikitiki tangata*, have small triangles carved on the handle. They are named *ni'o mango* (shark's teeth). The shark was a favourite food with the Maori, and the triangular teeth were set in wooden handles as a knife, the *mira tuatini*. No doubt sharks' teeth gave the name to the triangle amongst the Maoris, but his more figurative language expressed it in larger terms. Hence the Arawa name of *niho taniwha* (dragon's teeth). The Urewera call the triangle on the decorative borders of cloaks *niho pakake* (whale's teeth).

The lozenge motive leads to further complications in naming. The Arawa and Urewera call the lozenge *waharua*, whether in weaving or in lattice-work. An Urewera woman tried to explain that, in weaving, the base of a triangle was the *waha* (mouth), and the lozenge, consisting as it did of two triangles, had two mouths (*waharua*). The East Coast and the Whanganni call it *whakaruakopito*. When I tried to get further particulars of the meaning of the word from an old man of Whanganui he smiled compassionately at my ignorance and placed his thumb upon his navel. Williams's Dictionary gives *pito* as "navel," and *kopito* as "a pain in the abdomen." In the large lozenge, formed of cross-stitches, called *patiki* (flounder) by the Arawa, we can follow the connection.

Passing on to post-European work we stand on different ground. A multitude of motives were introduced into the country through the European invasion. Many of them were decorative, and the Maori began to introduce them into his work. In doing so he opened up new ground, and began also to introduce motives from his own environment that had hitherto not been attempted. The old simple patterns were now much too simple, and in many cases were only retained as part of a complicated design. With complicated designs the difficulty of naming becomes apparent. Where part of the design consisted of a known motive its name was usually applied to the whole panel. This is seen in the first three groupings of the designs illustrating this period.

In the second group pure European motives are introduced. Fig. 6 shows a design of small squares or chequers. Such a motive is very easy to produce, and might easily be Maori. The design is named *mumu*. Williams's Dictionary gives *mumu* as "a pattern in decorative lattice-work." In spite of *mumu* being an old Maori word, had any other name been applied to the design we might have been led into believing that a series of small squares was an original pattern. The name, however, reveals its origin. The Maori are very fond of the game of draughts, which, having been introduced by Europeans, had to have a Maori name coined for it. The Maori named it from a word that is constantly used in the game. When a player said "Nawai te *mu?*" or "Nau te *mu*" he meant "Whose *move* is it?" or "It is your move." Thus the word *mu*, which was as near as he could get to the English word "move," was, according to Williams, adopted into the language, for draughts. Hence we get the name *mumu* applied to a chequer pattern, the motive of which is derived from the European draught-board. Fig. 7 shows a motive of octagonal figures. This is derived from linoleum. Many modern houses were decorated by a dado of linoleum nailed round the wall, so that it was an easy transition to reproduce it in modern lattice-work. Even the Maori, with all his stoutness of heart, hesitated at translating *linoleum* into Maori and applying it to a design. He fell back on *pekapeka*, the flat nine-strand plait at the top of the design, as a name.

The third group, with the Maori motives of a fly-flap, bird-spear, front of a house, and Mokoia Island, are sufficiently obvious to present no difficulty in naming. In the same group we come across a new source for decorative motives—namely, the game of cat's cradle (*whai*). *Mokoia* (fig. 12) and *mangati* and *mangata* (lower parts of fig. 5) are not very clear, but *rapakaheru* (lower third of fig. 11) bears a distinct resemblance to the blade of the old wooden spades (*kaheru*) that have been found in swamps. In each case the name of the cat's-cradle figure has been applied to the panel design. Another source of motives has been the decorative borders of dress cloaks. In these cases the name of the garment has been applied to the design.

In the fourth group, fig. 13 shows a combination of lines and angles that bear no resemblance to any motive. In the middle third of the design, however, it will be seen that the cross-stitches are closer together. This is due to the fact that they are stitched round one *kakaho* stake at the back of the rods, whereas in the other parts, two *kakaho* are treated as a single element in stitching. The cross-stitches, therefore, in the middle third, whilst just as long as the others, are only half as wide. With this fanciful data the naming craftsman named the groupings of narrow stitches "the coil of string of the kite of Whakatau." It is left to the imagination to see a kite in the upper third of the panel, and the hillock (*taumata*), from which Whakatau flew the kite, in the triangles in the lower third. In fig. 14 there are very obvious crosses in the upper and middle thirds, the lower one being mounted on a stepped base, as in a cemetery. This motive was obviously European; but the name applied was the *aka matua*—the firm root by which Tawhaki climbed to the heavens in search of his daughter. Since the advent of Christianity the cross is regarded as the way to heaven. Thus we see a modern motive, as far as the Maoris are concerned, with the ideas it suggests, being referred back to a similar idea in Maori mythology, and the Maori name being adopted for the panel design. A lesser imaginative artist might have chosen a ordinary name, but not so the Maori; and the Maori is not the only artist who has named a picture where the application of the title is hard to follow.

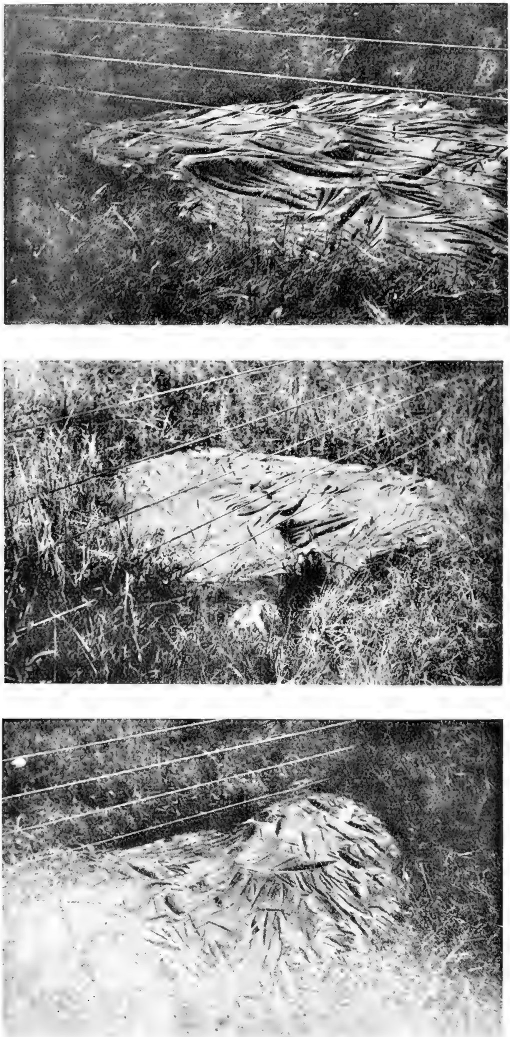
Conclusion.

I have to thank the Rev. F. A. Bennet and Mr. J. McDonald for the photographs and Mr. Elsdon Best for the drawings used in this article. If there is too much of theory it is due to the material carefully weighed and thought over, and not to any preconceived ideas. After all, theories, having been given, are meant to be criticized, that more information may be gathered.

Afterword.

Since the above was written I find that the *waharua* pattern (Plate LXVIII, fig. 3) is called *papaka* (crab) by the Whanganui.

With regard to the present-day existence of the art, it has disappeared amongst the tribes of Waikato, Maniapoto, and Taranaki. There is a modified survival in the carved house at Te Kuiti, where the designs are painted on the woodwork in the same manner as those at Taumarunui.



Three views of supposed sharpening-stone, showing grooves.

[*Face p. 471.*

ART. L.—*An Account of a (supposed Maori) Sharpening-stone.*

By ROBERT FULTON, M.D.

[*Read before the Otago Institute, 9th November, 1920; received by Editor, 31st December, 1920; issued separately, 12th August, 1921.*]

Plate LXX.

IN 1917, when travelling from Tauranga to Whakatane, I was informed of a Maori sharpening-stone near the Mimiha crossing, near Matata, and I seized the opportunity of examining an object of such great interest. At that time the railway was not constructed, and the stone was near the coach-road, half under a wire fence bordering a piece of swampy land. It was almost embedded in very damp ground, and was partly covered with rank vegetation. From memory I should say it was about 4 ft. or 5 ft. long, and 2 ft. wide—a hard, volcanic-looking rock, possibly a meteorite, and so far as I could judge there was no sign of any stone in the neighbourhood the least approaching to it in character. The roads were not metalled, and there did not seem to be any of the usual andesite blue road-metal one sees in so many places in the South. Rarely did one see a pebble or a pebbly stream, but all along the coast there was an abundance of soft sandstone, and cliffs of sandstone and clay, so soft as to be curiously cut and channelled by the sand-laden wind, and also by the extraordinarily heavy downpours of rain occasional in that locality. The only hard rock I saw for many miles was Pohaturoa, the famous sacred rock at Whakatane; but even that appeared to me to be quite different in character. I had no chance of taking photos or even of making a careful description, with measurements, &c., being on the spot for only a few minutes; but what I saw of the stone was sufficient to make me anxious to learn something of its history, and, if possible, to secure photos. No one in Tauranga, where I made many inquiries on the three occasions of my visiting that town, could tell me much about it. People had vaguely heard of it; I could find no one who had actually seen it. The motor-driver, who often passed near it, had been told where it was, and said he thought he could find it for me. He had heard it said that the Maori of old came from far and near to sharpen their stones upon it; but he seemed to have remembered the mere facts, without the name of a single informant. No one in Whakatane seemed even to have heard about it, and I could find no reference to it in any book, nor could I learn anything from the leading authorities on Maori matters in New Zealand. After three years' endeavour I have, through the good offices of Mr. Arnold Woodward, surveyor, of Whakatane, secured some photographs, and he has also been kind enough to unearth what he could about its local history. The stone is in a spot about three miles north of Matata, and Mr. Fred Burt, who has lived there for thirty-five years, states that on his coming there the stone was covered with high manuka, and had not been used for many years. It was uncovered by Mr. Burt's father, but until the railway was built it was periodically covered with water dammed up by sandbanks after storms, and again left dry on the water breaking through the sandbanks.

Mr. Elsdon Best has referred me to a description, made by W. Best, of Otaki, about thirty-four years ago, of a *hoanga,* or Maori sharpening-stone, in the Mimiha Creek at practically the same spot. The description appears in the *Dominion Museum Bulletin No. 4,* p. 90, and in the *Monthly Review,* 1890, p. 481; but, whilst the locality is the same, there are several differences that make it fairly evident that two different stones are in question. Best's is described as an enormous rock which had fallen from the cliff above, and was of sandstone, 20 ft. by 10 ft., and projecting 7 ft. or 8 ft. out of the water. Burt's stone is not half that size, is flush with the ground, and not near the stream, which, however, may have changed its course in thirty years. Best's rock was later on entirely covered up and disappeared, while Burt's has been uncovered and known for many years. It must be noted, however, that Best's stone was sometimes uncovered, sometimes covered with silt. In Best's the grooves were 3 ft. long, and 10 in. to 12 in. in depth; while in Burt's I should say from memory they were no more than 3 in. to 6 in. long, and 1 in. to 2 in. deep. Best's stone was sandstone; Burt's seemed to me to be hard like andesite, or like a meteorite. The sandstone cliffs appeared to me to be very soft and not at all suitable for grinding. Captain Mair, in referring to this *hoanga,* said that the Maori asserted that they knew nothing about it, and that the grooves were the work of pre-Maori days.

The stone now lies almost on the road-line, and it is desirable that it should be carefully fenced in and made into a little reserve; or, better still, the whole stone should be lifted bodily, if possible, and removed to the Dominion Museum, Wellington, for it is certain that when the railway is opened and the stone cleared from surrounding vegetation it will very soon be chipped and broken by tourists and others endeavouring to remove portions as curios, and eventually destroyed.

As this stone has not heretofore been described, I felt the matter was of sufficient importance to bring forward, so that steps might be taken to have the stone carefully examined by geologists and ethnologists after it has been placed in a position of security.

Art. LI.—*The Food Values of New Zealand Fish: Part II.*

By (Mrs.) Dorothy E. Johnson, B.Sc. in Home Science.

Communicated by Professor J. Malcolm.

[*Read before the Otago Institute, 7th December, 1920; received by Editor, 31st December, 1920; issued separately, 12th August, 1921.*]

The investigations described in Part I (*Trans. N.Z. Inst.,* vol. 52, p. 20, 1920) have been continued along similar lines and by use of the same methods of analysis. An attempt was made to follow the seasonal variation of composition in groper and kingfish; some new varieties were examined (whitebait, red cod, &c.); and some further analyses were made of fish already reported on in Part I. The results are shown in the following tables.

TABLE I.—GENERAL TABLE SHOWING PERCENTAGE COMPOSITION OF FISH ANALYSED.

Common Name of Fish.	Specimen.	Scientific Name.	Date received.	Water.	Solids, by difference.	Fat.	Protein.	Ash.	Total.
Silver-fish	1	*Callorhynchus antarcticus*	1/3/20	73·71	26·29	0·61	23·77	1·37	99·46
Ling	1	*Genypterus blacodes* ..	9/3/20	80·26	19·74	0·16	17·61	0·98	99·01
,, ...	2	,, ..	2/7/20	81·08	18·92	0·11	17·58	1·23	100·00
Red cod..	1	*Lotella bacchus* ..	12/3/20	81·96	18·04	0·46	15·98	1·15	99·55
,, ...	2	,, ..	21/5/20	79·87	20·13	0·48	17·48	1·18	99·01
Blue cod (pakirikiri) ..	2	*Percis colias*	16/7/20	73·88	26·12	6·13	18·46	1·29	99·76
,, ,, ..	1	,, ...	16/10/19	79·70	20·30	0·90	18·79	1·05	100·44
Roe of groper	1	..	5/8/20	59·77	40·23	10·94	23·95	3·26	97·92
,, ...	2	..	20/8/20	61·03	38·97	9·35	24·65	1·35	96·38
Flounder (patiki) ..	1	*Rhombosolea monopus*	13/8/20	78·74	21·26	1·97	17·78	1·16	99·65
Roe of flounder	1	..	13/8/20	67·24	32·76	4·39	24·88	1·76	98·27
Whitebait	1	*Galaxias attenuatus* ..	9/9/20	79·70	20·30	1·79	16·27	1·41	99·17
,, ...	2	,, ..	24/9/20	79·70	20·30	1·82	16·32	1·59	99·43

TABLE II.

Name of Fish, &c.		Kind of Sample.	Price. (Pence.)	Weight. (Grammes.)	Edible. (Percentage.)	Waste. (Percentage.)
Silver-fish	1 ..	Slice ..	9	540	86·30	13·70
Ling	1 ..	,, ..	6	680	70·58	29·42
,,	2 ..	,, ..	9	750	76·51	23·49
Red cod	1 ..	,, ..	4	595	69·42	30·58
,,	2 ..	,, ..	10	654	80·58	19·42
Blue cod	1 ..	,, ..	21	744	47·44	52·56
,,	2 ..	Whole ..	36	1,368	50·00	50·00
Roe of groper	1 ..	,, ..	15	808	94·19	5·81
,,	2 ..	,, ..	12	822	93·31	6·69
Flounder	1 ..	,, ..	24	509	54·81	45·19
Roe of flounder	1 ..	,, ..	24	47	100·00	..
Whitebait	1 ..	Large number	24	160	100·00	..
,,	2 ..	Ditto ..	54	423	100·00	..

TABLE III.

Name of Fish, &c.		Calories per 100 Grammes of Undried Edible Material.	Cost of 100 Grammes Protein. (Pence.)	Cost of 1,000 Calories. (Pence.)
Silver-fish	1	103·18	8·12	18·72
Ling	1	73·69	7·10	16·96
,,	2	73·10	8·92	21·45
Red cod	1	69·81	6·06	13·91
,,	2	76·16	10·85	24·92
Blue cod	1	85·40	31·70	69·70
,,	2	132·71	28·51	39·66
Roe of groper	1	199·99	8·23	9·86
,,	2	188·02	6·35	8·32
Flounder	1	91·22	} 39·16	74·63
Roe of flounder	1	142·86		
Whitebait	1	83·31	92·19	180·06
,,	2	83·85	78·24	152·23

In compiling Tables IV, V, and VI the results of analyses given in Part I have been included.

TABLE IV.—SHOWING FISH IN ORDER OF FAT CONTENT.

		Per Cent.			Per Cent.
Roe of groper	1	10·94	Whitebait	1	1·79
Tarakihi	1	10·30	Crayfish	3	1·30
Mullet	1	10·09	Moki	1	1·63
Roe of groper	2	9·35	Blue cod	1	0·90
Blue cod	2	6·13	Crayfish	1	0·72
Roe of flounder	1	4·39	Silver-fish	1	0·61
Kingfish	1	4·32	Snapper	1	0·60
Sea-bream	1	4·25	Crayfish	2	0·52
Kingfish	2	4·10	Red cod	2	0·48
Groper	3	3·40	,,	1	0·46
Trumpeter	1	3·31	Snapper	2	0·42
Moki	2	3·21	Ling	1	0·16
Tarakihi	2	3·05	,,	2	0·11
Groper	4	2·93			
Baby groper		2·32			
Flounder	1	1·97	Eggs		10·50
Groper	2	1·90	Meat (beef)		5·50
Whitebait	2	1·82	Milk		4·00

TABLE V.—SHOWING FISH IN ORDER OF CALORIC VALUES.

		Calories.			Calories.
Roe of groper	1	200·00	Groper	3	96·39
,,	2	188·02	Moki	1	93·56
Mullet	1	172·89	Flounder	1	91·22
Tarakihi	1	167·45	Snapper	1	90·38
Roe of flounder	1	142·86	Crayfish	2	85·96
Blue cod	2	132·71	Blue cod	1	85·40
Sea-bream	1	119·51	Whitebait	2	83·85
Kingfish	2	119·47	,,	1	83·31
,,	1	116·93	Snapper	2	81·51
Tarakihi	2	111·64	Red cod	2	76·16
Groper	3	110·92	Ling	1	73·69
Trumpeter	1	110·20	,,	2	73·10
Moki	2	104·96	Red cod	1	69·81
Crayfish	3	103·73			
Silver-fish	1	103·18			
Groper	4	102·78	Eggs		158·33
Baby groper		102·56	Beef		137·25
Crayfish	1	100·59	Milk		70·00

TABLE VI.—SHOWING FISH IN ORDER OF COST OF 100 GRAMMES PROTEIN.

		Pence.			Pence.
Red cod	1	6·06	Moki	1	16·21
Roe of groper	2	6·35	Kingfish	1	17·22
Ling	1	7·10	,,	2	17·56
Groper	1	7·31	Moki	2	18·27
Silver-fish	1	8·12	Groper	4	19·78
Roe of groper	1	8·23	Trumpeter	1	20·11
Ling	2	8·92	Crayfish	2	22·98
Mullet	1	8·96	Blue cod	2	28·51
Groper	2	10·45	,,	1	31·70
Red cod	2	10·85	Flounder	1	39·16
Groper	3	11·80	Whitebait	2	78·24
Crayfish	1	11·49	,,	1	92·19
Snapper	1	12·35			
Crayfish	2	12·66			
Snapper	2	14·64	Beef		12·60
Tarakihi	1	15·61	Milk		14·62
,,	2	15·95	Eggs		32·94
Sea-bream	1	15·99			

Discussion.

The deductions of Part I are true for the further twelve samples analysed this year, though it may be noted that in the two samples of red cod the fat-percentage is practically the same (0·47), and the sample with 82 per cent. water has 16 per cent. protein, while the other with 80 per cent. water has 18 per cent. protein.

The following points are worthy of notice:—

1. The analyses of two samples of whitebait are almost identical.

Sample.	Water.	Solids.	Fat.	Protein.	Ash.
1	79·7	20·3	1·8	16·3	1·4
2	79·7	20·3	1·8	16·3	1·6

In these analyses a large number of the fish was used, giving as a result the average composition of that particular species. This eliminates to a large extent the variations noticeable in different samples of the same species of fish even when bought at short intervals. It indicates that in order to obtain the average analysis of any species a sample should be taken from the well-mixed muscle of as many fish as possible. That method would eliminate (1) the difference due to the different metabolism of the specimens taken, and (2), to some extent, the difference due to varying richness of feeding-grounds.

2. The analyses of the roes of groper and flounder show differences from the general analyses of fish-roe given in various books: *e.g.*—

——	Water.	Protein.	Fat.	Other Nitrogenous Matter.	Ash.
(1.) Caviare and approximately all fish-roe (Hutchison)	38·10	30·00	19·70	7·60	4·60
(2.) Garfish-roe (German authority)	55·00	15 to 28	16 to 28	1·50	0·36
(3.) Groper-roe	59·80	23·95	10·94	..	3·26
(4.) Flounder-roe	67·24	24·88	4·39	..	1·76

The figures 23·95 and 24·88 in (3) and (4) include all nitrogenous matter. In the case of the roe, the method of extracting the fat with ether alone is not entirely satisfactory, and in future analysis of this class of material it is intended to use Rosenfeldt's method (alternate extraction with boiling absolute alcohol and chloroform).

Some Experiments on the Seasonal Variation of Composition of Groper and Kingfish.

In Part I of this paper reference was made to the variation in fat content in different samples of the same variety of fish. It was suggested that it was a matter, say, of metabolism or of seasonal variation. Further work was done in this connection with the object of ascertaining what variation there was to the consumer in the food value of groper and kingfish at different times of the year. Eleven samples of groper and seven of kingfish were analysed. Table VII gives the results both of the variation in the composition and also in the price.

The graph shows the seasonal variation of the fat content of the two varieties of fish.

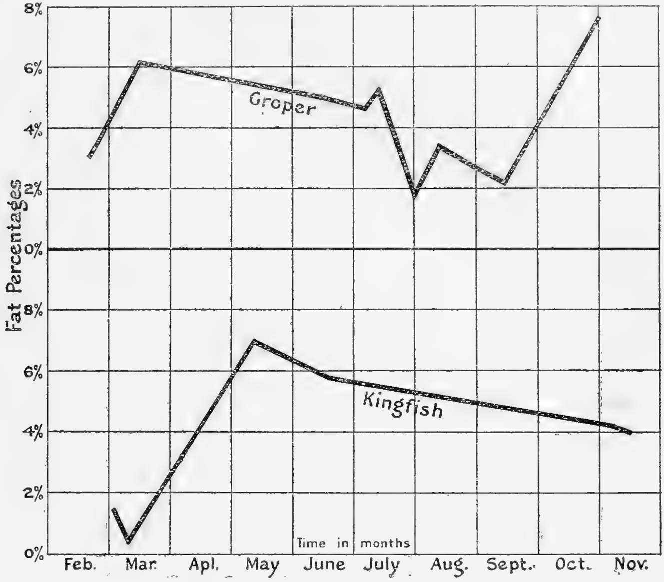


Table VII.—General Analyses showing Seasonal Variation of Groper and Kingfish.

Specimen.	Date received.	Waste. (Percentage.)	Water. (Percentage.)	Solids (by difference).	Fat. (Percentage.)	Protein. (Percentage.)	Ash. (Percentage.)	Calories per 100 Grammes Edible Material (calculated).	Market Price per Pound. (Pence.)	Cost of 1,000 Calories. (Pence.)
					Groper.					
1	23/2/20	15·91	76·86	23·14	3·17	18·37	1·08	95·08	8	22·14
2	24/2/20	24·52	76·38	23·62	3·58	18·70	1·09	109·95	8	16·43
3	17/3/20	16·48	73·89	26·11	6·16	18·91	1·10	134·87	8	13·16
4	17/6/20	14·84	74·36	25·64	5·07	19·10	1·20	125·45	15	23·35
5	6/7/20	23·88	74·99	25·01	4·88	18·94	0·98	123·06	12	19·86
6	10/7/20	4·16	75·57	24·13	5·26	17·98	1·03	122·66	15	23·12
7	30/7/19	5·38	76·00	24·00	1·90	19·20	1·27	96·39	6	20·80
8	11/8/19	2·95	76·10	23·90	3·40	19·34	1·08	110·92	6	20·60
9	28/8/19	12·68	77·03	22·97	2·93	18·42	1·08	102·78	9	34·40
10	11/9/19	60·69	76·41	23·59	2·32	19·75	1·10	102·56	..	..
11	1/11/20	13·08	72·14	27·86	7·63	19·84	1·09	152·30	15	23·03

TABLE VII.—GENERAL ANALYSES SHOWING SEASONAL VARIATION OF GROPER AND KINGFISH—*continued.*

Specimen.	Date received.	Waste. (Percentage.)	Water. (Percentage.)	Solids (by difference).	Fat. (Percentage.)	Protein. (Percentage.)	Ash. (Percentage.)	Calories per 100 Grammes Edible Material (calculated).	Market Price per Pound. (Pence.)	Cost of 1,000 Calories. (Pence.)
					Kingfish.					
1	3/3/20	27·84	78·25	21·75	1·31	18·52	1·19	88·11	11	37·05
2	8/3/20	20·23	80·04	19·96	0·54	17·49	1·22	76·75	10	37·12
3	12/5/20	21·57	73·20	26·80	6·79	19·49	1·19	159·44	12	14·99
4	17/6/20	24·07	72·63	27·37	5·57	19·54	1·26	131·92	15	24·34
5	1/11/20	22·20	74·99	25·01	..	18·46	1·02	..	15	..
6	3/11/19	26·70	75·65	24·35	4·32	18·72	0·93	116·93	12	28·10
7	11/11/19	21·75	74·37	25·63	4·10	19·84	1·14	119·47	15	28·60

Discussion.

It will be seen that the fat content of groper varies during the year from 1·90 to 7·63 per cent., while that of kingfish varies from 0·54 to 6·79, so there is considerable variation in the nutritive value. This is well shown by comparing the total calories per 100 grammes of fresh material:—

Fish.	Fat. (Percentage.)	Calories. (Percentage.)
Groper	1·90	96·39
,, ...	7·63	152·30
Kingfish	0·54	76·75
,, ...	6·79	159·44

The nutritive value of a fish at its best is double that of the fish in poor condition. When the high nutritive value of the roe is considered (calories per cent. of roe = 200), the low food value of fish after spawning is not remarkable.

Groper came into the market heavy with roe in July and August, but kingfish was hardly procurable in those months. The analyses give point to the probability of the spawning season for kingfish being in February or March.

The variations noted may be due to differences in age, sex, metabolism, richness of feeding-ground, or other causes, so that more must be known before the differences can be taken to represent seasonal variation alone. Were a sample taken from the mixed muscle of a number of fish, as in the case of whitebait, discussed above, some of these variations would be eliminated. The market, too, presents difficulties. The fish are not procurable at definite stated intervals. The results, however, embody the variation in the value that the consumer is obtaining when buying the same variety of fish at different seasons of the year.

All the expenses incurred in these investigations have been defrayed by a grant from the New Zealand Government, through the New Zealand Institute, and I have to thank the University of Otago for the use of laboratory-space and apparatus.

ART. LII.—*The Chemistry of Flesh Foods.—(5) The Nitrogenous Constituents of Meat-extracts.*

By A. M. WRIGHT, A.I.C., F.C.S.; (Miss) J. F. BEVIS, B.Sc.; and the late P. S. NELSON, M.Sc.*

[*Read before the Philosophical Institute of Canterbury, 1st December, 1920; received by Editor, 31st December, 1920; issued separately, 12th August, 1921.*]

THIS paper is a continuation of the investigations of flesh foods which are being carried out in the laboratory of the New Zealand Refrigerating Company (Limited) (1, 2), and covers a number of investigations dealing with the composition of meat-extracts. These have been carried out since the publication of a former contribution on the subject (3).

MANUFACTURE.

In general, commercial meat-extracts are manufactured from finely chopped lean meat (the muscular tissues of flesh), which is placed in tanks containing cold water; steam is admitted, and the material is heated for about half an hour. The liquor obtained from meat which is parboiled in the process of preparing certain canned meats is also utilized. The liquors while hot are pumped into a large tank and there settled in order to separate out in part the particles of meat-fibre which are present; the supernatant liquor is then filtered to remove any solids in suspension, the fat present is skimmed off, and the clear liquid is concentrated in steam-heated pans, either under vacuum or at ordinary atmospheric pressure, the partially concentrated liquor being finally transferred to a finishing-pan and heated until the water content approximates 20 per cent. and the material is of a syrupy consistency.

It is obvious, therefore, that meat-extract can contain only a small part of the nutriment of meat, for there is practically no albumen or fat present, and very little gelatine; the extract consists of salts and extractives of the meat. It is the nitrogenous extractives which give meat-extracts their chief value, and these have been classed under the somewhat loose term of "meat-bases" (3). The meat-bases are products of the breaking-down of proteins in the vital processes of the body, and are excreted for the most part unchanged, and have little or no value as builders of tissue; they cannot be strictly regarded as foods, but possess certain stimulating properties, and apparently furnish relief to fatigued muscle and are powerful excitants of gastric secretion.

The results of an examination and identification of the various nitrogenous constituents of a number of meat-extracts have already been published by one of us (A. M. W.) (3), so that it is unnecessary to record the data covering the work then published.

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* The late P. S. Nelson was killed in action during June, 1917.

Commercial Valuation.

The commercial valuation of meat-extracts, however, is not based upon the results of an extensive and detailed identification of the various nitrogenous constituents which give the value to an extract, but upon a consideration of the colour, flavour, and the proportion of the extract soluble in 80 per cent. alcohol ; it is the amount of the latter which to a large extent determines the value to the manufacturer of the meat-extract.

The method has been criticized adversely from time to time as being unsound in principle from a scientific point of view ; in commercial practice, however, this determination showed results which were in general accord with the demand of the purchaser, although the underlying reason was not apparent.

Nitrogenous Constituents.

It is only recently, however, that methods of analyses have been developed which enable the study of nitrogenous constituents to be carried out with a reasonable degree of accuracy and detail.

In the results to be described the following methods were used. For the determination of the moisture, mineral salts, chlorine, nitrogen, meat-bases, the methods outlined by one of us (A. M. W.) (3) were used. The "meat-base" nitrogen is that of the tannin-salt filtrate after deducting the ammoniacal nitrogen determined by the magnesium-oxide distillation method. This probably gives results lower than the actual for the "meat-base" nitrogen, for the reason that the magnesium-oxide distillation method for the determination of the ammoniacal nitrogen probably gives results which are too high. The results of a comparative study of the magnesium-oxide distillation method, and the Folin aeration method applied to the determination of ammoniacal nitrogen in meat-extracts, will be discussed later. As, however, in most of the recent work upon flesh products the magnesium-oxide method has been used, the results will be comparable with those of other workers. For the determination of the 80 per cent. alcoholic precipitate and the soluble extract the method described by Thorpe (4) was used.

	Calculated to Moisture-free Basis.					
	(1.)	(2.)	(3.)	(4.)	(5.)	(6.)
Organic matter	79·44	79·89	78·85	78·04	78·25	77·84
Mineral salts	20·56	20·11	21·15	21·96	21·75	22·16
Chlorine	2·16	2·36	2·46	2·36	2·32	2·60
Nitrogen, total	10·26	10·48	10·33	10·05	10·07	10·17
Nitrogen, meat-base	4·42	4·53	5·19	5·21	4·36	4·66
Soluble in 80 per cent. alcohol—						
Organic matter	47·95	49·35	49·23	47·47	50·57	50·00
Mineral salts	11·14	12·10	11·56	12·68	13·05	13·23
Chlorine	2·04	2·34	2·40	2·33	2·29	2·55
Nitrogen	5·71	6·28	6·31	6·18	6·70	6·54
Nitrogen, meat-base	3·99	4·60	5·01	4·32	4·44	4·40
Insoluble in 80 per cent. alcohol—						
Organic matter	31·49	30·54	29·62	30·57	27·68	27·84
Mineral salts	9·42	8·01	9·59	9·28	8·70	8·93
Chlorine	0·12	0·02	0·06	0·03	0·03	0·05
Nitrogen	4·55	4·20	4·02	3·87	3·37	3·63
Nitrogen, meat-base	0·43	– 0·07	0·18	0·46	– 0·08	0·26

It is thus found that 62·4 per cent. of the organic extractives are soluble in 80 per cent. alcohol, 61·4 per cent. of the total solids, 57·7 per cent. of the total mineral salts, and 63·1 per cent. of the total nitrogen, while 94·3 per cent. of the meat-bases and 99 per cent. of the chlorides are thus soluble.

From a consideration, therefore, of the results it is seen that the meat-bases, to which is due the principal physiological value of a meat-extract, are nearly completely soluble in 80 per cent. alcohol; consequently the results obtained by the commercial method of valuation are in agreement with the physiological.

The nitrogenous constituents insoluble in 80 per cent. alcohol are principally compounds similar to gelatine; and, while gelatine has a physiological value as a sparer of protein in metabolism, it has but little value as a food.

NON-PUTRESCENCE OF SOLID MEAT-EXTRACTS.

It has been a matter of common knowledge that solid meat-extracts do not undergo bacterial decomposition. While this fact has been noted in connection with the report of the Commission appointed to investigate the methods of manufacture of meat-extracts (8), the question has arisen as to whether in the absence of special precautions solid meat-extract remains free from bacterial growth and decomposition. Commercially it is known that even after a period of several years solid meat-extract has been found to be undeteriorated. In order, however, to ascertain whether there is any evidence of bacterial or other decomposition we have made a number of determinations covering extracts which have been held in jars with loosely fitted tops after exposure to the atmosphere; these extracts have in some cases been held for as long as six months.

As is well known, ammonia is one of the decomposition products of nitrogenous foods, and the determination of the loosely bound nitrogen as ammonia which occurs in the nitrogenous constituents of meat-products has proved to be one of the most reliable methods for indicating the decomposition or otherwise of such substances; it has been shown that a marked rise in the amount of ammoniacal nitrogen occurs in meat products before the senses can detect any decomposition (11, 12, 13, 14, 15).

The methods used in the determination of the ammoniacal nitrogen were (*a*) the magnesium-oxide distillation method (9), and (*b*) Folin's aeration method (10, 16).

(*a*.) The magnesium-oxide method used was as follows: 1 gramme of the extract (or an aliquot portion of a solution of the extract equal to 1 gramme of extract) was placed in a distillation-flask with 300 c.c. of water and 5 grammes of magnesium oxide free from carbon dioxide; after connecting the flask with a condenser, 100 c.c. of the liquid was distilled into N/50 acid, and titrated as usual, using congo-red as an indicator.

(*b*.) The Folin aeration method used was as follows: An aliquot portion of a solution of the extract equal to 1 gramme of extract was placed in a large tube; 0·5 c.c. saturated solution of potassium carbonate and 1 c.c. saturated solution of potassium oxalate with 2 c.c. kerosene (to minimize frothing) were added. The mixture was aerated from a water-blower with water-injector pump, the air being passed through 30 per cent. sulphuric acid in order to remove any traces of ammonia before passing through the aeration-tube. The period of aeration was four hours, at the rate of 80 litres of air per hour; the ammonia from the extract was collected in N/50 acid through which the air from the aeration-tube was passed; congo-red was used as an indicator.

The results are shown as follows :—

Ammoniacal Nitrogen expressed as Percentage of Total Nitrogen.

	Magnesium-oxide Distillation Method.	Folin's Aeration Method.
	Per Cent.	Per Cent.
(1.)	6·95	4·86
(2.)	6·94	4·37
(3.)	7·05	4·73
(4.)	6·82	5·36
(5.)	6·10	4·27
(6.)	6·21	4·17
(7.)	5·71	3·81
(8.)	6·81	4·77
Average ..	6·57	4·03

In a former paper (3) the ammoniacal nitrogen in freshly prepared extracts was shown to average 7·06 per cent. of the total nitrogen, using the magnesium-oxide method.

It will thus be seen that even after six months' storage and after ordinary atmospheric exposure no decomposition is found by either method.

Ammonia Test for Spoilage of Solutions of Meat-extracts.

In a former paper it was shown that the ammoniacal nitrogen determined by the magnesium-oxide method increases markedly in known cases of decomposition of meats, and it was established that this method was capable of demonstrating incipient decomposition (1). As, however, the magnesium-oxide distillation method is somewhat empirical—because if a further quantity of water is added to the solution in the distillation-flask, and another 100 c.c. are distilled, it will be found that the distillate contains a further amount of ammonia—it has been customary to determine the ammonia in the first 100 c.c. of the distillate only. It is apparent that, in addition to liberating the loosely bound ammoniacal nitrogen, the magnesium oxide is capable of producing hydrolysis, with the result that ammonia is being continuously split off from the nitrogenous compounds. Our experiments confirm those of others, that after four hours' continuous aeration at a rate of 80 litres of air per hour little, if any, ammoniacal nitrogen is liberated by continuing the aeration.

In order to determine whether the aeration method is applicable to the determination of ammoniacal nitrogen in known cases of decomposition of aqueous solutions of meat-extract, solutions of various dilutions were prepared and contaminated by exposure to the ordinary bacteria of decomposition present in the air. The results of the determinations of the ammoniacal nitrogen by the aeration method are as follows :—

Ammoniacal Nitrogen expressed as Percentage of Total Nitrogen.

	0·5-per-cent. Solution.	1-per-cent. Solution.	4-per-cent. Solution.
After 9 days ..	8·52	5·13	..
After 10 days ..	10·40	6·28	..
After 11 days ..	12·56	8·74	7·99

It is thus seen that the method is capable of detecting decomposition of dilute solutions of meat-extract, and it is therefore applicable in the examination of the solid meat-extracts. It can therefore be assumed that had the solid meat-extracts been even incipiently decomposed the method would have revealed the fact. Further work on the point is being carried out in order to determine the factors which inhibit the decomposition.

Copper in Liver-extract.

Our work in connection with meat-extracts from various sources has led to the examination of extracts manufactured from edible portions of the carcase other than true muscle-tissue, and it has been found that the mineral salts of an extract manufactured from liver invariably contain copper. Of course, if copper utensils were used in the preparation of these extracts the presence of copper might be expected, but we have been able to detect this metal in liver-extracts manufactured under conditions which exclude the possibility of casual contamination from copper utensils; moreover, in extracts manufactured from true muscle-tissue no copper has been found in the mineral salts. The presence of copper in liver has, however, been recorded, notably by Aston (5) in his investigations upon bush sickness, and its presence as a normal liver-constituent is also noted by Hammerstein (6) and Emery and Henley (7); it is thus not surprising to find it a normal constituent of extracts manufactured from liver.

The presence of up to 10 per cent. of glucose is also recorded by us as a normal constituent of liver-extract.

Summary.

1. The commercial valuation of a meat-extract based upon the percentage of the material soluble in 80 per cent. alcohol is in accord with the physiological value, which depends upon the "meat-bases" present.

2. The incipient decomposition of nitrogenous foods can be detected by the determination of the percentage of ammoniacal nitrogen before such decomposition is evident to the senses.

3. A comparative study of two methods of determining ammoniacal nitrogen is given.

4. Solid extract of meat is a non-putrescible substance.

5. In extracts manufactured from liver both copper and glucose are found to be present.

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Art. LIII.—*The Anticomplementary Properties observed in certain Serum Reactions.*

By A. M. Wright, Captain N.Z.M.C., Bacteriologist N.Z.E.F.

[*Read before the Philosophical Institute of Canterbury, 1st December, 1920; received by Editor, 5th December, 1920; issued separately, 12th August, 1921.*]

The notes put on record in this paper have been made in connection with the determination of nearly ten thousand Wassermann reactions carried out for the New Zealand Expeditionary Force during the author's overseas service.

In general the Wassermann reaction was determined in conformity with the recommendations of the Medical Research Committee, using the method elaborated by Colonel L. W. Harrison, K.H.P., D.S.O.,* the measurement of the reagents being carried out by the method adopted by Donald.†

When care is exercised in standardizing the pipettes used, Donald's dropping method was found by comparison to give complete concordance with methods using hand-pipettes. The principle involved in Donald's method is that "at constant temperature and pressure, and at a constant delivery-rate which does not exceed one drop per second, the size of a drop of any given liquid which is delivered by a vertically held nozzle is constant, and depends on the circumference of the delivery-nozzle at its outlet."

When large numbers of tests have to be carried out the monotony and eye-strain involved in using the hand-pipettes are considerable; with the dropping-pipettes, after a standardization is made, the determination is almost automatic, and accuracy is independent of fatigue. This principle is also applicable to many determinations involved in ordinary chemical analyses, as well as those carried out in connection with bio-chemical reactions.

Antigen.

An important consideration in the Wassermann reaction, as well as in other serum tests, is the nature of the antigen used. While, doubtless, individual workers obtain concordant results with various antigens, it has been the writer's experience that the human-heart extract, with cholesterin, as recommended by the Medical Research Committee, gives the most satisfactory and concordant results, if prepared in strict conformity with the instructions laid down by Fildes and McIntosh‡ and from fresh heart-muscle, the extract-heart-cholesterin being diluted 1 in 15 with normal physiological saline (0·85 per cent. NaCl).

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* Medical Research Committee's Report, *Path. Methods*, No. 1, pp. 13–27, 1918.
† R. Donald, *Proc. Royal Soc.*, vol. 86, pp. 198–202, 1913.
‡ P. Fildes and J. McIntosh, *Brain*, vol. 36, p. 193, 1913.

This antigen, if accurately and carefully prepared, shows little inhibitory action upon the complement used: it is immaterial whether the heart is diseased or not; it should not, however, be decomposed, otherwise certain substances soluble in alcohol may be extracted which are in action inhibitory to complement.

One such antigen was prepared from a human heart removed at autopsy thirty-six hours after death and while not obviously decomposed. The resulting preparation deviated 0·75 minimum haemolytic doses (M.H.D.) of complement. The use of antigen prepared from guinea-pig heart was not found to be satisfactory, owing to a similar marked anticomplementary action.

Anticomplementary Reaction of Human Sera.

Normal human-blood sera show, in the majority of cases, certain anticomplementary properties. In a series of tests carried out to determine the inhibitory power towards complement it was found that with a number of normal sera the average deviation of complement was 0·5 M.H.D. In conjunction with these tests the sera were also quantitatively examined to ascertain what, if any, complement-deviation occurred in the presence of the antigen prepared as noted above, such antigens having been found to be non-inhibitory; it was found that the average deviation of complement towards such negative sera was 0·75 M.H.D.

It is thus evident that the normal subject contains in the blood small amounts of antibodies, similar to, and having complementary deviation-properties identical with, the antibody upon which the Wassermann reaction depends for its specificity.

Of course, in the actual determination of the Wassermann reaction the controls adequately secure the true interpretation of the reaction, and allow for the small amounts of inhibitory antibody, as well as the anticomplementary properties of the patient's serum. The specificity of the Wassermann reaction depends upon its *quantitative* and not its *qualitative* determination.

Browning's* observation that the blood-serum of the normal rabbit gives a positive Wassermann reaction is confirmed by the writer's experiments; and, whatever interpretation may be placed upon this, it is nevertheless established that there are present in rabbit-sera sufficient antibodies similar to the Wassermann substance in complement-deviation power to produce a positive quantitative reaction. Controls demonstrated that the inhibitory properties were not of themselves merely anticomplementary, but depended upon the presence of the specific antigen in addition to bring about the reaction, which amounted to the deviation of as much as 3 M.H.D. of complement in one case.

In the course of the work one serum was encountered which showed very strongly marked anticomplementary power, deviating by itself nearly 7·00 M.H.D. of complement; later the serum from this patient showed but 4·00 M.H.D. of complement-deviation; and some months later the serum was normal in complement-deviation power. This serum was so abnormal that its properties were examined at the Bland Sutton Institute of Pathology, Middlesex Hospital, and the results of the investigation published in a separate paper.†

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* C. H. Browning, *Applied Bacteriology.*

† E. L. Kennaway and A. M. Wright, *Jour. Hygiene,* vol. 18, pp. 255–59, 1919.

An interesting point in connection with this serum showed that the first specimens were frozen and examined two months later, when it was found that the anticomplementary properties had disappeared.

Specificity of the Wassermann Reaction.*

In connection with the routine determination of the Wassermann reaction, the blood-sera from fifty-nine patients suffering from malaria were examined for the evidence of specific reaction to the Wassermann test. It has been recorded by various observers that malarial subjects have given a positive reaction.

While a number of the fifty-nine patients from whom the blood-sera was taken had either just had a rigor or were in the midst of one, and so should, if malarial antibodies influenced the Wassermann reaction, have been expected to show a positive test, yet the whole fifty-nine patients were found to give a negative reaction.

The influence of chloroform anaesthesia was also determined in a number of cases, the blood being taken before, and at twelve and also at twenty-four hours after, anaesthesia : in all cases the reactions were negative.

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* J. W. Marchildon, "Wassermann Reaction."

PROCEEDINGS.

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE.

MINUTES OF THE ANNUAL MEETING OF THE BOARD OF GOVENORS.

Wellington, 22nd January, and Palmerston North, 24th January 1921.

The annual meeting of the Board was held in the Dominion Museum Library on Saturday, the 22nd January, 1921, at 10 a.m.

Present: Professor T. H. Easterfield, President (in the chair); Mr. B. C. Aston, Professor Charles Chilton, Dr. L. Cockayne, Dr. F. W. Hilgendorf, Professor H. B. Kirk, Dr. P. Marshall, Professor H. W. Segar, Professor A. P. W. Thomas, Dr. J. Allan Thomson, Ven. Archdeacon H. W. Williams, and Mr. A. M. Wright.

The Hon. Secretary called the roll, which—the Government nominees, Messrs. Chilton and Ewen, having been reappointed—was the same as at last year's meeting.

Apologies for non-attendance were received from Mr. C. A. Ewen on account of illness, and from Professor J. Malcolm and Mr. H. Hill.

On the motion of Dr. Chilton, it was resolved to send a letter o sympathy to Mr. C. A. Ewen, Hon. Treasurer, hoping for his speedy restoration to health.

Incorporated Societies' Reports and Balance-sheets, except those of Hawke's Bay, Poverty Bay, and Wanganui, were laid on the table. Professor Marshall mentioned that the Wanganui report had been sent to the Editor in error.

Address of the Hon. the Minister of Internal Affairs.—At this stage the Hon. G. J. Anderson, Minister of Internal Affairs, entered the room and was received by the President. The Hon. Minister addressed the meeting and welcomed the Governors to Wellington. He spoke briefly on the subject of the importance of scientific and industrial research, but stated that, after consulting his colleagues, he would deal with the intention of the Government in the matter when he addressed the Congress at Palmerston North.

Standing Committee's Report.—The annual report of the Standing Committee was read, and adopted as amended.

Report of the Standing Committee for Year ending 31st December, 1920.

Meetings.—Sixteen meetings of the Standing Committee were held during the year, the attendance being as follows: Professor Easterfield (President), 15; Professor Kirk, 8; Dr. Cockayne, 5; Hon. G. M. Thomson, 6; Mr. C. A. Ewen, 5; Dr. J. Allan Thomson, 12; Mr. A. M. Wright, 1; Mr. M. A. Eliott, 1; Mr. B. C. Aston (Hon. Secretary), 15.

Hutton Award.—The award for 1919 was made to Rev. Dr. J. Holloway; and at a meeting of the Philosophical Institute of Canterbury held on the 2nd June, 1920, Dr. Chilton, in the absence of Professor Easterfield, President, presented to Dr. Holloway the Hutton Memorial Medal, and stated that the award was made in recognition of his researches in connection with New Zealand botany. Dr. Chilton said that the recipient's work in this direction had made his name well known throughout New Zealand, and his works were also read in England and elsewhere.

Hector Award.—The award for 1920 was made to Mr. S. Percy Smith, F.R.G.S., of New Plymouth, for research in Polynesian ethnology. On the 19th June, 1920, there was a large and representative gathering of citizens in the New Plymouth Carnegie Library, when the presentation of the Hector Medal was made by the Mayor of New Plymouth, the late Mr. James Clarke, who, together with Mr. W. T. Jennings, M.P., and Mr. W. H. Skinner, eulogistically referred to Mr. Smith's valuable work in connection with Polynesian research.

Transactions of the New Zealand Institute, volume 52, was issued to the societies in bulk in September, 1920, and to the exchanges in October. Copies of volumes 51 and 52 were laid on the tables of the Legislative Council and the House of Representatives on the 24th August, 1920.

Publications.—The following have been placed on the mailing-list by the Standing Committee, and will in future receive the *Transactions* as published:—

Forestry Department, Wellington.
Geological Survey Office, Dublin.
The Library, Advisory Research Council, Ottawa.
Consulate-General of the Czecho-Slovak Republic, Sydney.
National Herbarium of Victoria.
The Director, Brooklyn Botanical Gardens, New York.
University of Illinois.
The Director, Museo Nacional de Historia Natural de Buenos Aires.
The Director, Volcano Observatory, Hawaii Islands.
Arnold Arboretum, Harvard University, Jamaica Plains, U.S.A.
Natal Museum, Africa.
Director, Royal Gardens, Kew, England.

Resolutions of the Standing Committee adopted during the year and not otherwise mentioned in the report:—

1. On the 27th May it was resolved to circularize all late enemy exchanges to ascertain those which desired to continue receiving the publications of the Institute. Several societies have since signified their desire to resume relations.

2. On the 27th May it was resolved to leave the appointment of an assistant secretary in the hands of the President, with power to act. In August, Miss M. Wood, of Wellington, was appointed to this position.

3. On the 27th May it was resolved to combine with the Board of Agriculture and other interested bodies and Departments in forming a deputation to the Hon. Minister with reference to the establishment of a technological library, to include the books of the Institute under suitable safeguards so as to ensure that members should have access to them. It has not yet been possible to take action in this matter.

4. On the 27th May it was resolved to remind the Agricultural Department of the necessity for some work on New Zealand grasses, and suggest that the Department, with Mr. Petrie, again take up the matter, which had been interrupted by the war. This was done, and the Committee was informed on the 1st October that it was proposed to refer the matter to the Science and Art Board for action.

5. On the 27th May it was resolved that the President should write inviting the Australasian Association for the Advancement of Science to meet in Wellington in 1923, the organization of the meeting to be left with the Wellington Philosophical Society. According to newspaper reports this invitation has been accepted.

6. On the 24th June it was resolved to appoint Professor Charles Chilton and Dr. J. Allan Thomson as delegates to the Pan-Pacific Science Congress, to be held in Honolulu in August, 1920.

7. On the 18th August it was resolved that it be a recommendation to the annual meeting that in future the description of each nominee for the Fellowship of the New Zealand Institute shall not exceed twenty lines of typewritten matter, and that the best method of obtaining this information be considered by the annual meeting.

8. On the 4th October it was resolved to thank Major Wilson for his offer to report on the wapiti of George Sound, and to accept same.

9. On the 4th October it was resolved to appoint Professor H. B. Kirk as representative of the New Zealand Institute at the meeting of the Australasian Association for the Advancement of Science to be held in Hobart in 1921. On the 29th October Dr. Cotton was appointed in place of Professor Kirk, who reported that he was unable to attend the meeting.

10. On the 4th October it was resolved that it be a recommendation to the annual meeting that the separate publication of the proceedings of the annual meeting be discontinued.

11. That it be a recommendation to the annual meeting to affirm the principle of the Standing Committee that when refusing to recommend a grant for research no reasons for doing so be given.

Amendment of New Zealand Institute Act.—On the 29th March the President wrote to the Hon. Minister of Internal Affairs laying before him the facts of the New Zealand Institute's financial position, and asking that the Government amend the New Zealand Institute Act to enable £1,000 to be paid annually, instead of £500. On the 28th July a copy of the Bill amending this Act was received, and, it having been passed and become law, the £1,000 has since been paid in to the credit of the Institute's account at the Bank of New Zealand.

Annual Reports and Balance-sheets.—The annual reports and balance-sheets of the following societies have been received, and are now laid on the table :—

Wellington Philosophical Society, for year ending 30th September, 1920.
Philosophical Institute of Canterbury, for year ending 31st October, 1920.
Otago Institute, for year ending 31st December, 1920.
Manawatu Philosophical Society, for year ending 31st October, 1920.
Auckland Institute, for year ending 20th February, 1920.
Nelson Institute, for year ending 31st December, 1920.

Donation of Partial Sets of Transactions has been made to the following :—

Library of Hillside Railway Workshops.
Library of United States Department of Agriculture, Washington.
Forestry Department, Wellington.
Director, Brooklyn Botanical Gardens, New York.
Director, Volcano Observatory, Hawaii Islands.

Fellowship of the New Zealand Institute.—A committee consisting of Dr. Thomson (convener), Professor Easterfield, Professor Segar, Dr. Adams, and Mr. C. A. Ewen was appointed to draw up rules for the election of Fellows of the New Zealand Institute. The original recommendations of this committee did not meet with the approval of the Standing Committee. Professor Sommerville was added to the committee, and the following rules were subsequently agreed upon, and it is suggested that these should now be gazetted as regulations for conducting future elections of Fellows :—

1. Each voter arranges all the candidates' names in order of preference.

2. The voter may bracket any number of names in any place.

3. If the voter omit the names of any of the candidates from his list these names shall be added by the returning officer, and bracketed in the last place on the voter's paper.

4. On receipt of the ballot-papers the returning officer enumerates all the preferences. In the case of a small electorate this may be done conveniently in the following way : A schedule is prepared for each candidate on computing-paper, containing in the top row the names of the candidates, or the letters representing them, and in the left margin the numbers denoting the different ballot-papers. The spaces are then filled, entering "2" for a preference as against the candidate whose name stands at the top of the column, and "1" in the case of a bracket (Table II).* The columns are then summed, and the numbers transferred to another schedule (Table III), in which the names of the candidate are placed both in the top row and in the left margin. Table III then gives for each pair of candidates—*e.g.*, A and B—the number of times A is preferred to B and B to A, each multiplied by 2. It is most convenient to arrange the table so that A's preferences are in a column. The numbers may be checked by noting that A's preferences against B plus B's preferences against A are always equal to the number of voters multiplied by 2.

5. The columns in Table III are then summed. The sums are checked by summing the sums, the total of which should be equal to np (p1), where p is the number of candidates and n the number of voters.

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* It is more usual to enter "1" for a preference and "½" for a bracket, but by taking the numbers 2 and 1 the awkward fractions are eliminated, and the final results are the same.

6. The candidate with the lowest total is then rejected and his row is struck out. The columns are again summed, or, more conveniently, the numbers in the cancelled row are subtracted from the previous sums. The results are checked again by summing to the total n ($p1$) ($p2$).

7. The candidate who now has the lowest total is rejected, and the process is continued until the number left is equal to the number of vacancies.

8. If at any stage two or more candidates are equal with the smallest totals they must be rejected together, provided that the number of candidates left is not less than the number of vacancies. In the latter case the candidate or candidates for the last place should be decided by drawing lots.*

Professor Sommerville has worked out a hypothetical election, and has supplied an example of the calculations (to be exhibited at the meeting).

The following references may be consulted: E. J. Nanson, "Methods of Election," *Trans. Roy. Soc. Victoria*, 1882; G. Hogben, "Preferential Voting in Single-member Constituencies, with Special Reference to the Counting of Votes," *Trans. N.Z. Inst.*, vol. 46, p. 304, 1914; D. M. Y. Sommerville, "A Problem in Voting," *Proc. Math. Soc. Edinburgh*, 1910, p. 23.

The Standing Committee suggest, in addition to these rules, one making it obligatory on the society which forwards nominations to certify that it has obtained the consent of every nominee.

All the incorporated societies were circularized on the 12th April, 1920, to send in nominations, to be accompanied by a statement of the candidates' qualifications. Wellington, Auckland, Canterbury, and Otago Societies sent in twenty nominations, which were issued to the Fellows for them to make a selection of eight. On the 18th August Professor Segar was appointed by the Standing Committee to act as honorary returning officer, and on the 23rd October he forwarded the results of the selection, which was communicated to every Governor on the 27th October, 1920. It now remains for the Board of Governors to elect from these the number of Fellows it is decided to elect, up to four Fellows, to accord with Regulation 23 of the regulations governing the Fellowship of the New Zealand Institute.

Catalogue of New Zealand Fishes.—The Hon. G. M. Thomson and Dr. J. Allan Thomson were appointed a committee to compile an estimate of the cost of such a catalogue. Their estimate of £1,725 was forwarded to the Hon. Minister of Internal Affairs, who replied on the 22nd October, 1920, that the matter was being dealt with by the Marine Department, and the Minister of Marine had directed that it was to be held over for consideration with next year's estimates.

Resolutions of the Science Congress, Christchurch, 1919.—Some further information in regard to these had come to hand:—

1. (*a.*) The Hon. Minister of Lands replied on the 15th November, 1920, that his Department fully recognized the importance of establishing bench-marks and tide-gauges. In 1908 permanent bench-marks connected to tide-gauges were established at Auckland, Wellington, Lyttelton, Port Chalmers, Nelson, and Westport. In 1918 two additional bench-marks connected to mean sea-level were established at New Plymouth and Dunedin, and other bench-marks and tide-gauges will be erected at various places on the coast from time to time when the importance of the records obtained from them for useful or scientific purposes warrants their establishment. Precise levelling connecting the bench-marks is contemplated in the near future.

(*b.*) An electrograph recording the variations of the electrical state of the atmosphere had been suggested by Dr. Chree, F.R.S., of Kew Observatory, and had been ordered from England.

2. The Hon. Minister of Mines had reported on the 2nd November, 1920, that Mr. J. Marwick, M.A., with first-class honours in geology, had been appointed to the position of Assistant Geologist, to specialize in palaeontology.

3. (*a.*) The Hon. Minister of Internal Affairs replied on the 13th November, 1920, that legislation was introduced this session to give effect to the recommendation to alter the standard time from eleven hours and a half to twelve hours in advance of Greenwich mean time, but it was not possible to place it upon the statute-book.

(*b.*) The matter of introducing fresh legislation to preserve the native fauna, and also of taking measures to promote education on the subject in the schools, will be considered during the recess.

(*c.*) Regarding the offer of Yale Observatory, it has been decided that Dr. Adams, Government Astronomer, should visit Otago and report on suitable sites for the establishment of an observatory.

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* The alternative to this is to take a fresh ballot with these candidates alone; but, as it is evident that in this case the preferences of the voters as a whole must be very indifferent as regards these candidates, it is quite fair that it should be decided by lot and thus avoid the vexation of a second ballot.

Collection of New Zealand Coleoptera.—On learning of the desire of the New Zealand Institute to have Major Broun's collection of coleoptera retained in New Zealand for a time in order to give entomologists an opportunity to refer to it and determine authentic specimens of as many species as possible, the British Museum authorities wrote, on the 17th March, 1920, agreeing that the collection should be housed in the Dominion Museum for a period of two years. A copy of their letter was forwarded to the Hon. Minister of Internal Affairs, who replied on the 23rd June, 1920, that if the British Museum authorities would agree to extend the period of deposit from two to five years he would agree to find fireproof storage and skilled attention for the collection, and give a permit to export the collection at the end of that period.

Index to Last Ten Volumes.—The index to the last ten volumes of the *Transactions*, which had been compiled by a returned soldier paid to do the work by Major R. A. Wilson, D.S.O., had been approved by the Standing Committee after referring it to Professor Kirk and Dr. Cotton, and is in course of publication.

Dixon's Bulletin of Mosses.—It was resolved that the Publications Committee be authorized to proceed with the publication of Dixon's bulletin on the mosses of New Zealand, the cost not to exceed £60.

Scheme of Scientific and Industrial Research.—A proposal of the Science and Art Board for a Board of Trustees to control the Dominion Museum, Turnbull Library, Scientific and Technological Library, Dominion Art Gallery, and the publication of scientific and historical papers, including also the control by the same Board of the organization of scientific and industrial research, was considered by the Standing Committee. The committee could not support the association of the organization of scientific and industrial research with the control of the Dominion Museum, &c., and agreed that in case the Government could not see its way to expend the sum recommended by the Efficiency Commissioners the following scheme should be approved:—

1. That the annual sum to be appropriated for scientific and industrial research be £6,000, to be divided as follows: (*a*) £1,000 should be distributed in small grants to investigators working in the Dominion who were unable to devote their whole time to research; (*b*) £4,000 to £5,000 should be distributed in salaries and travelling and other expenses to those who are able to devote their whole time to carrying out research under approved supervision.

2. That the distribution of the £6,000 be effected by the New Zealand Institute, subject to such safeguards as the Minister thought best. The salaries paid to investigators to be of sufficient amount to enable them to live.

3. That the scheme of local advisory committees described on page 57 of Mr. Hogben's scheme (National Efficiency Board's Report, Schedule II) should be given effect to.

4. That the President should make it clear to the Minister that only the smallness of the amount available had necessitated the modification of the original scheme of the Institute as set forth in the National Efficiency Board's report.

It was left with the President to put the above matter before the Hon. Minister.

Contoured Topographical Map.—A resolution passed at the last annual meeting urging the necessity of a contoured topographical map was forwarded to the Hon. Minister of Lands, who replied on the 25th October, 1920, that he regretted that owing to interruptions and delays occasioned by the war it had not been possible to organize a staff or to obtain the necessary equipment to undertake this pressing work.

Catalogue of Scientific Literature.—The resolution of the last annual meeting expressing the view that the catalogue would be of little value without the subject-index, and offering to urge the Government to subsidize a subscription for three further copies of the catalogue, was forwarded to the Royal Society. The society held a conference in September, 1920, to discuss the future of the *International Catalogue of Scientific Literature*, and the Standing Committee asked Professor Dendy to represent the New Zealand Institute at that conference. Unfortunately, Professor Dendy was able to attend only the opening meeting of the conference, but he forwarded the agenda paper, reports, and balance-sheets which were presented at the conference, and since then the report of the conference has come to hand.

Regulations to be gazetted.—A committee consisting of Professor Easterfield, Dr. J. Allan Thomson, Mr. C. A. Ewen, and Mr. B. C. Aston was appointed to formulate resolutions of the Institute which have the force of regulations, in order that where advisable they might be gazetted.

Yellow-leaf Disease in Flax.—A resolution from the last annual meeting urging the Government to take steps to investigate the yellow-leaf in flax, and suggesting that this could best be done by assisting the Cawthron Institute to obtain a plant pathologist, was forwarded to the Hon. Minister of Agriculture, who replied on the 14th July that officers of the Department of Agriculture had carried out extensive investigations into the cause and treatment of yellow-leaf disease in New Zealand flax, and some experimental work initiated by them was still in progress; and that, as it was intended to continue the investigations, it was not considered necessary to provide funds for the Cawthron Institute to deal with the matter.

Thermal Regions of New Zealand.—A resolution passed on the 31st January, 1914, at the twelth annual meeting, to the effect that the Government be urged to undertake the preparation of a complete scientific report on the thermal regions of the North Island, and that the matter of choosing a time for approaching the Government be left in the hands of the Standing Committee, with power to act, has not yet been put into effect, as the Standing Committee has not considered the time opportune for approaching the Government on the matter.

Kapiti Island.—A committee was last year set up by the Hon. Minister of Lands, who asked that a member to act on that committee be appointed by the Standing Committee to represent the Institute. Professor Kirk was accordingly appointed by the Standing Committee to represent the New Zealand Institute. It is to be regretted that the clause in the "washing-up" Bill empowering the Government to purchase the native interests in this island was thrown out by the Native Committee.

Science Congress, Palmerston North.—The invitation of the Manawatu Philosophical Society to hold a Science Congress in Palmerston North in 1921 having been accepted, it was decided to place the Manawatu Society on the same footing as the Philosophical Institute of Canterbury had been placed when the Congress was held in Christchurch, with the exception that certain officers were appointed by the Standing Committee to be Presidents and Secretaries of the various sections, and on these officers devolved the responsibility of carrying out the arrangements and work of their particular sections. Dr. J. Allan Thomson was also appointed Hon. Secretary of the Scientific Programme. It was resolved, too, that twenty guests, to be entertained by the Manawatu Philosophical Society, should be invited by the Institute.

Hamilton Prize.—Negotiations between the Standing Committee and representatives of the Wellington Philosophical Society had been entered into with a view to formulate the rules and regulations which should govern the yearly award of the Hamilton Prize. A draft of the rules which have been drawn up by the President in consultation with Mr. Von Haast is as follows:—

"*Rules and Regulations made by the Governors of the New Zealand Institute in relation to the Hamilton Memorial Fund.*

"1. The fund placed in the hands of the Board by the Wellington Philosophical Society shall be called 'The Hamilton Memorial Fund," in memory of the late Augustus Hamilton, Esq. Such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

"2. The fund shall be vested in the Institute. The Board of Governors of the Institute shall have the control thereof, and shall invest the same in the Common Fund of the Public Trust Office.

"3. The memorial shall be a prize to be called 'The Hamilton Memorial Prize,' the object of which shall be the encouragement of beginners in scientific research in New Zealand.

"4. The prize shall be awarded at intervals of not less than three years by the Governors assembled in annual meeting, but in no case shall an award be made unless in the opinion of the Governors some contribution deserving of the honour has been made. The first award shall be made at the annual meeting of the Governors in 1922.

"5. The prize shall be awarded for scientific research work carried out in New Zealand or in the islands of the South Pacific Ocean, which has been published within the five years preceding the 1st day of July prior to the annual meeting at which the award is made. Such publication may consist of one or more papers and shall include the first investigation published by the author. No candidate shall be eligible for the prize who prior to such period of five years has published the result of any scientific investigation.

"6. The prize shall consist of money. Until the principal of the fund amounts to £100, one-half of the interest shall be added annually to the principal and the other half shall be applied towards the payment of the prize. So soon as the said principal amounts to £100, the whole of the interest thereon shall be applied in payment of the prize, in each case after the payment of all expenses necessarily incurred by the Governors in the investment and administration of the said fund and the award of the said prize.

"7. A candidate for the prize shall send to the Secretary of the New Zealand Institute, on or before the 30th day of June preceding the date of the annual meeting at which the award is to be made, an intimation of his candidature, together with at least two copies of each publication on which his application is based.

"8. Whenever possible the prize shall be presented in some public manner."

Samoan Observatory Committee.—A committee consisting of Professors T. H. Easterfield, C. Coleridge Farr, E. Marsden, D. M. Y. Sommerville, and Mr. G. Hogben was set up to confer with the Government Astronomer and the Hon. Minister of External Affairs as to the best means to be adopted for the maintenance of the Samoan Observatory. On the 12th February this committee consulted with the Hon. Minister and the Government Astronomer. At a meeting of the Standing Committee held on the 25th June it was resolved that Dr. C. A. Cotton, Dr. C. E. Adams, and Mr. A. C. Gifford be added to the committee; that the scope of the committee be enlarged to allow it to make representations on all matters relating to earth physics and astronomy in New Zealand and dependencies, the committee to act strictly through the Standing Committee of the Board of Governors of the New Zealand Institute. It was resolved to ask the Observatory Committee to concentrate at present upon the following lines of work:—

(1.) Investigation of the most suitable site for a central astronomical observatory.
(2.) Consideration of the means of acceptance of the Yale offer.
(3.) Reliable estimates of costs to be framed on all matters in connection with the above.
(4.) Any report to take into consideration the desirability of retaining in their present sites any seismographs.
(5.) To report on the desirability of instituting a vulcanological observatory in New Zealand.

The following resolutions of the Observatory Committee were forwarded to the Hon. Minister of Internal Affairs, who replied that the fullest consideration would be given to the report and recommendations:—

"That the Committee, having heard of the munificent offer of the Yale Observatory of astronomical instruments of the highest grade, strongly urges the acceptance of the offer by the Government. The committee is of the opinion that most advantageous use can be made of the offer by combining at one central spot the equipment of the Hector Observatory and the Christchurch Magnetic Observatory with the Yale instruments. The committee considers that some site in the highlands of Central Otago could be found offering astronomical and geophysical conditions that would be unique in the Southern Hemisphere. Further, the combination of the observatories in one locality would be a distinct economy compared with the present separate establishments. The increased facilities which would thus be offered to the scientific staffs for mutual discussion and co-ordination of work would of necessity tend to greater efficiency. If these suggestions meet with the approval of the Government the committee will be glad to aid by giving further advice as to the scope of the proposed single observatory and its cost.

"That this committee, having heard and considered Professor Marsden's report on the Samoan Observatory, cordially endorses the opinions and recommendations contained therein. The committee is of the opinion that the work being carried on in Samoa is of the very greatest scientific and economic importance, and strongly urges that an immediate decision be made to carry on the work of the observatory.

"That the committee, having considered Dr. Adams's letter to the President of the New Zealand Institute, is of opinion that the scope of the committee should be enlarged to cover matters relating to New Zealand's observatories, and that the committee should be empowered to make recommendations in the name of the Institute for unifying the work and control of such observatories. That in order to carry out such larger functions the committee be given power to co-opt other suitable scientific gentlemen to aid in their deliberations. That the permanency of such a committee be considered at the next annual meeting of the Board."

The following is a report of the Observatory Committee, held on the 25th June:—

"A. *Samoan Observatory.*—The committee, having heard of Professor Angenheister's early retirement from the post of Director of Apia Observatory, deputes Drs. C. Coleridge Farr and C. E. Adams to approach the President of the Institute with a view of urging upon the Minister of External Affairs the urgent necessity of appointing a successor. The committee recommends that a committee of selection be set up, consisting of Sir A. Schuster, Dr. Chree, and G. W. Walker, F.R.S., such selection committee to consider the claims of Messrs. Kidson and Johnston. The committee further suggests that an Assistant Director is urgently required at Samoa, and that this assistant could probably be obtained in New Zealand.

"B. *Yale Offer.*—The committee reiterates its original proposals of the 9th April, and is of the opinion that the acceptance of this offer, together with the concentration of the astronomical and geophysical activities in New Zealand, will not cost more than £1,000 per annum in addition to what is already spent. The committee desires the Institute to request the Hon. Minister of Internal Affairs to give leave of absence to Dr. C. E. Adams, so that he may undertake an investigation of suitable sites for an observatory, the investigation to commence with Central Otago. The committee suggests that, other things being equal, the farther south the proposed site is situated the better.

"C. *Vulcanological Observatory.*—The committe considers that, although the matter of a vulcanological observatory is not as immediately urgent as the co-operation with Yale, it is in entire sympathy with its proposed establishment. Although this observatory would naturally not be situated at the same place as the proposed central observatory, it might come under the guidance of the same committee of visitors to be appointed by the Institute. The committee understands that there is a report from Dr. Jaggar, and after seeing that report it hopes to give further deliberation to the subject."

The above report was forwarded to the Hon. Ministers of External and Internal Affairs, and the following reply was received from the latter :—

"Yale offer: The representations of your committee thereon are noted. Dr. Schlesinger was written to some little time ago and asked to supply further details in regard to the offer of telescopes, &c., and it had been decided that until a reply is received the question of the Government Astronomer proceeding to Central Otago or elsewhere to investigate the most suitable site for a Government Observatory has to stand over." (The Minister subsequently stated that Dr. Adams was to visit Otago at once for the purpose of investigation as above.) "It is noted that the committee is in entire sympathy with the proposal to establish a vulcanological observatory in New Zealand. The Director of the Dominion Museum on his recent visit to Honolulu was instructed to report on the vulcanological observatory work being done there, and to make a recommendation on his return as to whether it is desirable or otherwise to establish an observatory on similar lines in this Dominion. In the meantime I have pleasure in forwarding herewith a copy of Dr. Jaggar's report."

Dr. Jaggar's report has since been published in the *Journal of Science and Technology* (vol. 3, pp. 162–67, 1920).

Method of electing Fellows.—It was resolved, on the motion of Dr. Cockayne, seconded by Professor Segar, that a committee be appointed to draw up rules for a simple method of voting.

It was resolved, on the motion of Dr. Cockayne, seconded by Professor Segar, that Professor H. W. Segar, Professor D. M. Y. Sommerville, Dr. J. Allan Thomson, and the President be a committee to draw up the simple rules for election.

It was resolved, on the motion of Archdeacon Williams, seconded by Mr. Wright, that the question as to whether in any one year the Governors shall be obliged to fill all the vacancies be submitted to the committee on voting, and that if necessary they recommend a method of procedure to meet the case.

Index to Last Ten Volumes.—On the motion of Professor Kirk, seconded by Dr. Thomson, it was resolved, That the Institute express its appreciation of Major Wilson's action in having a manuscript index of the last ten volumes of the *Transactions of the New Zealand Institute* prepared and handing over the index to the Institute for publication.

Scientific and Industrial Research.—The President read a copy of his letter of the 27th July to the Minister. On the motion of Dr. Chilton, seconded by Dr. Hilgendorf, the action of the President was approved.

Hamilton Prize.—The President made a statement as to the correspondence and conference with the Wellington Philosophical Society. The draft regulations for administering the prize as drawn up by Mr. Von Haast were read and approved. On the motion of the President it was resolved, That application be made forthwith to the Wellington Philosophical Society to hand over the moneys of the Hamilton Memorial Fund for administration by the New Zealand Institute, in conformity with the above rules.

Circulation of Proceedings of this Meeting.—On the motion of Dr. Hilgendorf, seconded by Mr. Wright, it was resolved, That the issue of separate copies of the minutes of the annual meeting of the Board of Governors be discontinued, but that copies of an abstract of the minutes be sent to each incorporated society as soon as possible.

Finance.—On the motion of Professor Kirk, seconded by the Ven. Archdeacon Williams, it was resolved, That the Institute express to the Hon. Minister of Internal Affairs its appreciation of the action of the Government in forwarding the passing of the New Zealand Institute Amendment Act, 1920.

Election of Fellows.—Correspondence between the Standing Committee and Professor Park in connection with the election of Fellows was read and discussed. Professor Segar was appointed honorary returning officer, and it was decided that voting-papers could be handed in either at this meeting or in Palmerston North.

Hector Award.—The report of the Hector Award Committee, recommending that the award for 1921 be awarded to Mr. R. Speight, of Canterbury Museum, was read and adopted.

REPORT OF HECTOR MEMORIAL AWARD COMMITTEE.

The committee that was appointed to make the award of the Hector Medal for 1921 have unanimously decided to recommend to the Institute the name of Mr. R. Speight, M.A., M.Sc., F.G.S., F.N.Z.Inst.

The committee considers that there is no lack of geologists in New Zealand who are fully qualified by their ability and work to be recipients of the medal. We are unanimously of opinion that Mr. Speight has special claims to the honour in virtue of his valuable work in petrology, physiography, and stratigraphy, which has been carried on continuously with energy and zeal since 1892.

P. MARSHALL.

Annual Meeting.—It was resolved that the next annual meeting be held on Tuesday, 31st January, 1922.

The meeting at 3.30 p.m. adjourned to Palmerston North, to sit again on Monday, 24th instant, at 9 a.m.

The adjourned meeting was held in the High School, Palmerston North, at 9 a.m. on Monday, 24th January, 1921.

Present: Professor Easterfield (President), Mr. B. C. Aston, Dr. L. Cockayne, Professor Charles Chilton, Mr. M. A. Eliott, Hon. G. M. Thomson, Dr. J. Allan Thomson, Mr. A. M. Wright, and Ven. Archdeacon H. W. Williams.

Financial Statements.—Hon. Treasurer's reports: The statements of receipts and expenditure, and liabilities and assets, duly audited by the Auditor-General, were read and approved.

On the motion of Dr. J. Allan Thomson, seconded by Ven. Archdeacon Williams, it was resolved, That each year, unless otherwise provided for by resolution of the Board of Governors, the annual interest on the Endowment Fund be added to the capital of the fund,

On the motion of the Ven. Archdeacon Williams, seconded by Mr. M. A. Eliott, it was resolved, That for every copy of Volume 53 of the *Transactions* received by the incorporated societies a contribution of 2s. 6d. towards the cost of printing shall be made during the current year by such society.

New Zealand Institute.—Statement of Receipts and Expenditure for the Year ending 31st December, 1920.

Receipts.	£	s.	d.	*Expenditure.*	£	s.	d.
Balance at 31st December, 1919	1,818	4	8	Government Printer ..	83	19	0
Government statutory grant	1,000	0	0	Whitcombe and Tombs—stationery	1	2	9
Publications sold ..	108	3	9	Travelling-expenses of Governors	37	16	0
Affiliated societies' levy ..	116	0	0	Petty cash, postages, and clerical	53	6	2
Government grants for research	800	0	0	Assistant secretary—salary	69	6	0
				Fire-insurance premium ..	5	0	0
				Bank charge	0	10	0
				Travelling - expenses, Professor Farr, Samoan Committee	7	11	6
				Subantarctic Report purchased	2	1	8
				Whitcombe and Tombs—binding	4	5	0
				Research grants, as per list	1,041	7	11
				Balance, as under ..	2,536	2	5
	£3,842	8	5		£3,842	8	5

	£	s.	d.
Balance in—			
Bank of New Zealand	479	17	9
Post Office Savings-bank .. .	2,056	4	8
	£2,536	2	5

	£	s.	d.
Made up as follows—			
Endowment Fund	56	4	8
Balance Government research grants ..	1,268	5	1
Institute's General Purposes Account ..	965	17	8
Library Fund	245	15	0
	£2,536	2	5

Chas. A. Ewen, Hon. Treasurer.

The Audit Office, having examined the balance-sheet and accompanying accounts required by law to be audited, hereby certifies the same to be correct.

R. J. Collins,
Controller and Auditor-General.

New Zealand Institute.—Statement of Liabilities and Assets, at 31st December, 1920.

Liabilities.	£	s.	d.	*Assets.*	£	s.	d.
To Hector Memorial Fund	1,062	0	0	By Balance in Public Trustee's hands—			
Hutton Memorial Fund	898	19	5	Hector Memorial Fund	1,062	0	0
Carter Bequest ..	4,780	5	9	Hutton Memorial Fund	898	19	5
Balance Government research grants ..	1,268	5	1	Carter Bequest ..	4,780	5	9
Balance Endowment Fund	56	4	8	Outstanding accounts ..	13	0	7
Government Printer's Accounts— Vol. 52, ..£870 0 0; Extracts, &c. 33 4 5	903	4	5	Bank of New Zealand	479	17	9
Unpaid accounts ..	43	18	0	Post Office Savings-bank	2,056	4	8
Library Fund ..	245	15	0				
Balance in hand ..	31	15	10				
	£9,290	8	2		£9,290	8	2

New Zealand Institute.—Government Research Grants.

1920.			Dr. £ s. d.	Cr. £ s. d.
Jan. 1.	By	Balance on hand	..	1,509 13 0
May 14.		Government grant	..	200 0 0
July 7.		Government grant	..	150 0 0
July 28.		Government grant	..	200 0 0
July 28.		Government grant	..	50 0 0
July 28.		Government grant	..	50 0 0
Dec. 3.		Government grant	..	100 0 0
Dec. 3.		Government grant	..	50 0 0
Jan. 20.	To	Grant to Lancaster and Cornes	15 0 0	
Jan. 24.		Grant to Dr. Allan Thomson	28 5 6	
Jan. 28.		Grant to Mr. W. G. Morrison	40 0 0	
Jan. 29.		Grant to Professor Marsden	50 0 0	
Feb. 12.		Grant to Professor Easterfield	45 0 0	
Feb. 13.		Grant to Dr. Thomson	30 15 0	
Feb. 19.		Grant to Professor C. C. Farr	95 0 0	
Feb. 24.		Grant to Professor Malcolm	35 0 0	
Mar. 8.		Grant to Professor Farr	15 0 0	
Mar. 30.		Grant to Dr. Adams	50 0 0	
April 30.		Grant to Professor Malcolm	20 0 0	
May 28.		Grant to Professor Evans	120 0 0	
June 22.		Grant to Professor Easterfield	60 0 0	
July 19.		Grant to Professor Malcolm	25 0 0	
July 19.		Grant to Mr. H. D. Skinner	21 10 0	
July 28.		Grant to Sir D. E. Hutchins	25 0 0	
Aug. 12.		Grant to Mr. H. D. Skinner	43 0 0	
Sept. 3.		Grant to Professor Malcolm	25 0 0	
Sept. 6.		Grant to Mr. H. D. Skinner	41 10 0	
Oct. 6.		Grant to Professor Evans	60 0 0	
Oct. 15.		Grant to Miss K. M. Curtis	21 3 0	
Nov. 5.		Grant to Mr. H. D. Skinner	69 0 0	
Nov. 15.		Grant to Mr. G. S. Thomson	50 0 0	
Nov. 15.		Grant to Mr. H. D. Skinner	21 10 0	
Dec. 3.		Grant to Professor Marsden	20 0 0	
Dec. 3.		Grant to Professor Marsden	14 14 5	
			1,041 7 11	
		Balance	1,268 5 1	
			£2,309 13 0	£2,309 13 0

Hutton Memorial Research Fund.—Statement of Account for the Year ending 31st December, 1920.

	£ s. d.	Dr. £ s. d.	Cr. £ s. d.
By Balance		..	856 14 5
Public Trust Office—			
Interest to 31st December, 1920, at 4½ per cent.	38 11 0		
Bonus to 31st March, 1920	3 14 0		
		..	42 5 0
To Balance		898 19 5	..
		£898 19 5	£898 19 5

Hector Memorial Fund.—Statement of Account for the Year ending 31st December, 1920.

			Dr.			Cr.		
			£	s.	d.	£	s.	d.
By Balance			..			1,057	3	11
Public Trust Office—								
Interest to 31st December, 1920, at 4½ per cent.	£ s. d. 45 4 1							
Bonus interest to 31st March, 1920 ..	4 12 0							
			..			49	16	1
To New Zealand Institute Account—								
S. Percy Smith: Hector Prize for 1920 ..			45	0	0			
Balance			1,062	0	0			
			£1,107	0	0	£1,107	0	0
By Balance			..			£1,062	0	0

Carter Bequest.—Statement of Account for the Year ending 31st December, 1920.

			Dr.			Cr.		
			£	s.	d.	£	s.	d.
By Balance			..			4,555	11	6
Public Trust Office—								
Interest to 31st December, 1920, at 4½ per cent.	£ s. d. 205 0 3							
Bonus on interest to 31st March, 1920	19 14 0							
			..			224	14	3
To Balance			4,780	5	9			
			£4,780	5	9	£4,780	5	9
By Balance			..			£4,780	5	9

Assets.

	£	s.	d.
Balance as per accounts	£4,780	5	9

Liabilities.

	£ s. d.
Legacy—Museum and New Zealand Institute	50 0 0
Public Trustee's commission	At scale rates.

Public Trustee's reports on (*a*) Carter Bequest, (*b*) Hutton Memorial Fund, (*c*) Hector Memorial Fund, were received.

Hutton Research Grant Fund.—A report from Miss Mestayer was received.

Report of Grant from Hutton Research Fund.

Miss Mestayer, who was granted £10 from the Hutton Fund, reports that during the year she received the drawings of three new species of Amphineurs from Miss J. K. Allan, and of an established species needed for the purpose of comparison, the account for which was £4 5s. Miss Mestayer has been able to finish and hand in to the Hon. Secretary of the Wellington Philosophical Society the paper relating to them. Another short paper, for which no drawings were required, was also handed to him. There is a balance of £5 on hand.

Government Research Grant Fund.—The report of the Research Grant Committee was received and considered. On the motion of Ven. Archdeacon Williams, seconded by Mr. Eliott, it was resolved, That all unexpended balances of research grants made prior to January, 1919, be refunded on or before 31st March in the present year, the grantee in each case being left free to apply for a renewal of the grant.

The administration of the grants made to Dr. Adams and the question of the unexpended balance of the vote to the late Sir David Hutchins were left in the hands of the Standing Committee to deal with.

With regard to the grant to Mr. Morrison, on the motion of Dr. Cockayne, seconded by Dr. Thomson, it was resolved, That the Standing Committee be instructed to ascertain from the Forestry Department whether they are prepared to give Mr. Morrison facilities for carrying out his research and so relieve the Research Fund of this expense.

Report of Research Grant Committee, 1920.

(Dr. J. Allan Thomson, Mr. Furkert, and Mr. Aston.)

(For previous reports see *Trans. N.Z. Inst.*, vol. 50, p. 333; vol. 51, p. 462; and vol. 52, p. 479.)

Professor J. Malcolm, who in 1919 was granted £275, and in 1920 £150, through the Otago Institute, for a research on the chemical composition and food value of New Zealand fishes, reported on the 3rd December, 1920, that Mrs. D. E. Johnson, B.Sc., had, under his supervision, continued this research throughout the year. Samples of groper and kingfish were analysed at fairly regular intervals from February to September to give some idea of the seasonal variations. Some new varieties were analysed—*e.g.*, whitebait—and a detailed qualitative analysis of the edible parts of the groper had been commenced, and the results would be published in vol. 53, *Trans. N.Z. Inst.*, as Part II of the series of papers on the subject. About £220 had been expended, and liability for apparatus ordered but not come to hand had been incurred up to about £50, leaving a balance of about £150. Professor Malcolm desires to continue the research next year.

Professor J. Malcolm, who in 1918 was granted £30 through the Otago Institute for a research on New Zealand plant poisons, reported on the 3rd December, 1920, that owing to the claims of University work and the research of the food values of fish he had been unable to complete the work, and, as there still remained about £14 unexpended, he would like to have the time extended for another year.

Dr. C. Chilton, who in 1918 was granted £50 through the Philosophical Institute of Canterbury for investigation on the New Zealand flax (phormium), reported on the 22nd November, 1920, that owing to Mrs. Dr. B. D. McCallum being still in Edinburgh, and it being impossible to find any one to continue the work, no progress had been made with this research. He hoped that one of the students now finishing their honours course would be able to take up the work; if not, the balance of the grant would be refunded.

Mr. H. D. Skinner, who in 1920 was granted £200 through the Otago Institute for work among the South Island Maoris, reported on the 15th November, 1920, that Mr. Beattie, his assistant, had been working in the field between the Bluff and Kaiapoi, and had secured a large amount of entirely new material relating to Maori life in Otago, Canterbury, Westland, and Nelson. In view of the scantiness of the material previously recorded from the South Island, Mr. Beattie's results are of very great importance. An amount of £3 10s. is still unexpended.

Messrs. R. Speight and L. J. Wild, who in 1916 were granted £50 through the Philosophical Institute of Canterbury for a research on the phosphatic limestones of Canterbury, reported on the 21st October, 1920, that it had not been possible to do any work in connection with this grant during the current year, and no further sum had been expended, so that the amount of £7 remaining from last year is still left over, and the grantees would be glad if the Board would consent to its being available for the ensuing year, when it is confidently expected that the investigation will be completed. It is still possible, though not probable, that one or two outlying masses of limestone not yet examined may furnish material in commercial amount, and their possibilities should be thoroughly determined before the research is discontinued.

Mr. R. Speight, who in 1919 was granted £225 through the Philosophical Institute of Canterbury for a geological survey of Malvern Hills, reported on the 21st October, 1920, that the work had been carried out during the year, and a complete examination had been made of Cordys Flat and the country adjoining it. This work had been facilitated by the recommencement of prospecting in the neighbourhood of Hill's old mine, and the results encourage the hope that payable coal may be located in the flat, but further prospecting, either by shafts or by boring, on some plan, will have to be resorted to before the existence of a payable field can be established. An investigation of other parts of the district is in progress, and may yet disclose the presence of large and payable deposits. The investigations carried on up to the present are of the nature of field-work, and it is hoped that during the ensuing year arrangements may be possible with the Chemical Laboratory at Canterbury College which will allow the chemical and physical properties of the sands and clays to be determined with accuracy. The work involved an expenditure of £15 3s. 6d.

Mr. L. J. Wild, who in 1918 was granted £30 through the Philosophical Institute of Canterbury for a research on soils, reported on the 10th December, 1920, that some of the material collected in connection with this grant had been used in a paper "On the Calcium-carbonate Content of some Canterbury Soils," which had been published in the *N.Z. Journal of Science and Technology,* vol. 3, No. 2. The sum of 18s. only had been expended.

Messrs. Lancaster and Cornes, who in 1919 were granted £50 through the Auckland Institute for a research on the growth of New Zealand timber-trees, reported on the 30th October, 1920, that owing to Mr. Cornes's removal to Nelson and to a heavy University College session very little headway had been made with this research. Mr. Lancaster trusted, however, that he would soon be able to devote a considerable time to the growth of kauri, and he was engaged in making a careful analysis of microscope sections of the stems of young kauri to determine whether the kauri, particularly when young, produced one ring of wood per year. None of the grant had been expended.

The late Sir David Hutchins, who in 1920 was granted £60 through the Wellington Philosophical Society for research in forestry, reported on the 1st November 1920, that he had made journeys to Napier, to the Taupo Totara Timber Company, and to the King-country, making daily journeys into the bush with the bushmen and examining the trees as they were felled. At the same time collections of young planted trees of known ages were examined and measured up as opportunities offered. He had obtained sufficient figures to complete his growth-data for white-pine, rimu, and totara (kauri being already completed). He required only data for celery-top and a few minor timbers. Expenses amounting to £53 11s. had been incurred. A further application for a grant of £25 to Sir David had been approved by the Standing Committee, but his lamentable death rendered this grant unnecessary. Your committee learns with satisfaction that the whole of the notes and the manuscripts left by the late gentleman have been handed over unconditionally to the Forestry Department, the chiefs of which are anxious to have some use made of the material. It is suggested that a grant from the research vote should be made to some competent person working under the direction of the Secretary of the Forestry Department to collate the material left by Sir D. Hutchins in order that what is suitable should be finally edited by Mr. E. Phillips Turner and published.

Professor W. P. Evans, who in 1920 was granted a further £200 through the Philosophical Institute of Canterbury for a research on New Zealand coals, reported on the 10th December, 1920, that an analysis had been made of Avoca, Taratu, Coal Creek Flat, Puponga, and Charleston coals; distillation tests, producer runs, and extractions had been made of a number of coals; and calorific values had been taken of Homebush, Mossbank, Mount Somers, Inangahua, Taratu, Kaitangata, Coal Creek Flat, Puponga, and Charleston coals. An analysis of gas from Charleston coals, an estimation of sulphuretted hydrogen in producer-gas, and experiments with residues from oils in Kaitangata, Avoca, and Charleston coals had also been completed. Experiments with coaldust had been postponed pending further more detailed reports of work in the United States of America. Mr. Gilling had been most assiduous in carrying on the experimental portion of the work. Professor Evans applied for a further grant of £200, as there remains only about £60 of the old grant. £150 is for the salary of an assistant and the remainder for the apparatus. This grant has been approved subject to the Hon. Minister's approval.

Mr. G. Brittin, who in 1919 was granted £100 through the Philosophical Institute of Canterbury for a research in fruit-diseases, reported on the 7th December that the work for the past twelve months had been very satisfactory in regard to the experimental portion, but, owing to the instruments and books indented not having arrived, very little could be done microscopically. Pruning had again been carried out on the same lines, and had again proved beneficial in regard to die-back of the fruit-trees. Spraying had also been conducted experimentally, and had proved very satisfactory in preventing bud-dropping. A paper on the research was now ready for publication, and is to be forwarded to the *Journal of Agriculture.* Experimental work had also been done in regard to *Venturia inequalis* (black spot) and *Sclerotinia fructigena* (brown rot). There remained a balance of about £97.

Professor C. Coleridge Farr, who in 1919 was granted £100, and in 1920 an additional £30, through the Philosophical Institute of Canterbury, for a research on the porosity of high-voltage insulators, reported on the 19th November, 1920, that £110 had been expended in constructing a testing-vessel and the mechanical appliances necessary for manipulating the heavy masses of iron which were required in the construction of a vessel to stand such high pressure. The tests were entirely satisfactory. The testing-vessel stood a pressure of 2,000 lb. to the square inch for several days without serious leakage. The tests for porosity were made on complete unbroken insulators. These tests proved that the breakdowns upon the Lake Coleridge system were in a very large measure due to porous insulators, and a test was devised which was imposed upon recent tenderers for insulators for the Dominion by the Public Works Department. It is hoped shortly to publish a detailed account of the tests and the results arrived at from them. An application from Dr. Farr for a further grant of £75 for a research into the physical properties of gas-free sulphur has been approved subject to the Hon. Minister's consent.

Miss K. M. Curtis, who in 1920 was granted £100 through the Nelson Institute for a research in parasitic mycology, and in particular with reference to fruit-tree disease in New Zealand, reported on the 13th December, 1920, that the question being considered in connection with the black spot of apple and the brown rot of stone-fruits is that of immunity to disease. The experiments are being run conjointly for the two diseases, and those so far carried out concern the determination of the optimum physical conditions for spore-germination, the selection of the most suitable media to secure the rapidity, the greatest percentage, and the virility of cultures following spore-germination, and the determination of the age-limits of the cultures within which infection of the host can be relied upon to take place. The sum of £21 has been received, and will cover the cost of certain books ordered.

Mr. George Gray, who in 1920 was granted £50 through the Philosophical Institute of Canterbury for an investigation on the waters of Canterbury, reported on the 14th December, 1920, that owing to delay caused by having to fit up a laboratory for the work, and the difficulty in obtaining suitable apparatus, the investigation had been in abeyance, and requested that the grant, of which no portion had been expended, should be available for next year.

Dr. C. E. Adams, who in 1919 was granted £55 through the Wellington Philosophical Society, reported on the 15th December that this amount had been forwarded to the British Astronomical Association, and out of it a micrometer eye-piece had been purchased and had been received here. The eye-piece had been adapted to the Wellington Philosophical Society's equatorial telescope at Wellington, and has been partly tested, but so far the weather has not permitted a systematic use of the micrometer. It is, however, available and ready for measurement of any comets, &c., that may be discovered. The British Association reports that owing to the high cost of the other apparatus it is desirable to postpone purchase at present, with which view Dr. Adams concurs; and the association has been asked to make inquiries for suitable second-hand apparatus. There is a balance of £36 12s. 2d.

Dr. C. E. Adams, who was further granted £150 through the Wellington Philosophical Society for a research on astronomical and geophysical sites, reported on the 16th December, 1920, that preliminary investigations had been carried out in parts of Central and North Otago, and arrangements have been made with a number of voluntary workers to report on the weather conditions at various places in Otago. Part of the grant has been spent in obtaining thermometers, &c., for this work. Of this grant there is still an unexpended balance of £134 14s.

Mr. W. G. Morrison, who in 1919 was granted £100 through the Philosophical Institute of Canterbury, reported on the 12th December, 1920, that owing to limited leave comparatively small progress had been made in the gathering of data. Without extended leave he could not visit exotic plantations and native forests other than those situated within easy reach of Hanmer, and in consequence his research work had been confined to the North Canterbury district only. Nevertheless, some useful data had been collected, and numerous photographs illustrative of natural seeding in various stages of development had been supplied to the Director of Forestry, who had described them as being "wonderful" and of superlative interest. A preliminary report on the native forests of the Hanmer district was compiled and forwarded to the Director of Forestry, who has acknowledged the work done as of great value. There is still an unexpended amount of £30.

Dr. J. Allan Thomson, who was granted £100 through the Wellington Philosophical Society for a research into the chemical characters of igneous rocks, reported on the 5th January, 1921, that in his original application he stated that there was reason to believe the superior analysis of igneous rocks, conforming to the standards selected, would number about three thousand, of which he had previously calculated one thousand. On receipt of Washington's second edition of *Superior Analysis of Igneous Rocks* it was found that the number greatly exceeded the three thousand estimated, and that the grant of £100 would not suffice to pay assistants to calculate them all. He therefore restricted the employment of the assistants to plotting the chief constituents against silica, and this has been completed for Al_2O_3, Fe_2O_3, FeO, MgO, CaO, K_2O, and Na_2O. Owing to his absence from New Zealand during the latter part of 1920, Dr. Thomson has been unable to study the plots in detail and decide whether it is advisable to apply for a further grant for completing the calculations, or to publish the results deducible from the work already carried out. This he hoped to do during 1921. An amount, £15 12s. 6d., of the grant is unexpended, and Dr. Thomson applies for a renewal of this, in case it is found desirable to prepare the plots for publication.

Hon. G. M. and G. S. Thomson, who were in 1919 granted £50 through the Otago Institute for a research on the economic value of whale-feed, reported on the 11th November that owing to delay in obtaining apparatus required it had not been possible to make much progress as yet with the research. A considerable amount of material had been collected and observations made on the occurrence of the whale-feed, but no actual analytical work had yet been done. Advice had been received that the apparatus ordered had arrived in New Zealand, and £50 would be required on account, which would in all probability, owing to the increased prices, be considerably over £80, making it necessary to apply later for an increased grant.

Professor T. H. Easterfield, who in 1919 was granted £250 through the Wellington Philosophical Society for an investigation of New Zealand oils, waxes, and resins, reported on the 6th January, 1921, that £98 19s. had last year been spent in salaries of assistants, and a further £98 in the year following, leaving a balance of £53 1s. A paper embodying the results of the investigation will be read at the Palmerston North Science Congress. The research is being continued.

Publication Committee's Report.—The report of the Publication Committee was read and received.

REPORT OF PUBLICATION COMMITTEE.

Thirty-seven papers, by twenty-six authors, were accepted for publication in volume 52 of the *Transactions of the New Zealand Institute*, and the volume was issued on the 9th August, 1920. It is practically the same size as the previous year's volume, and contains xxx plus 544 pages (of which 78 are devoted to the Proceedings and Appendix), 30 plates (one coloured), and a large number of text-figures.

No extra publications were issued during the year, but two bulletins—viz., Dixon's *Mosses* and Broun's *Coleoptera*—and also the Index to volumes 41-51, are now in the printer's hands. For the Committee.

JOHANNES C. ANDERSEN, Hon. Editor.

Library Report.—The report of the Library Committee was read and received, and, on the motion of Ven. Archdeacon Williams, seconded by Mr. Wright, it was resolved, That the Board of Governors of the New Zealand Institute desires to urge once more upon the Cabinet the paramount necessity for the erection, with the least possible delay, of a suitable building for the accommodation of the Museum and the library of the Institute, and in doing this would point out once more that the continued neglect of the Government in this respect is involving the risk of the irreparable loss of many unique and priceless specimens and volumes which are still housed in an unsuitable wooden building.

On the motion of Dr. Cockayne, seconded by Mr. Eliott, it was resolved, That the Board of Governors are of the opinion that the Dominion Museum would be greatly benefited by being placed under the control of a National Board of Trustees; and that this resolution be forwarded to the Government.

REPORT OF LIBRARY COMMITTEE.

No favourable change in the condition of the library during 1920 can be reported. The accommodation available is too small to house all the books of the library, and a large proportion of the older books are packed away in boxes in the Museum store-shed. During the coming year it will be necessary to store a further proportion to make room for the incoming exchanges, unless further shelf accommodation can be provided. This is not possible in the present room.

Owing to the absence of the Honorary Librarian during the latter months of 1920, no steps have been taken to secure fresh quotations for binding. With the prospect of falling prices this may be found expedient in 1921. The greater part of the £250 voted for this purpose by the Government in 1919 is still unexpended.

A list of the publications received during 1919 was published in the annual volume for 1920.

J. Allan Thomson, Hon. Librarian.

Regulations Committee Report.—The report of the Regulations Committee was read and received, and the committee was appointed for another year.

Report of Regulations Committee.

(Hon. Librarian, Hon. Editor, Hon. Treasurer, and Hon. Secretary.)

The committee reports that the minute-book and published reports have been carefully searched for matter which has the force of regulations, and the results have been classified in a schedule which has been prepared and which it is hoped to go into fully during the coming year. The committee therefore suggests that its term of office should be extended for another year.

Honorary Members' Roll.—There was no response to the President's invitation for any Governor to notify any vacancy in the roll of honorary members through death.

Election of Fellows.—The ballot for the election of Fellows resulted in the election of the following, as reported by the hon. returning officer: Dr. C. A. Cotton, Dr F. W. Hilgendorf, Rev. Dr. Holloway, Professor James Park.

Correspondence.—It was resolved to refer the International Catalogue of Scientific Literature Report to the Standing Committee to deal with Applications for publications were referred to the Standing Committee.

It was resolved, in connection with certain proposals brought before the Board by Mr. G. V. Hudson, That, as Mr. Hudson's proposals would involve altering the constitution of the Institute, with a corresponding amendment of the Act, no action be taken.

With reference to a letter dated 7th November, 1920, from the Philosophical Institute of Canterbury, regarding the Carter library, permission was given the Standing Committee to house the Carter collection in the Turnbull Library if suitable arrangements for doing so could be made

In reference to a letter dated 23rd December, 1920, from the Philosophical Institute of Canterbury, it was resolved, on the motion of Dr. Thomson seconded by Hon. G. M. Thomson, That a committee consisting of Professor D. M. Y. Sommerville and Mr. G. E. Archey be set up to frame a practicable scheme for a printed catalogue of scientific serials in the various libraries of the Dominion, and report to the Standing Committee.

In reference to a letter from Mr. Henry Woods, who wrote to say he had not received his certificate of membership, it was resolved to issue a plain honorary membership certificate, the supply of parchment forms being exhausted.

Election of Officers.—President, Professor T. H. Easterfield; Hon. Treasurer, Mr. M. A. Eliott; Hon. Editor, Mr. Johannes C. Andersen; Hon. Librarian, Dr. J. Allan Thomson; Hon. Secretary, Mr. B. C. Aston.

On the motion of Ven. Archdeacon Williams, seconded by Dr. Chilton, it was resolved, That the Board desires to place on record its appreciation of the valuable services rendered to the Institute by Mr. C. A. Ewen during the many years in which he has acted as Hon. Treasurer of the Institute.

Election of Committees.—Library Committee: Dr. Thomson (convener), Dr. Cotton, Mr. Andersen, and Professor Sommerville.

Publications Committee: Professor Kirk, Dr. Cotton, Mr. J. C. Andersen, Dr. Thomson, and Mr. Aston (reappointed).

Research Grants Committee: Standing Committee and Mr. Furkert.

Hector Award Committee: Professor Easterfield (convener), Professor F. D. Brown, and Sir E. Rutherford.

Regulations Committee: Mr. Andersen, Dr. Thomson, Mr. Eliott, and Mr. Aston.

Observatory Committee: Professors Easterfield, Farr, Marsden, Dr. Cotton, Dr. Adams, and Mr. Gifford (reappointed).

Travelling-expenses.—It was resolved to pay travelling-expenses of the members of the Board of Governors.

Minutes.—Authority was granted to the Standing Committee to confirm the minutes.

Votes of Thanks were passed to the Palmerston North High School Board for the use of the school for this meeting, and to the honorary officers of the Institute for their work during the year.

PROCEEDINGS OF THE NEW ZEALAND INSTITUTE SCIENCE CONGRESS.

PALMERSTON NORTH, JANUARY, 1921.

The second Science Congress of the New Zealand Institute was held at Palmerston North from the 25th to the 29th January. The attendance was smaller than that of the former Congress, but the standard of papers and discussions was equally high, and the general expression of opinion of the members participating was that the Congress was a great success.

A very attractive booklet for the meeting was issued by the Borough Council, in the form of an illustrated Municipal Year-book, with a full statement of the situation, population, early history, waterworks, public reserves, and municipal enterprises of the borough, and an appendix giving the programme of the Science Congress, including articles on the plants of the Manawatu, by Dr. L. Cockayne; the geology of the Palmerston district, by Dr. P. Marshall; notes on the Manawatu swamps and district, by Mr. R. Edwards; and notes on the botany of the Esplanade, by Mr. R. Black. This booklet will always form a useful handbook for visitors to Palmerston North.

The programme of the Congress was similar in general outlines to that of the Christchurch meeting in 1919. The sectional and general meetings were held in the Boys' High School buildings, the public addresses in the Municipal Hall. The afternoons were devoted to excursions to the waterworks at Tiritea, the "Glaxo" factory at Bunnythorpe, and to a garden party at the Esplanade. On Saturday a full-day excursion was made, first to the Miranui flax-swamp and Messrs. A. and L. Seifert's flax-mills, and later to the Mangahao hydro-electric works. The evenings were occupied by the opening meeting, two public lectures, and a conversazione.

Officers of the Congress.

President of the New Zealand Institute.

Professor T. H. Easterfield, M.A., Ph.D., F.N.Z.Inst., Cawthron Institute, Nelson.

Hon. General Secretary.

Mr. C. T. Salmon, P.O. Box 293, Palmerston North.

Local Executive Committee.

Chairman, Mr. M. A. Eliott; Vice-Chairman, Mr. J. Murray; Hon. Treasurer, Mr. J. R. Hardie; and the Mayor (Mr. J. A. Nash, M.P.), Dr. H. D. Bett, Messrs. W. F. Durward, E. H. Crabb, A. Whitaker, H. Seifert, J. B. Gerrand, W. Park, C. N. Clausen, E. Larcomb, C. A. Hertzell, R. Edwards, R. F. G. Grace, A. J. Colquhoun, J. J. Stevenson.

General Executive Committee.

Professors T. H. Easterfield and C. Chilton, Drs. L. Cockayne and J. Allan Thomson, Hon. G. M. Thomson, and Mr. M. A. Eliott, representing the Board of Governors; Sir James Wilson, Professor J. Park, Messrs. E. Miller, and L. Birks, as Chairmen of sections; and Dr. D. H. Bett and Messrs. J. Murray and C. T. Salmon, representing the local executive. Hon. Secretary, Dr. J. Allan Thomson.

Officers of the Sections.

Agriculture.—President, Sir James Wilson, Bulls; Secretary, Mr. J. J. Stevenson, 44 Grey Street, Palmerston North.

Biology.—President, Dr. C. Chilton, M.A., F.N.Z.Inst., F.L.S., Biological Laboratory, Canterbury College, Christchurch; Secretary, Mr. W. R. B. Oliver, Dominion Museum, Wellington.

General Section.—President, Mr. E. V. Miller, 71 Upland Road, Remuera, Auckland; Secretary, Mr. E. K. Lomas, Training College, Wellington.

Physics, Chemistry, and Engineering.—President, Mr. Laurence Birks, B.Sc., M.Inst.C.E., M.I.E.E., M.I.M.E., Public Works Department, Wellington; Secretary, Mr. J. A. Colquhoun, M.Sc., 18 Bryant Street, Palmerston North.

Geology.—President, Professor J. Park, F.G.S., University of Otago; Secretary, Dr. J. Allan Thomson, M.A., F.G.S., F.N.Z.Inst., Dominion Museum, Wellington.

Opening Meeting.

The opening meeting of the Congress was held in the Town Hall on Tuesday night, 25th January, and was well attended not only by members of the Congress, but also by residents. Mr. J. A. Nash, M.P., Mayor of Palmerston North, welcomed the visitors in the name of the Borough Council, and outlined the progressive policy they had pursued in regard to municipal enterprises, and especially in the matter of reserves. He hoped that when the next Congress was held there, which he trusted would be only a few years hence, further great improvements now in train would be visible.

The Hon. G. J. Anderson (Minister of Internal Affairs), in declaring the Congress open, stated that during the last year he had given a good deal of attention to three matters dear to the heart of the Institute. He mentioned as desirable the acceptance of the gift of telescopes offered by the Yale University. Inquiries had shown, however, that, instead of costing only £7,000 for installation, the preliminary cost would be £16,000, and in the present serious condition of the world's money-market and the country's finances, desirable as it was, he could not recommend so large an expenditure to Cabinet. Otago, with its proverbial patriotism, had offered to raise by subscription the sum of £7,000, and he regretted to damp their enthusiasm by telling them how much more would be necessary. As very desirable the Minister characterized the proposal to found in the volcanic district a vulcanological observatory. Dr. Jaggar, of the Hawaiian Volcano Observatory, had presented him with a very able report on the subject, and had convinced him that such an observatory in New Zealand, by issuing warnings of eruptions, might be the means of saving life. No sum of money was too great to expend in saving valuable lives, and as the sum needed for an observatory was modest he intended to ask Cabinet for it. The Minister said he had intended to do something last session in the matter of encouraging scientific and industrial research, and his colleague the Hon. Mr. Parr and himself were made a committee by Cabinet to deal with the matter. He referred to the complexity of the scheme prepared by the New Zealand Institute and National Efficiency Board, and to the large amount, £20,000 for a period of five years, which that scheme demanded. He had not yet made up his mind just what form the Government assistance would take, but emphasized the need for all the scientific bodies co-operating fully with one another and preventing all overlapping of effort and expenditure.

The President of the New Zealand Institute, Professor T. H. Easterfield, referred to the loss by death of two members whom all had looked forward to seeing at this Congress—Mr. K. Wilson and Sir David Hutchins. At his invitation the meeting stood in silence in their memory. He then delivered his presidential address (see page xxv of the present volume).

Public Lectures.

Public lectures were given on Wednesday and Thursday evenings in the Town Hall, and were well attended by the citizens and visitors. On Wednesday Dr. Tillyard gave an illustrated address on "Modern Methods of Scientific Control of Insect Pests." American practice, he said, was far above British in these matters, and he must "take off his hat" to the Americans. Time permitted of a selection only of cases illustrating the general principles involved. The first was quarantine and fumigation at the ports of entry. In Honolulu the sugar-planters had thought it worth while to supplement the salary of the Government officers in order to secure fully qualified men, and the museum of the pests that had deen detected and kept out was a most educative one. Various mechanical devices for catching or trapping insects were described, and spraying was also illustrated by a picture which looked like a fire brigade at work, throwing spray over a high forest-tree. It was found that the important thing in spraying was the pressure, and large quantities of weak solutions of the sprays were used. Injections of chemicals into the sap of trees was at one time believed to be of little use, but recently the Italian Government had had great success by this method, though it was being kept a close secret at present. The most successful methods of control were biological. These were of two kinds—the selection of strains immune from disease, often the only possible and sometimes a very successful method of meeting the ravages, and control of insects by their own insect enemies. Predatory insects often served to keep pests under control, and many such could be advantageously introduced into New Zealand. "Big fleas have little fleas upon their backs," and very many insects could be controlled by their own parasites. In introducing useful insects to a country it was all-important to see that their own parasites were not introduced at the same time. The lecturer concluded with an account of his own work in bringing to New Zealand an enemy of the woolly aphis.

On Thursday Mr. J. H. Edmundson, of Napier, gave a lecture on "Liquid Air." It was illustrated by lantern-slides of famous investigators in the science of liquefaction, and by diagrams. Following upon the explanations, the lecturer carried out some very remarkable and spectacular experiments showing the results of extremely low temperatures. These included the liquefaction on the stage of atmospheric air and pure oxygen.

Discussion on the Flax Industry.

The problems of the New Zealand flax industry were discussed at a general session of the Congress on the morning of Thursday, 27th January.

The subject was introduced by Mr. A. Seifert, who gave an account of the dimensions of the industry, and mentioned the ravages of the yellow-leaf disease, which had caused during the last year the abandonment of 5,000 acres of flax swamp. He compared the return per acre of land under flax with that of land grazed for dairy-produce, and concluded that the growing of flax was a much more profitable method of utilizing the land. Compared with the difficulties confronting other types of fibre, New Zealand flax was in a favourable position, but it was necessary to obtain immunity from the yellow-leaf disease. His firm had made some experiments with fertilizers, and, though it was too early to give definite results, they were so far in favour of the use of fertilizers, especially superphosphate.

Dr. J. W. McIlraith spoke on the economics of the flax industry. The price of flax had steadily risen, and at a greater rate (136 per cent. in the last twenty years) than other agricultural products (104 per cent. during the same time). In the "nineties" flax formed only ½ per cent. of our exports; now it formed 3 per cent. He concluded that it would have been profitable to grow more flax in the past, and mentioned the existence of large swamp areas which he thought should be utilized.

Mr. A. H. Cockayne mentioned the improvement of the Manawatu swamps by draining, after which pure stands of flax automatically sprang up. The district now possessed 23,000 out of the 50,000 acres of flax in New Zealand. The gross returns per acre were greater than for any other form of agriculture except orcharding. Diseases were now the limiting factors of production; of these the yellow-leaf disease was the most serious, rendering 6,000 acres unproductive. He exhibited specimens of diseased plants, showing how the outer leaves of the fans assume a yellow colour and ultimately shrivel up, while the next inner leaves are attacked, and so on. The problem his department had to solve was whether the disease was caused by bacteria, fungi, insects, or other pests. They had isolated six species of bacteria infecting the roots, none of which had developed under experimental conditions any pathogenic symptoms. A nemotode worm had also been investigated—one of these worms is the cause of a disease called "yellow stripe" in the similar monocotyledonus daffodils—but the numbers found were not sufficient to account for yellow-leaf disease. Insects also failed to account for the disease, though they caused trouble of another sort. Finally a fungus had been isolated, *Ramularia phormii*, and was held to be the cause of the disease. The delay in its isolation was the difficulty of sterilizing the surface of the roots, owing to their great porosity. Field experiments showed that only that portion of the root which absorbs water could be infected; this was not the primary root, but the secondary or tertiary branches. Once these are infected, the fungus spreads and reaches the primary roots. As it destroys the water-absorbing roots, the fungus prevents the absorption of water. When the swamps get very dry the disease spreads very rapidly. Unless the disease can be eliminated the industry is doomed. The fungus had been isolated, developed in pure cultures, reintroduced into healthy plants, and had produced yellow-leaf disease. Three methods of combating soil-diseases were known: (1.) Soil-treatment, of which well-known cases were the use of lime for club-root in cabbages, and sulphur for onion-smut. On the whole, few diseases could be controlled by this method. (2.) Crop-rotation, a method used successfully with a large number of diseases, such as "take-all" in wheat. All such cases were diseases attacking annuals, and the method was not possible with flax, which was a perennial. (3.) The use of disease-resistant strains. Wonderful success had been secured by this method in a great variety of diseases, including some caused by other species of *Ramularia*—*e.g.*, Irish-flax wilt, tomato-wilt, cotton-wilt, &c. Healthy plants growing in diseased areas had been selected for breeding, and the diseases had been combated. The control of yellow-leaf disease must be found along this line.

Mr. R. Waters, who had conducted the isolation of the fungus under the direction of Mr. Cockayne, mentioned the difficulty of sterilizing the exterior of so porous a root. In the end slightly infected roots were selected, a jelly was infected, and a growth obtained, of which he exhibited specimens. The results of infection of healthy plants was at first negative until seedlings were tried, when the disease quickly appeared. In answer to Professor Easterfield, who asked whether disease-resisting plants showed any root-infection, Mr. Waters stated that no work on disease-resistant strains had yet been done, but root-infection was absent from healthy plants.

Dr. L. Cockayne stated that flax grew under almost all conditions—dry areas, wet areas, sweet soils, sour soils, rocky slopes, wet clay, dry clay, &c. No one could say yet under what circumstances we get the best flax, and so an accurate survey of the plant as it grew in nature was needed. The question to be settled was whether flax would not be a profitable crop on poor lands. In his opinion, quite possibly the sand-dune areas might be turned into flax-fields. He briefly alluded to his previous work on the flax,* and stated that he did not at first believe it to be a disease, but merely an effect of a non-correct system of swamp-management.

Dr. C. Chilton asked whether Koch's conditions as to proof of pathogenicity had been fulfilled, whether spores of the fungus had been obtained, and whether treatment of the soils might not also help.

In reply, Mr. Waters stated that all of Koch's conditions had not yet been fulfilled, owing to the short time since the discovery. Spores of two kinds had been obtained, both from the cultivated fungus and from diseased plants.

Dr. Tillyard referred briefly to the insects found on or in the flax-plants, and mentioned the work of Mr. Miller on the *Xanthorhoe* grub. A noctuid grub, a species of *Melanchra*, also bit out the sides of leaves, but did not do serious damage. Syrphid grubs were found in the rotting jelly inside the leaves, and a mealy bug at the leaf-bases. Mr. Miller was ably investigating these insects. A scale insect, *Pseudococcus*, had been described many years ago from New Zealand flax by the late Mr. Maskell, but his type specimen was in very bad condition and practically indeterminable. A similar scale was found on sugar in Honolulu, and

* *N.Z. Jour. Sci. & Tech.*, vol. 3, No. 4, pp. 190–96, 1920.

the Americans were very anxious to learn all they could about all the scales on New Zealand flax. Specimens shall be collected and sent to America for determination. It had been shown that the work on flax demanded expert mycologists, entomologists, chemists, agriculturists, horticulturists, &c., and this was only possible in a central station. He described briefly what had been done for the sugar industry in Hawaii by the sugar-planters' experimental station, and advocated the formation of a similar station by the flax-planters.

Dr. J. A. Thomson, in supporting Dr. Tillyard's recommendations, expressed disappointment with what he had heard so far. Mr. Seifert had stated that the control of the disease was not the flax-millers' business. Knowing Mr. Seifert's activities in this direction, he thought that it would be unfortunate if this statement were allowed to stand. Three years ago Dr. Cockayne had suggested the selection of disease-resisting strains, but nothing seemed to have been done, and he had not heard any mention that it was proposed now to be done by any one in particular. Was it to be left solely to the Government?

Mr. Seifert, in explanation, stated that he had meant that the actual investigations were not the business of the millers, but of the scientists. As the industry was likely to expand greatly by the planting of flax on a large scale, it was not fair to saddle the present small areas with the whole cost. The question to be decided was how much the present areas should stand, and how much the Government, representing the whole people, should contribute.

Professor Easterfield then dealt with the chemical aspects of the industry, and traced the history of the leaf from the swamp to the finished fibre, showing the amount of loss of weight at each stage. He stated that in reality the machinery was much more efficient than was generally supposed. It was foolish to think of turning stripper-waste into paper, and this fact must have been known to those who made paper from flax as far back as 1830. A number of other possible uses of flax-waste were mentioned, and a scheme outlined for the extraction of alcohol, the manufacture of fertilizer, and the provision of boiler-fuel from this material, of which one mill in the Manawatu provides over 30 tons daily.

Mr. Bell deprecated comparison of the flax industry with the sugar industry in the Hawaiian Islands, on the ground that in the latter place the land was only fit for growing sugar, whereas in New Zealand the flax swamps could easily be converted into dairying-land. Consequently, if it was desired to retain the flax exports, it was a matter not for the millers but for the Government, and not for a flax-millers' experimental station.

Dr. Tillyard, in reply, pointed out that quite a considerable area of good land in the Hawaiian Islands was being put under pineapples instead of sugar, and this was an exact parallel to the position here, where it was suggested that dairying should replace flax-growing.

After some further discussion, in which flax-millers and representatives of the Department of Agriculture took part, it was resolved, on the motion of Dr. Tillyard, That a committee of flax-millers and members of the Congress be set up to go into the matter of forming a biological station to have the yellow-leaf disease investigated from all sides. The following were appointed members of the committee: Messrs. Ross, Seifert, and Bell, representing the flax-millers; and Professor Easterfield, Dr. Tillyard, Messrs. A. Cockayne, and R. Waters, representing the Congress.

At a general session of the Congress held next morning the committee submitted the following report, which was adopted by the Congress. The committee were asked to continue their deliberations, reporting as occasion demanded to the Standing Committee of the Institute.

Report of Committee.

1. The first essential of the flax problem is to find out whether or not races of *Phormium* exist which are resistant or immune to yellow-leaf disease.

2. For the carrying-out of this research it is recommended that a small flax experiment station should be built, and placed in charge of a skilled plant-propagator, with one or more assistants.

3. The minimum salary to be offered for the position of chief investigator should be £500 per annum, with guarantee of employment for five years.

4. A levy of 2s. per ton on flax should be collected through the Grading Department, and devoted to payment of salaries, cost of building, equipment, and upkeep of the experiment station.

5. The experiment station should be under the direction of a committee of the Flax-millers' Association.

Papers read at the Sections.

Agricultural Section.

Presidential Address: "Science and Agriculture," by Sir James G. Wilson.

Abstract.

After insisting on the dependence of New Zealand on the agriculturist and pastoralist, Sir James Wilson referred to the general deficiency of New Zealand soils, after a few preliminary crops, in phosphates, especially in the North Island. They are equally necessary in dairying. The relative merits of the different forms of application were briefly discussed. Fortunately there is apparently sufficient nitrogen in most New Zealand soils, and the deficiency that may arise in time can be met by fixation of atmospheric nitrogen in New Zealand. Meanwhile the natural method of fixation by the growing of leguminous plants should not be neglected. Potash is available in New Zealand in only small quantities, but kainit can now be imported from our ally France. Lime exists in quantity, and in general it will pay to lime our soils where the cost is reasonable, but the question of liming is one which requires very careful study and experiment by experts.

The humidity of the New Zealand climate combined with the high temperature gives great assistance to fungoid pests, and the absence of hard frosts in many districts leaves our insect pests almost without an enemy. We have now got to rely on the plant-breeder to find us resistant varieties to help us to cope with our troubles. Judicious stocking with sheep and cattle will help to keep the weeds in our pastures down. Where the weeds have got such a hold that it would be ruinous to try and eradicate them, they will tend to dwindle and gradually come under control by the exhaustion in the soil of the particular ingredients they need, while some will be attacked by natural enemies.

"Some Important Insect Problems of 1920," by D. Miller.

Abstract.

Although beneficial insects have occasionally done good work, they should be looked upon merely as auxiliaries in the reduction of destructive insects. The insect pests of New Zealand are mostly of European origin; very few native species have become destructive. The address was illustrated by numerous lantern-slides showing the life-history of the injurious species upon which the author was at present working. Among these is the pear-midge, which is causing so much damage in the pear-orchards of the Auckland district; the gall-making insect destroying the blue-gums around Palmerston North and in many other parts of the country; and the common wood-borer, upon which he had located a natural insect enemy. Other important insects referred to were the cattle-tick, the grass-grub (the life-history of which he had recently worked out), and the flax-grub.

Discussion on Fire-blight.

A lecture on fire-blight was given to the Agriculture and Biology Sections jointly by Messrs. A. H. Cockayne and R. Waters, and the subject was further discussed by Drs. Tillyard and L. Cockayne and Mr. J. B. Garnett. A committee consisting of Sir James Wilson, Mr. Campbell, and Dr. Tillyard was appointed to consider steps to be taken to assist in combating the ravages of this pest.

(A paper on this subject, by R. Waters, "Fire-blight: Bacteriological History in New Zealand," appears in the *N.Z. Journal of Agriculture*, vol. 22, pp. 143–45, 1921, and another, by A. H. Cockayne, "Fire-blight and its Control," in the same *Journal*, vol. 23, pp. 30–36, 1921.)

"Some Fodder Crops of England and New Zealand," by J. B. Garnett.

Abstract.

It has been definitely shown in the past that although forage crops are not able to compete with grass for cheapness of production in New Zealand, yet they fill a very necessary part in the economy of both dairying and sheep-farming, in so far as they are able to supply a succession of green food at times of the year when the pastures are bare. The man who has no supplementary feed ready at these times loses a great deal of milk immediately, and also later, because his cows, once having dropped in yield, do not pick up again readily when the next growth of grass occurs. Various fodder mixtures were given which have proved useful for these purposes in England, and would probably, with slight modifications, prove equally good in New Zealand: (1.) Oats 2 bushels, peas 1 bushel per acre. (2.) Giant ryecorn 2 bushels, winter vetches 1 bushel per acre. The second mixture sown in autumn will grow right through the winter and come in early in the spring, before the grass starts. (3.) Field peas 1 bushel, buckwheat 1 bushel, rape ½ lb. per acre. This mixture sown in spring will produce a big bulk of succulent fodder in the late summer, when the pastures are dry and burnt up. It would be much freer from "blight" than rape sown alone. Various other fodder plants and the best varieties were dealt with, and finally the importance of the fuller study of the economics of the question was emphasized.

"The Economic Significance of Powdery Scab in Potatoes," by R. Waters.

"Science and its Relation to Field Instruction to Farmers," by T. H. Patterson.

"The Importance of Soil Survey," by T. Rigg.

"What constitutes a Fertile Soil," by G. de S. Baylis.

"Factors in the Establishment of Lucerne," by A. H. Cockayne.

"'Take-all' in Wheat," by R. Waters.

"Some Important Successions in Permanent Grassland in New Zealand," by E. Bruce Levy.

Biology Section.

Presidential Address: "New Zealand and the Biological Problems of the Pacific," by Professor C. Chilton.

Abstract.

A summary was first given of the various theories suggested by Hutton, Hedley, and others to account for the relationship of New Zealand with South America on the one hand, and with New Caledonia, New Guinea, &c., on the other. The similarity in several respects between the animals and plants of the Hawaiian Islands and New Zealand was pointed out, and it was suggested that a careful consideration of the two would not only throw light on the origin of the New Zealand fauna and flora, but would also give useful information on the methods of evolution which had taken place in these two groups of islands.

The address was followed by a short discussion, in which Drs. L. Cockayne and P. Marshall, and Mr. W. R. B. Oliver took part.

"Some Notes on the Habits and Uses of the Toheroa," by Miss M. K. Mestayer. (This paper appears in the *N.Z. Journal of Science and Technology*, vol. 4, pp. 84–85, 1921.)

"Notes on the Natural Camouflage of some Marine Mollusca," by Miss M. K. Mestayer.

ABSTRACT.

These notes on natural camouflage deal with some of the ways in which our marine molluscs protect themselves from their enemies. This end is achieved in two ways: either by the animal's own effort, or by the shell becoming encrusted with the surrounding animal and vegetable life. Some measure of protection is also obtained by those molluscs living above half-tide, through the action of sun, wind, and rain weathering their shells till they closely resemble the rocks they live on. The best example of deliberate camouflage among New Zealand molluscs is to be found in the Hauraki Gulf, at about 30 fathoms. It is known as the "carrier" shell, from its habit of cementing other shells or bits of stone to its own, till it looks like a heap of old shells. The commonest forms of this natural camouflage are those which depend on the surroundings of the shells concerned; some being covered with coralline and other seaweeds, others often having their shells more or less hidden by small barnacles or other animal ife.

"Plant-propagation," by P. Black.

"On Growth-periods in New Zealand Plants, especially *Nothofagus fusca* and the Totara," by Professor H. B. Kirk. (This paper appears in the present volume, pp. 429–32.)

"Littoral Plant and Animal Communities," by W. R. B. Oliver.

"A Remarkable New Mosquito," by D. Miller.

"The Popular Names of New Zealand Plants," by J. C. Andersen.

ABSTRACT.

The author has compiled lists of names used by various writers from the time of Captain Cook onwards, showing the common names given to various plants, and showing when the names were first applied, and how long and how consistently they have been used. The cabbage-tree (*Cordyline australis*), for example, has nearly twenty different names, and many trees have a dozen or more. The tree known as *Nothofagus Solanderi* has been called "black," "white," "red," and "black-heart" birch in various districts, whilst at the same time the names "black-birch," "white-birch," &c., have been given to many other trees as well, "black-birch" being applied to no fewer than five. The object of the paper was to make a list available so that scientists and others might adopt the same common name and avoid the confusion that had taken place in the past.

"Ecological Problems relative to Salmonidae," by W. J. Phillipps.

"The Order Hemiptera in New Zealand, with Special Reference to its Biological and Economic Aspects," by J. G. Myers.

"Notes on the Vegetation of the Mid-Clarence Valley," by B. C. Aston.

ABSTRACT.

The author stated that he had made five visits to this district since the first in April, 1915, when a journey through the remarkable Ure Cañon, or Ure Gorge, as it is called, was made, and the ascent to the summit of Tapuaenuku (9,450 ft.) from the Dee River was accomplished. The main features of the work accomplished were the botanical examination of the Medway, Ure, Kekerangu, Nidd, Mead, and Dee River basins, including the hills surrounding them (the last three being tributaries of the Mid-Clarence), and the limestone foothills and eastern slopes of Mount Tapuaenuku.

The results included the discovery of a remarkable polymorphic new species of gentian which exhibited different habits of growth according to the habitat. This semi-arid district was well supplied with moist, dark stations in close proximity to very dry, strongly isolated stations. The same species might grow on a dark, dripping river-cliff, a shingle-bed exposed to a large measure of sunlight, a dry shady hillside, or a rock-crevice. A *Carmichaelia*, which was probably *C. Monroi*, exhibited such a variety of forms under these conditions that a botanist might class them as distinct species if he did not know the conditions under which the specimens were growing. The rediscovery was made of *Wahlenbergia Matthewsii*, the finest of the New Zealand species of that genus, originally discovered by H. J. Matthews, and found to be common in the Ure Valley as a rock-plant. Flowering specimens of *Olearia coriacea* were found in the Mead Stream, a *Haastia* growing at 8,500 ft. elevation, and *Helichysum Purdiei*, which, as Dr. Cockayne had pointed out, was probably a hybrid between *H. bellidioides* and *H. glomeratum*, since *H. Purdiei* was always found in association with its reputed parents. The speaker also described the rock associations met with. A *Notospartium* was found to be abundant in the Inland Kaikouras, and it was this plant which Mr. Petrie was now naming *N. glabrescens*; it attained a height of 15 ft. to 30 ft.

"Inheritance in Self-fertilized Plants," by Dr. F. W. Hilgendorf.

"Wellington Island Soils and Florulas," by B. C. Aston.

Geology Section.

Presidential Address: "The Birth and Development of New Zealand as a Geographical Unit," by Professor J. Park. (This paper appears in the present volume, pp. 73–76.)

"The Cretaceous Rocks of the Kaipara District," by Dr. P. Marshall.

Abstract.

Up to the present time very few fossils have been found in rocks of Upper Cretaceous age in New Zealand. The author, however, gave a description of a rich series of important fossils that he had recently found. These were largely ammonites, and showed a great similarity to fossils of similar Cretaceous age in South India and Antarctica. This recent discovery enforces the opinion previously held that New Zealand was joined to Antarctica in late Cretaceous times, and that this land was not distant from an Indian extension.

"The Geology of Western Samoa," by Dr. J. Allan Thomson. (This paper appears in the *N.Z. Journal of Science and Technology*, vol. 4, pp. 49–66, 1921.)

"The Structure of the Mangahao No. 1 Gorge (Mangahao Hydro-electric Scheme), and its Bearing on the Construction of the Proposed Dam," by G. L. Adkin. (This paper appears in the *N.Z. Journal of Science and Technology*, vol. 4, pp. 1–4, 1921.)

"The Warped Land-surface of the South-eastern Side of the Port Nicholson Depression," by Dr. C. A. Cotton. (This paper appears in the present volume, pp. 131–43.)

"The Great Barrier Island," by J. A. Bartrum. (This paper appears in the present volume as "Notes on the Geology of Great Barrier Island, New Zealand," pp. 115–27.)

"The Geology of the Port Waikato District," by M. J. Gilbert, M.Sc. (Rev. Brother Fergus). (This paper appears in the present volume as "Geology of the Waikato Heads District and the Kawa Unconformity," pp. 97–114.)

"The Tertiary Geology of the Awamoho District," by G. H. Uttley.

"A Ball and Pillow Lava from Hawaii," by Dr. J. Allan Thomson.

Physics, Chemistry, and Engineering Section.

Presidential Address: "Electric-power Supply in New Zealand," by L. Birks.

ABSTRACT.

Dealing with the cost of electric-power plants, the author said that the legislation under which electric installations may be established in New Zealand, based on the assumption that the majority of the plants would be publicly owned, was exceedingly simple, and the legal procedure cheap compared with that of Great Britain and elsewhere. With regard to the future, the Government proposals provided for one horse-power for each five head of population — say, 240,000 horse-power for the whole Dominion. The normal coal-consumption for the Dominion was about 2,500,000 tons per year, and the possible saving in coal-consumption, averaging both city and country users at about 10 to 12 tons of coal per horse-power-year, was thus approximately the total amount of the present consumption of the Dominion. Of course, a large consumption must still be required for gas-generating, bunkering, and main-line railways; but, on the other hand, the electric supply would be largely required for new houses and new industries, and would also be largely used to replace candles, kerosene, petrol, and mainly firewood, as well as coal, leaving a fairly large demand for coal even when the full 240,000 horse-power is available from hydro-electric sources. As to future developments, the total recorded hydro-electric-power sources of 1,000 horse-power or over in the Dominion as recorded in the *Year-book* of 1914 are between 3,000,000 and 4,000,000 horse-power, apart from probably another 1,000,000 horse-power available in small units below 1,000 horse-power. As to the demand, the provision of one horse-power per five head of population was, of course, only a stage in the development, which would ultimately be exceeded, possibly many times over.

"Some New Zealand Mineral Oils," by Professor T. H. Easterfield and N. McLelland.

ABSTRACT.

A statement was given of the districts in New Zealand in which mineral oils had been found, and the paper also alluded to the attempts to supply mineral oil by the distillation of oil-shales at Orepuki, Southland. The sulphur content of the southern shales was stated to be a very serious objection, and a comparison was given of the properties of Taranaki and Kotuku oil. The former is said to be remarkable in the high content of benzoles and cycloparaffins. The proportion of toluol, used in the manufacture of T.N.T. explosive particularly, was higher than in the case of the light oil from coal-tar. A number of pure chemical compounds taken from Taranaki petroleums were exhibited.

Professor Easterfield stated that, in his opinion, the boring of new wells in Taranaki promised at present greater success than development in any other area, but urged that as a matter of Imperial interest systematic prospecting by bores should be carried out in a number of areas.

"The Quantum Theory," by Professor P. W. Robertson.

"The Horizontal Pendulum," by Dr. C. E. Adams.

"The Wet Process of recovering Mercury from Cinnabar," by W. Donovan. (This paper appears as "Thornhill's Sodium-sulphide Process for the Recovery of Mercury," in the *N.Z. Journal of Science and Technology*, vol. 4, pp. 129–34, 1921.)

Discussion on Isotopes in New Zealand Minerals.

At a joint meeting of the Physics and Geology Sections Professor P. W. Robertson introduced the subject by explaining the recent developments in chemistry which had shown that certain elements were mixtures of isotopes, while others were suspected to be mixtures. It would be useful to place on record the occurrences of New Zealand minerals which were available as sources of these suspected mixtures, in order that chemists might know where to turn for material. The subsequent investigations might prove to have fundamental geological significance.

After some discussion it was resolved to set up a committee (see "Resolutions," below).

"The Transit Micrometer," by Dr. C. E. Adams.

General Section.

Presidential Address: "Science and the Principle of the Relativity of Motion," by E. Miller.

ABSTRACT.

The aim of the address is not to give an adequate account of Einstein's theory of relativity, but to pick out therefrom certain features which should serve to fit the subject on to familiar scientific conceptions, and thereby render the most important results of the theory intelligible, perhaps even acceptable, to the non-specialist. The metaphysical notion of void space involves the relativity of all positions, directions, and motions, including rest, or zero motion. But the scientific conception of space has for ages past been more or less inconsistent with this view. The latter, however, has, during the progress of science, vindicated itself with regard first to position and direction, then in regard to uniform motions, and, within the past few years, with regard to all motions. Each such vindication has constituted a sudden and remarkable increase of intellectual power, and has involved a notable reconstruction of scientific conceptions. The conceptions chiefly affected by the recent intellectual advance are those of space and time, natural geometry, gravitation, and the other natural forces. Besides these, a new dominating conception has been introduced which, when it is once mastered, allows of a much more accurate and simple representation to our minds of what is really happening in the external world.

Events referred to this entity, which has four dimensions, lose certain refractory inconsistencies which they undoubtedly present when they are described in the usual terms of space and time. Just as ethereal radiation is put forward by science as the real external event giving rise to our subjective experiences of light and warmth, so our movement in this four-dimensional continuum is put forward in the address as giving rise to our subjective and other experiences of the measure of space and time which we associate with natural occurrences. The conception affords us a truer apprehension of what is really going on in the external world than we can receive directly by our space-and-time experiences, which have been found by modern science to vary with our relative motion in a most confusing and irreconcilable manner. The satisfactory unification, as seen from the new point of view, of previously unrelated facts, especially of the facts of gravitation, inertia, and centrifugal force, was described in the address; and, since non-Euclidean geometry is used in relativity investigations, a short popular account was given of what such a thing may be.

"Maori Culture Areas in New Zealand," by H. D. Skinner.

ABSTRACT.

The main culture-division in the island region of the Pacific lies between Melanesia and Polynesia. "Melanesia" is culturally a very ill-defined term, and appears to cover very heterogeneous material. The culture of Polynesia appears, on the other hand, to be remarkably homogeneous. Maori culture, taken broadly, shows features derived from Polynesia and others that find their closest relationships in Melanesia. In language and in social structure the Maoris are Polynesian, but their material culture shows many points of resemblance to that of the Western Pacific. Thus the rectangular, circular, and pile types of house common in New Zealand are without parallel in Central and Eastern Polynesia, but occur in almost identical form in Melanesia.

The material culture of the North Island shows strong affinities with the Western Pacific while that of the South Island seems more nearly related to the material culture of Polynesia. This division between the North Island and the South is the most important that can be made on cultural grounds in New Zealand There is a transitional belt embracing both shores of Cook Strait. The South Island may be divided into three other districts—Murihiku, south of the Rangitata; Kaiapoi, south of the Buller and the Awatere; and the Wakatu, including the rest of the Island except the transitional region about the Marlborough Sounds.

The North Island may be divided into four areas, exclusive of the transitional belt along the shore of Cook Strait. The West Coast Area stretches from the Rangitikei to a little north of the Mokau. The East Coast Area lies south of the Mahia. The Central Area includes the rest of the Island south of the Auckland Isthmus. The Northern Area includes the rest of the North Island. To these areas must be added the Chatham Islands, which show many points of resemblance to Murihiku.

"The Strange Disappearance of Maoris in Fiordland," by W. H. Beattie.

(This paper appears as "A Mystery of Fiordland: A Vanished Maori Tribe," in the *N.Z. Journal of Science and Technology*, vol. 4, pp. 86–90, 1921.)

"Maori Anthropometry," by Dr. P. H. Buck.

ABSTRACT.

In his paper Dr. Buck pointed out that anthropometry, which dealt with the measurements of the human body so as to establish the standard type of genus of a race, had been neglected as regards the Maori branch of the Polynesians. It was absolutely necessary to set up the Maori type in order to study his relationship to the other branches of the Polynesians, and to determine what Melanesian characteristics existed amongst them. The Americans had four scientific expeditions working in Polynesia, and, since New Zealand administered Samoa, the Cook Group, and Niue Island, we should not lag behind in the scientific study of those Polynesian branches under our control. Attention was drawn to the unsatisfactory condition that existed with regard to standard Polynesian and Melanesian types owing to insufficient measurements of a large enough number of living persons. Our primary duty was to remove this charge of scientific neglect as regards ourselves by first establishing the Maori type or types. He detailed some of the measurements made of over eight hundred members of the Maori Battalion that served in the late war. For full-blooded Maoris he established racial standards of 5 ft. 7¼ in. in height and 11 stone 9 lb. in weight, which were 1¼ in. and 22 lb. greater than those so far accepted on too few observations. Head, face, and nose measurements were detailed, and attention drawn to the tribal differences that existed. An interesting feature was the modification of face and nose width which occurred amongst those of mixed blood, the narrowing in these two measurements being shown to increase with the greater admixture of white blood. The whole subject opened up a new field of great scientific interest, and further investigation would probably throw additional light on tribal and racial origin, and have an important bearing on the culture differences that existed in various parts of New Zealand.

"Some Investigations into the Variations in the New Zealand Price-level: the Political, Social, and Industrial Effects following therefrom," by Dr. J. W. McIlraith.

"The Horizontal Pendulum," by Dr. C. E. Adams.

"History of the Offer of the Yale Telescopes to New Zealand," by Dr. C. E. Adams.

"The Earthquake of 20th September, 1920," by Dr. C. E. Adams.

"A National Observatory for New Zealand," by Dr. C. E. Adams. (This paper appears in the *N.Z. Journal of Science and Technology*, vol. 4, pp. 91–94, 1921.)

Resolutions of the Science Congress.

1. That this Congress, recognizing *Bacillus amylovorus* as being in the forefront of destructive plant-diseases, views with alarm its introduction into New Zealand, and urges upon the Government the necessity of adopting the most effective means towards its early eradication, and is further of the opinion that it will be little short of criminal not only to the fruit-grower and general public of the present day, but to future generations, should any consideration of expediency whatever be allowed to interfere with the vigorous prosecution of such a policy.

2. This Congress is of opinion that an absolutely complete census of all hawthorn hedges or single plants and all other hosts of fire-blight should be carried out in conjunction with the forthcoming general census.

3. That the time has arrived when the Marine Department ought to establish systematic observations of the sea temperatures on the coasts of New Zealand. In Europe and the United States, where such observations have been regularly made for thirty years or more, important economic

results have been obtained, it being found possible from temperature-observations to predict the arrival at certain points of migratory food fishes, such as herring, some time beforehand.

4. That this Congress congratulates the Government on the beginning made to equip the Hector Observatory with improved seismological equipment, as urged at the last Congress, and that, owing to the importance of seismology to New Zealand, the Congress desires to urge the Government to add to the equipment of the Hector Observatory by providing another Milne-Shaw seismograph, so that both horizontal components may be determined, and that a vertical-component seismograph also be provided.

5. That a sub-committee consisting of Dr. Thomson, Mr. P. G. Morgan, and Mr. Donovan (Dr. Thomson as convener) be set up and requested to collect available information with respect to the New Zealand occurrence of minerals containing suspected isotopes of certain elements, and that this be handed to Professor Robertson for publication in some suitable journal.

6. That this Congress urges upon the Government and people of New Zealand the great importance of accepting the generous offer to New Zealand of astronomical equipment and staff made by the Yale University Corporation, New Haven, Connecticut, U.S.A.

7. That this Congress urges upon the Government the importance of taking steps to participate in the determination of the longitude of the Hector Observatory by radio-telegraphy from the Greenwich and Paris Observatories, as recommended by the Bureau des Longitudes, Paris.

WELLINGTON PHILOSOPHICAL SOCIETY.

Since the 30th September, 1919, eight meetings of the society have been held, when papers were read as follow :—

22nd October, 1919 (annual meeting) : Hon. G. M. Thomson, " Powdered Coal."

3rd December : Dr. R. J. Tillyard, " Neuropteroid Insects."

28th April, 1920 : Professor D. M. Y. Sommerville, " Map Projections."

26th May : Dr. T. A. Jaggar, " The Study of Volcanoes."

23rd June : H. Rands, " Research in a Chemical Munition Factory, with Special Reference to the Ammonia-oxidation Process."

28th July : T. E. Perks and W. Donovan, " Some Notes on the Corrosion of Muntz Metal " ; Dr. C. E. Adams, " New Zealand Observatories and American Co-operation."

28th August : J. H. Edmundson, " Liquid Air."

22nd September : E. K. Lomas, " The Geographical Foundations of the Peace Treaty Boundaries."

In addition the following papers were taken as read :—

22nd October, 1919 : Dr. L. Cockayne, " Notes on New Zealand Floristic Botany, No. 4 " ; Miss M. K. Mestayer, " Notes on New Zealand Mollusca—No. 1, Three New Species of Polyplacophora, and other New Species " ; G. C. Burton and W. Donovan, " Distillation Experiments with Waikaia Shale " ; E. Bond, " A Note on Candle-nuts from Rarotonga " ; W. Donovan, " A Note on Sting-ray-liver Oil " ; Dr. J. A. Thomson, " The Notocene Geology of the Middle Waipara and Weka Pass District," " The Cretaceous Brachiopods of New Zealand," " Some Fossil Species of the Genus *Neothyris* (Brachipoda)."

3rd December : G. V. Hudson, " Illustrated Life-histories of New Zealand Insects—No. 1, *Gnophomyia rufa, Limnophila sinistra, Melanostoma decessum.*"

22nd .September, 1920 : E. Meyrick, " Notes and Descriptions of New Zealand Lepidoptera."

27th October, 1920 : Miss M. K. Mestayer, " Notes on New Zealand Mollusca—No. 2, *Callochiton empleurus* (Hutton) " ; P. G. Morgan, " Notes on the Geology of the Patea District " ; G. H. Cunningham, " New Zealand *Cordyceps*," " The Rusts of New Zealand " ; D. Miller, " Material for a Monograph on the Diptera Fauna of New Zealand—Part II, Syrphidae ; Part III, Empididae " ; J. G. Myers, " Supplement to Cicadidae of New Zealand," " Bionomic Notes on some New Zealand Spiders," " Life-history of some New Zealand Insects," " Notes on the Hemiptera of the Kermadec Islands."

17th November, 1920 : W. R. B. Oliver, " Notes on Specimens of New Zealand Ferns and Flowering-plants in London Herbaria," " The Crab-eating Seal in New Zealand."

The average attendance at ordinary meetings has been thirty-eight.

Council Meetings.—Nine meetings of the Council have been held, and, in addition to the general management of the society, the following subjects have been considered:—

Research Grants: Consideration and favourable recommendation were given to an application from Professor Marsden for a grant of £125 for radium to be used in a research on the disintegration effect of the impact of *a* particles on matter, and for another for £60 towards the expenses of a research into the relative efficiency of coal, gas, and electricity for domestic purposes in Wellington.

An application from Sir David Hutchins for a grant of £50 for research into the growth of native trees was also approved, and granted by the Government.

Dr. C. E. Adams made application for a grant of £250 for the purchase of a Henrici Harmonic Analyser for various researches. The Council has referred the matter to a sub-committee for report.

Hobart Meeting of the Australasian Association for the Advancement of Science.—Professor H. B. Kirk and Dr. C. A. Cotton were appointed as the society's delegates to the Australasian Association for the Advancement of Science meeting in Hobart in January, 1921.

Pan-Pacific Science Conference at Honolulu in August, 1920.—Dr. J. Allan Thomson was appointed as delegate to the Pan-Pacific Science Conference at Honolulu in August, 1920.

Museum, Library, and Research Committee.—A committee was set up to urge on the Government (1) the need for a new and fireproof building for the Dominion Museum, (2) for the establishment of a scientific and technological library, and (3) for the establishment of a Board of Science and Industry.

Hamilton Memorial Prize.—Rules have been drafted and forwarded to the Institute for controlling the award of the Hamilton Prize, which, when approved, will be gazetted.

Natural History and Field Club Section.—On the 3rd December, 1919, a new section, the Natural History and Field Club Section, was formed, and in connection therewith the society agreed to the introduction of associate members, at a subscription of 5s., who may belong to any one section, but shall not receive the annual volume of the *Transactions.* During the year twenty-six persons were elected associates, and meetings and field excursions have been held on several occasions.

Fellows of the New Zealand Institute.—Since the last annual report was compiled the election of original Fellows of the New Zealand Institute has been announced, and the following five members of the society have received Fellowships: B. C. Aston, G. Hogben, G. V. Hudson, H. B. Kirk, and J. Allan Thomson.

Yale Observatory Committee.—On the 28th July a committee was set up to further the project of the Yale University to establish an astronomical observatory in New Zealand. A strong committee was formed, and met on the 5th August. It is now communicating with the Director of the Yale Observatory.

Membership.—During the year the membership has slightly increased, there being now 206 on the roll. Forty-one new members were elected, nine resigned, and four were removed from the roll, as their letters were returned. Six ordinary members and one life member died, and one member was elected a life member. The associates number twenty-nine.

Library.—The periodicals have been received regularly by the Librarian. Some back numbers have been written for to complete the files.

The sum of £62 7s. 10d. was allocated to the library, which, added to last year's balance, makes a total of £174 9s. 7d. Of this sum £48 18s. was spent, leaving a balance of £125 11s. 7d. to be expended.

Committee and Officers for 1921.—President—C. E. Adams, D.Sc., F.R.A.S. *Vice-Presidents*—P. G. Morgan, M.A., F.G.S.; J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst. *Council*—C. G. G. Berry; Elsdon Best, F.N.Z.Inst.; L. Birks, B.Sc., M.I.E.E.; C. A. Cotton, D.Sc., F.G.S., F.N.Z.Inst.; H. T. Ferrar, M.A., F.G.S.; A. C. Gifford, M.A., F.R.A.S.; R. W. Holmes, I.S.O., M.Inst.C.E.; Captain Hooper, F.R.A.S.; G. V. Hudson, F.E.S., F.N.Z.Inst.; H. B. Kirk, M.A., F.N.Z.Inst.; J. S. Maclaurin, D.Sc., F.C.S.; E. Marsden, D.Sc., F.R.A.S., M.C.; P. W. Robertson, M.A., M.Sc., D.Ph. *Secretary and Treasurer*—H. Hamilton, A.O.S.M. *Auditor*—E. R. Dymock, F.I.A.N.Z. *Representatives to the New Zealand Institute*—T. H. Easterfield, M.A., Ph.D., F.N.Z.Inst.; H. B. Kirk, M.A., F.N.Z.Inst.

ASTRONOMICAL SECTION.

Three meetings of the committee and five of the section have been held, at the latter of which an average attendance of twenty was maintained.

The society having introduced a rule admitting associates to any one section at a small subscription, advantage has been taken of this, and two associates have joined. This form of membership when it becomes more widely known may tend towards an increase of interest in astronomy.

The bad weather conditions prevailing during the session, and the lack of leisure, were factors in reducing the work done at the Observatory. Predictions were calculated and observations made of a few occultations of stars by planets and by the moon. In one case valuable observations were made at Lick of an occultation by Jupiter of an eighth-magnitude star as the result of data supplied by Dr. Adams and Mr. Westland.

Papers were read as follow:—

1st October, 1919: Professor E. Marsden, "Some Recent Work on the Constitution of Matter."

3rd June, 1920: A. C. Gifford, "The Initial Radiation of a Nova," "The High Velocities of the Planetary Nebulae"; Dr. C. E. Adams and Professor E. Marsden, "The Samoan Observatory."

7th July: Mr. C. J. Westland, "The Prediction of Eclipses"; Dr. C. E. Adams, "Notes on Time Observations."

4th August: Professor E. Marsden and Professor D. M. Y. Sommerville, "A Symposium on Relativity."

1st September: "An Evening at the Observatories."

Observatory and Instrument.—The building is in fair repair, but requires painting, and the dome dressing. The instrument is in good order; electric lights have been fitted to the circles and the cross-wires. The lighting has been rearranged, and a sounder, beating seconds from the clock, has been added. A micrometer eye-piece has been obtained, but so far no systematic work has been done with it.

The Observatory has been open during the year on the second and fourth Tuesdays in each month, and a good attendance has been the rule. The public are learning to take advantage of the combined tramway and Observatory tickets. A special evening was arranged for the Brooklyn School, when twenty scholars and a teacher were shown some of the wonders of the sky. An invitation was sent to the Workers' Educational

Association to visit the Observatory, but advantage of it was not taken. The work of keeping the telescope in order and opening the Observatory to the public has devolved mainly on Dr. Adams, Mr. C. J. Westland, and the Honorary Secretary, and it is hoped that other members of the section will come forward and help in this direction.

Committee.—The following subjects have come before the committee: Astronomical Union at Brussels; determination of longitude 129° E.; eclipse of the sun, September, 1922; the Yale offer of telescopes, &c.

The section wrote urging the Government to send an expedition to Australia to observe the eclipse of September, 1922, the only total eclipse observable from any point as near as Australia for many years to come. In connection therewith valuable information was obtained from the Commonwealth Meteorologist, Melbourne, concerning the climatic conditions and the best site for an observing-station.

The section notes with pleasure that a Bill is before Parliament defining New Zealand mean time as twelve hours ahead of Greenwich mean time.

Proctor Library Fund.—A proposal to use part of the interest on the Proctor Library Fund for purchasing books for the Observatory library is in abeyance, pending a reply from Miss Proctor.

Officers.—The following officers for the year were elected at the annual meeting on the 1st October, 1919: *Honorary Member*—Miss Mary Proctor. *Chairman*—Dr. C. E. Adams, D.Sc., F.R.A.S. *Vice-Chairmen*—Mr. A. C. Gifford, M.A., F.R.A.S.; Professor D. M. Y. Sommerville, M.A., D.Sc. *Committee*—Professor E. Marsden, D.Sc., F.R.A.S., M.C.; Mr. C. P. Powles; Mr. C. J. Westland, F.R.A.S.; Mr. R. D. Thompson, M.A.; Mr. J. Darling; Mr. D. J. Kerr; Captain G. S. Hooper. *Director and Curator of Instruments*—Dr. C. Monro Hector, M.D., B.Sc., F.R.A.S. *Hon. Treasurer*—Dr. C. E. Adams, D.Sc., F.R.A.S. *Hon. Secretary*—C. G. G. Berry.

TECHNOLOGICAL SECTION.

Six meetings have been held, the August meeting having to be deferred until September owing to the restriction in the tram service and electric lighting. The meetings have been well attended.

The thanks of the society are due to the various contributors of papers, and in particular to Mr. L. M. Sandston, who came from Christchurch to read his paper on "Highway Engineering." The following papers have been read:—

12th May, 1920: W. S. La Trobe, inaugural address, "Technological Education."

16th June: G. B. Bradshaw, "The Cement-gun."

21st July: L. M. Sandston, "Highway Engineering."

9th September: Professor E. Marsden, "A Simple Method for the Determination of Peak Voltages"; "The Interference of Transmission-lines with Telephone-lines."

15th September: W. S. La Trobe, "Notes on the General Theory of Mechanism."

20th October: R. Roberts, "Ring Problems peculiar to Electrical Machinery."

Owing to his leaving Wellington during the year, it was unfortunately necessary for Mr. Owen to resign from the position of Secretary, and Mr. G. B. Bradshaw has been appointed in his place for the remainder of the year.

Committee and Officers for 1921.—*Chairman*—L. Birks, B.Sc., M.I.E.E. *Vice-Chairmen*—J. S. Maclaurin, D.Sc., F.C.S.; W. S. La Trobe, M.A. *Committee*—R. W. Holmes, I.S.O., M.Inst.C.E.; F. W. Furkert, Assoc.M.Inst.C.E., A.M.I.M.E.; H. Sladden, member of Board of Surveyors; E. Marsden, D.Sc.; J. E. L. Cull, B.Sc. *Hon. Secretary*—G. B. Bradshaw.

GEOLOGICAL SECTION.

Six ordinary meetings have been held. A number of exhibits have been brought by members to the meetings, and these have aroused considerable interest and given matter for discussion.

Eleven papers have been read and discussed. The titles and authors of these are as follow:—

20th August, 1919: Dr. J. Allan Thomson and Miss Mestayer, "A Study of a New Zealand Limpet"; E. K. Lomas, "Some Geological Observations in the Hatuma District, Hawke's Bay."

10th September: Dr. J. Henderson, "The Geology of the South-western King-country."

8th October: W. Donovan, "The Natural-gas Resources of New Zealand"; G. L. Adkin, "Examples of Readjustment of Drainage in the Tararua Western Foothills"; G. H. Uttley, "Tertiary Geology of the Wharekuri–Kurow Area," and "Notes on *Geological Survey Bulletin No. 20*."

12th May, 1920: G. H. Uttley, "Notes on the Geology of the Oamaru District."

5th June: P. G. Morgan, "Fossils of the Mount Radiant Subdivision, Karamea," and "Notes on the Stratigraphy and Palaeontology of the Greymouth and Westport Districts."

14th July: J. Henderson, "The Geology of the Raglan District."

Committee and Officers for 1921.—Chairman—H. T. Ferrar. *Vice-Chairman*—G. H. Uttley, M.A., M.Sc., F.G.S. *Committee*—Dr. J. Henderson, M.A., D.Sc., B.Sc. in Eng. (Metall.); R. W. Holmes, I.S.O., M.Inst.C.E.; E. K. Lomas, M.A., M.Sc.; P. G. Morgan, M.A., F.G.S.; Dr. J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst. *Hon. Secretary*—Dr. C. A. Cotton, D.Sc., F.G.S.

HISTORICAL SECTION.

The annual and five general meetings have been held, when papers were read as follow:—

18th May, 1920: Elsdon Best, "The Maori Genius for Personification."

15th June: Miss Hetherington, "The Discovery and Opening-up of the Goldfields in the Hauraki Peninsula."

20th July: Johannes C. Andersen, "Further Maori String Games."

17th August: F. P. Wilson, "Early Days in Wellington."

21st September (annual meeting): Elsdon Best, "Old Redoubts, Blockhouses, and Stockades of the Wellington District."

19th October: H. Baillie, "New Zealand and Naval Protection"; P. Beckett, "Some Notes on Shell-middens at Paraparaumu Beach."

About the middle of the season the section lost the services of Mr. E. N. Hogben, owing to his removal to Palmerston North. His resignation from the committee was accepted with regret, as he was a good and enthusiastic worker.

Officers for 1921.—Chairman—Elsdon Best, F.N.Z.Inst. *Vice-Chairman*—Colonel T. W. Porter, C.B. *Committee*—Miss Hetherington, M.A.; Dr. C. Prendergast Knight; Messrs. H. Baillie, F. P. Wilson, M.A., J. Cowan, E. G. Pilcher. *Hon. Secretary*—Johannes C. Andersen.

NATURAL HISTORY AND FIELD CLUB SECTION.

Since the formation of this branch on the 3rd December, 1919, a series of field excursions and indoor meetings have been held, and the attendances have been very satisfactory. Twenty-six associate members have joined the Philosophical Society through the medium of this section. Seven field excursions were successfully held, and four indoor meetings followed in the winter months. Botany, geology, entomology, and marine zoology formed the chief subjects for discussion.

The following papers and addresses were given at the indoor meetings:—

1st June, 1920: J. G. Myers, "New Zealand Cicadas."

6th July: D. Miller, "Mosquito Investigations in North Auckland"; Professor T. H. Johnston, "Some of Australia's Insect Pests."

3rd August: G. H. Cunningham, "Fungi."

7th September: D. Miller, "Hover-flies and their Economic Importance"; W. J. Phillipps, "Notes on the Edible Fishes of New Zealand"; G. E. Mason (communicated by H. Hamilton), "Observations on Parasites found on the Huia Bird and not previously recorded."

Officers for 1920–21.—Chairman—G. V. Hudson, F.N.Z.Inst., F.E.S. *Vice-Chairmen*—Professor H. B. Kirk, M.A., F.N.Z.Inst.; Dr. J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst. *Committee*—T. Ralph; E. K. Lomas, M.A., M.Sc., F.R.G.S.; C. A. Cotton, D.Sc., F.G.S.; H. Baillie; D. Miller. *Hon. Secretary*—H. Hamilton, A.O.S.M.

AUCKLAND INSTITUTE.

At the annual meeting (28th February, 1921) the annual report and balance-sheet were read and adopted.

Abstract.

At the expiry of another year it is the duty of the Council to submit to the members and the general public their fifty-third annual report on the condition of the society and the progress it has made during the year.

Members.—The number of new members added during the year has been twenty-four. Against this, twenty-nine names have been removed—nine by death, fourteen by resignation or removal from the provincial district, and six for non-payment of subscription for mor than two consecutive years. The net loss has thus been five, the number of members at the present time being 450.

Several of the members removed by death have been long in association with the Institute, and have rendered important services to it. Mr. John Reid served on the Council from 1895 to 1915, and was appointed a trustee in 1906, a post which he occupied until his death. Mr. E. K. Mulgan has contributed lectures and papers of importance, while his position as an educationist of the first rank renders his loss a severe one. The decease of the Hon. J. A. Tole should also be referred to, for, although he took no active part in the affairs of the Institute, his work in connection with education generally placed him in sympathetic accord with it.

Finance.—The total revenue of the Working Account, after deducting the balance in hand at the beginning of the year, has been £1,867 5s. 7d., being a decrease of £8 19s. 8d. on the amount of the previous year. Examining the various items, it will be noted that the members' subscriptions show an increase from £407 8s. to £429 9s. The receipts from the Museum Endowment have amounted to £764 12s. 10d., or almost exactly the same sum as that credited last year. The invested funds of the Costley Bequest have yielded £466 10s., also showing a slight increase on the amount realized during the previous year. The total expenditure has been £1,753 9s., and the cash balance in hand is £373 13s. 4d.

The invested funds of the society, which now amount to the sum of £23,211 8s. 9d., have had the careful attention of the trustees during the year.

Meetings.—Nine meetings have been held during the year, at which various lectures were delivered, and an opportunity offered for discussion. Certain papers were also forwarded for publication in the *Transactions of the New Zealand Institute.* The following is a complete list of both papers and lectures: C. M. Carter, "Ceylon, its People and its Archaeology"; Dr. A. B. Fitt, "Some Applications of Modern Psychology"; Professor J. C. Johnson, "Coral Islands, Part I—The Reef, its Structure and Origin," and "Coral Islands, Part II—The Island, with Particular Reference to Polynesia"; E. V. Miller, "The Theory of Relativity"; Professor F. P. Worley, "Atoms and the Transmutation of the Elements"; Professor R. M. Algie, "The Scenic Attractions of the Tongariro National Park"; Dr. P. H. Buck (Te Rangi Hiroa), "Maori Warfare"; T. F. Cheeseman, "New Species of Plants"; D. Petrie, "Descriptions of New Native Plants"; J. A. Bartrum, "Notes on the Geology of the Great Barrier Island"; M. J. Gilbert, "Notes on the Geology of the Waikato Heads District"; L. T. Griffin, "Descriptions of Four Fishes new to New Zealand"; Dr. P. H. Buck, "The Maori Food-supplies of Lake Rotorua," and "Maori Decorative Art."

Those of the above papers which were intended for publication in the *Transactions of the New Zealand Institute* have been forwarded to the Editor, and will probably appear in volume 53, now in the press. Volume 52, containing the papers read before the various branches of the Institute during the year 1919, has been issued during the year, and distributed among the members.

Library.—About £150 has been expended over the library during the year; but some expenditure incurred for the purchase of books and for bookbinding has still to be met. Two consignments of books, numbering over one hundred volumes, have been received during the year. Six weeks ago another order was despatched, which should arrive during the autumn. The magazine and other serial publications subscribed to by the Institute have been regularly received, and have been made available for the use of readers. Various books and memoirs have been received in exchange, and several donations have been made by private individuals. Under this heading special mention should be made of a set of fifty bound volumes of the periodical

Engineering, presented by the trustees of the late H. Metcalfe, C.E. The gift is of considerable importance from a technological point of view, and will form a welcome addition to the library.

The scarcity of shelf-room in the library has long been a source of anxiety to the Council. An attempt has been made to mitigate the evil by erecting a temporary range of shelving in the assistant's room, to which the geographical portion of the library has been transferred. This has slightly improved matters, but the position will soon be as acute as before. At the present time there can be no proper classification of the books on the shelving, making it more difficult for readers to consult the library, and causing much increased work to the custodians.

Museum.—With the exception of a very short period necessarily reserved for cleaning and rearrangement, the Museum has been open to the public during the whole of the year. The attendance has been most satisfactory, as proved by the following statistics. Taking the Sunday attendance first, the register kept by the janitor shows that 27,102 people entered the building on that day, being an average of 521 for each Sunday. The greatest attendance was 887, on the 4th April; the smallest 88, on the 26th September. The total number of visitors on the ten chief holidays of the year was 8,478, or an average of 847 for each holiday. The greatest attendance on any one holiday was 4,320, on the 23rd April, the date of the arrival of the Prince of Wales. But this extraordinary attendance was purely caused by the massing of huge crowds at the foot of Princes Street in order to see the Prince's vessel arrive and pass up the harbour to her berth. The next largest attendance was on King's Birthday, amounting to 975; but the number of visitors on Easter Monday and Labour Day almost equalled that. As explained in last year's report, it is impossible to give the actual attendance on ordinary week-days, but it is believed to be about 250, which would give a total of 75,000. Adding this number to that counted for Sundays and holidays, the grand total becomes 112,500. Last year the number was estimated at 107,787.

In the report for the previous year the Council stated that in the present congested state of the Museum it is practically impossible to make any changes of importance therein, or to exhibit more than a small proportion of the many additions that are being regularly received. The correctness of this statement will become more obvious with each succeeding year. All that can be done at present is to keep the collections in good order and condition, and to see that they are properly labelled and arranged for public exhibition. In short, until a new building is provided little work can be done in the Museum itself beyond those minor alterations and improvements that can still be carried out. During the year it has been proved that excellent work can be done, and important results obtained, by a series of short collecting trips into various parts of the country. It is suggested that this plan should be extended during the coming year.

The additions and donations received or announced during the year have been exceptionally numerous and valuable, but only the more important can be mentioned here. Among them, the chief place must be given to Mr. J. B. Turner's superb collection of Fijian and Polynesian ethnological specimens. For nearly fifty years Mr. Turner has been engaged in building up this collection, which is recognized as being the finest and most complete in Fiji. It contains sets of nearly all the articles necessary to fully illustrate the manners and customs of the ancient Fijian, and when placed in association with the Maori collection in the Auckland Museum and the numerous Polynesian articles already there will render the Museum pre-eminent as a centre for the study of Polynesian culture. Mr. Turner is a native of Auckland, and his magnanimous gift will ensure him a high place among the benefactors of the city.

During a collecting tour made by Mr. Griffin through the Hauraki Plains and other districts, donations of Maori articles were received from many settlers. Mr. L. Carter presented three large ancient stone-worked carvings, a bundle of seventeen long rods presumably used in house-building, two fine wooden wedges, together with a number of other objects. Interesting Maori articles were also presented by Messrs, Miln, Benny, and Bond, R. Muir, J. A. Lennard, J. Kidd, T. Dunbar, Mrs. Shelley, and others. Articles of note from other districts have been received from G. Graham, Colonel Boscawen, S. A. Browne, D. Munro, R. Wild, F. Wood, and numerous others.

Attention should also be directed to an interesting collection of ethnological articles from Assyria, comprising seventeen inscribed clay tablets, a Roman lamp, four scarabs, thirty ancient coins, the whole presented by Mr. Graham Findlay. Finally, it is well to mention a collection of ethnological specimens from Australia received in exchange from the Australian Museum, Sydney.

The War Memorial Museum and the Appeal for Funds.—At the last annual meeting, held on the 23rd February, 1920, full particulars were given of the progress of the scheme up to the time of the meeting. Briefly stated, it had been decided that the War Memorial for the City of Auckland should consist of a suitable building to be erected on Observatory Hill, in the Auckland Domain. It was further decided that the building should form a combined museum and war collection; and that it should be planned on an impressive and dignified scale, so as to keep permanently alive the purpose and aim of its existence as a memorial of the Great War.

The first step was clearly to obtain information as to the minimum cost of a building large enough to accommodate the war collections and associated "Hall of Memory," together with the collections of the present Auckland Museum. Without such particulars it was obviously impossible to frame an appeal for funds of a sufficiently definite nature to place before the citizens of Auckland. A committee of the Council was therefore appointed to investigate the matter, and sufficient evidence of a reliable nature was obtained to enable the committee to form an adequate idea of museum requirements.

After consideration it was decided that the next step should be to ascertain what assistance could be obtained from the State. The Mayor, as President of the Institute, appealed to the Prime Minister on the subject. After the facts of the case had been fully and clearly represented, a reply was received to the effect that a grant of £25,000 would be made if a similar sum was obtained by public subscription.

It was then determined to apply to the major financial institutions of the city, the name of the Auckland Savings-bank heading the list. The request was generously and willingly received by the bank, which unanimously agreed to give a donation of £25,000—probably the largest single donation ever made in Auckland. Then came a reply from the Auckland Racing Club, which at first voted a donation of £2,000, which was afterwards generously increased to £5,065, that sum representing the net profits derived from the race meeting given in honour of the visit of the Prince of Wales to Auckland.

At this stage it was felt that the time had arrived for setting up an organization to promote the furtherance of the appeal for funds, and to enlarge the number of workers in the cause. A public meeting was therefore held in the Town Hall on the 22nd October, the Mayor in the chair. It was then resolved to appoint a Citizens Committee to promote and organize a public appeal throughout the Auckland District for the balance of the funds required to erect in the Auckland Domain a War Memorial Museum, which was declared to be the most appropriate form for Auckland's War Memorial to take; and, further, the meeting resolved that all questions arising therefrom be referred to such Citizens Committee, with power to act. At a subsequent meeting of the committee, Mr. J. H. Gunson (President of the Auckland Institute and Museum) was appointed chairman of the committee, Mr. V. J. Larner treasurer, and Mr. W. Elliot secretary. It was further resolved that these three gentlemen should be the trustees of the Building Fund. On further consideration, it was decided to fix £200,000 as the objective of the fund, the general opinion being that such a sum will be required to erect a memorial worthy of the city and its inhabitants.

Almost immediately after the appointment of the committee the City Council, acting with a high sense of civic responsibility, decided to vote £10,000 to the fund. This was followed by a donation of £5,000 from the Auckland Harbour Board, while the two chief insurance companies—the New Zealand and the South British—have each given the sum of £2,000.

Since than many public institutions and private individuals have made large contributions. So far, the Citizens Committee have published no authoritative list of donations, but it is understood that such will be shortly issued. In the meantime, it is no breach of confidence to say that the total of the contributions made, a considerable proportion of which has been actually received, is sufficiently large to ensure the final success of the movement.

It is not without justifiable pride that this sketch of the attempt to provide funds for the Auckland War Memorial has been written. The beginning has been so unexpectedly full and generous that it cannot be doubted that the objects of the promoters will be fully attained. And, if so, the citizens of Auckland will leave behind them a proof of far-seeing generosity that it will be difficult to match in cities of much larger size.

Election of Officers for 1920–21.—President—J. H. Gunson, Mayor of Auckland. *Vice-Presidents*—Hon. E. Mitchelson, M.L.C.; Hon. C. J. Parr, C.M.G., M.P. *Council*—J. Kenderdine; T. W. Leys, Ph.D.; A. J. Lunn; E. V. Miller; H. H. Ostler; T. Peacock; D. Petrie, M.A.; Professor H. W. Segar, M.A.; Professor A. P W. Thomas, M.A, F.L.S.; H. E. Vaile; Professor F. P. Worley, D.Sc. *Trustees*—T. Peacock; Professor A. P. W. Thomas; J. H. Upton; H. E. Vaile. *Secretary and Curator*—T. F. Cheeseman, F L.S., F.Z.S., F.N.Z.Inst. *Assistant and Preparator of Specimens*—L. T. Griffin, F.Z.S. *Auditor*—S. Gray, F.R.A.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

At the annual meeting (1st December, 1920) the annual report and balance-sheet were adopted.

ABSTRACT.

Council.—Eleven meetings of the Council have been held during the year. The personnel remains the same as at last election.

Membership.—During the year twenty-one new members were elected and seventeen names were removed from the roll, which now stands at 234, as against 230 at the beginning of the session.

Obituary.—It is with regret that the Council records the death of six of our members during the year—namely, J. B. Struthers, P. Schneider, A. Kaye, G. E. Blanch, E. Herring, and Miss Hall; and the sympathy of the Institute is extended to the relatives. The Council further desires to record its sense of the loss sustained by the New Zealand Institute in the death of Mr. George Hogben, the well-known Dominion seismologist. Mr. Hogben was President of the Philosophical Institute of Canterbury in 1887.

Meetings of the Institute.—During the year eight ordinary and two additional ordinary meetings were held at Canterbury College, and in addition meetings were held at Kaiapoi and Methven. Towards the end of January Dr. R. J. Tillyard, Macleay Research Fellow of Sydney (since appointed entomologist to the Cawthron Institute), gave an illustrated lecture on "Dragon-flies." In April a social evening was held, at which, through the kind permission of the Board of Governors of Canterbury College, the Physics, Chemistry, and Biological Laboratories were thrown open to members and their friends. To the professors in charge, who had kindly arranged demonstrations and exhibits, the best thanks of the Institute are due.

At the May meeting Mr. L. P. Symes delivered his presidential address on the subject, "Fats, Edible and Otherwise." Other lectures delivered were: Dr. T. A. Jaggar, of the Volcano Observatory at Hawaii, "The Study of Active Volcanoes"; Dr. C. C. Farr, "Relativity and the Einstein Hypothesis"; Professor E. Marsden, "Gun-location on the Western Front"; Dr. C. Chilton, "The First Pan-Pacific Science Conference."

Fifteen technical papers were also read during the session, comprising six botanical, four zoological, three geological, and two chemical.

The attendances throughout the year have been most gratifying.

Following the practice instituted last year, the Council arranged a number of meetings at places out of Christchurch, and this year they were held at Methven and Kaiapoi, where the following addresses were given: At Methven—G. Archey, "Mosquitoes and Man"; L. J. Wild, "Science in the Development of Agriculture." At Kaiapoi—L. P. Symes, "Edible Fats"; Dr. F. W. Hilgendorf, "The Waimakariri Artesian System." The attendances at these lectures was most encouraging, and the appreciative interest taken in the matters dealt with fully warrants the continuance and development of the policy of holding meetings outside Christchurch.

Government Research Grants.—On the recommendation of this Institute a grant of £200 was made to Dr. W. P. Evans for "Research on the New Zealand Brown Coals," and one of £50 to Mr. George Gray for research on the "Composition of Canterbury Waters." Other research grants, covering operations that are still proceeding, which the Institute has been instrumental in obtaining, are: L. J. Wild, "Soil Survey"; R. Speight, "Geological Survey of the Malvern Hills"; Dr. C. C. Farr, "Porosity of Porcelain"; G. Brittan, "Fruit-tree Diseases"; W. Morrison, "Afforestation on the Spenser Ranges"; Dr. C. Chilton, "Investigations on the New Zealand Flax (Phormium)."

Library.—The extended accommodation indicated in last year's report is not yet available, but it is hoped that as soon as building conditions become more favourable the contemplated extensions to the Public Library will be completed. The need for more space has become so acute that arrangements have been made to remove some of the older and less-used books from the shelves and store them in cases, in order to make room for the later journals and periodicals as they are bound. Beyond these journals, very few books have this year been added, owing partly to the lack of room and partly to the high cost. Altogether, thirty-one volumes have been bound, and twenty-nine more await binding. It is hoped shortly to form a Pacific Section of the library, on the lines of the Antarctic Section already existing. Several of the publications are already available, and steps are being taken for opening up exchanges with other scientific institutions whose researches bear on the Pacific. The following donations of books and periodicals have been received by the honorary librarian: Dr. Chilton—Shackleton's *South* and Davis's *Voyage of the "Aurora"*; Mr. English—*Journal of the Chemical Society*; Mr. L. P. Symes—*Journal of the American Chemical Society.*

Riccarton Bush.—The Institute's representative on the board of trustees of Riccarton Bush reports that the bush has been open to the public as usual during the year, that improvements have been made as far as funds permitted, and that the bush is in a very satisfactory condition. As stated in last year's report, the funds are insufficient to effect any extensive improvements, and the Council commends this object to members as worthy of their hearty support.

Pan-Pacific Scientific Conference.—The Institute was represented at the Pan-Pacific Scientific Conference at Honolulu in August, 1920, by Dr. Charles Chilton, who reports that the Conference was successful even beyond the ardent expectations of its promoters. It was attended by over a hundred representatives from all the countries surrounding the Pacific, all of them, either from their own official position or from their researches, being specially qualified to deal with the scientific problems presented by the Pacific. The meetings were held in the Throne-room of the Capitol of Honolulu, the morning meetings being occupied with general questions of interest to all the members, and the afternoon meetings being devoted to the consideration of the more special matters by the different sections of Anthropology, Biology, Botany, Entomology, Geography, Geology, Seismology, and Volcanology.

Dr. Gregory, Professor of Geology at Yale University and Director of the Bishop Museum, was elected chairman of the Conference, and Dr. A. L. Dean, President of the University of Hawaii, vice-chairman and secretary. Dr. Chilton was elected leader of the Biology Section. Many matters dealing with the Pacific were discussed, and much information received concerning the marine laboratories and other institutions around the Pacific. The Samoan Geophysical Observatory, referred to later in this report, was mentioned, and the hope expressed that a Director would speedily be appointed to continue the important work already done.

The second week of the Conference was spent in a visit to the active volcano of Kilauea, the meetings of the section of Seismology and Volcanology being continued at the volcano. The third week was mainly devoted to drawing up statements of the principal problems in connection with the Pacific that require most urgent attention, and in endeavouring to arrange for the co-operation of the different Governments and institutions for the carrying-out of the work. It is hoped that the resolutions passed, together with the proceedings of the meetings, will be issued shortly, while a second part of the proceedings, containing papers read before the Conference, will be published at a later date. Many of the subjects, especially those referring to the volcanological research and matters connected with the Cook and Samoan Islands, are of peculiar interest to New Zealand, and it is hoped that members of the Institute will be able to assist in the work which has been outlined. The Institute is grateful for the hospitality so liberally extended by the residents of Honolulu to the delegates to the Conference.

Artesian Wells.—An Artesian Wells Committee has been set up to carry on and extend the work which was done by the committee of some years ago. It is proposed to review the earlier work and records, and to make further investigations, including systematic observations of water-level, a number of automatic recorders now being available for this purpose.

Samoan Geophysical Observatory.—Last year the Council reported having made representations to the Hon. Minister of Marine urging the continuation of the observations of the Samoan Geophysical Observatory. A committee set up by the New Zealand Institute conferred with the Government in reference to the future conduct of the Observatory, and has made recommendations by which it is hoped this important observatory will be put on an Imperial footing. It is hoped that a Director will soon be appointed. Mr. Westland has been appointed first scientific assistant, and will shortly take up his new duties.

Hutton Memorial Medal.—The Hutton Memorial Medal, which was awarded by the Board of Governors to Dr. Holloway, a member of this Institute, for researches in botany, was, in the unavoidable absence of the President of the New Zealand Institute, presented to Dr. Holloway by Dr. Chilton at the June meeting.

Butler's House.—In February a deputation of the Council waited on the Hon. W. Nosworthy in reference to the preservation of Butler's house and Sinclair's grave, situated on his property at Mesopotamia. Though he could not see his way to transfer these two sites to the Institute, Mr. Nosworthy sympathetically undertook to mark the site of Sinclair's grave and personally to guarantee the preservation of Butler's house. Mr. Nosworthy has since supplied the Institute with photographs of Butler's house, and these are now being framed and will be preserved in the Institute's rooms. To Mr. Nosworthy the Institute extends its sincere thanks for the interest he has taken in this matter.

Finance.—The balance-sheet shows the total receipts, including a balance from the previous year, to be £420 6s. 9d. £35 19s. 7d. has been expended on the library, the amount being smaller than usual, as the yearly account for scientific journals and periodicals has not been received, owing to abnormal conditions resulting from the war. The levy to the New Zealand Institute of £30 2s. 6d. has also been paid, leaving a credit balance on the ordinary account of £110 11s. 9d., and of £142 16s. 3d. in the Research Fund Account. The Life Members' Subscription Account now stands at £175 16s. 9d., deposited with the Permanent Investment and Loan Association of Canterbury.

Election of Officers for 1921.—President—A. M. Wright, A.I.C., F.C.S. *Vice-Presidents*—L. P. Symes; L. J. Wild, M.A., B.Sc., F.G.S. *Council*—Professor A. Wall, M.A.; C. Coleridge Farr, D.Sc., F.P.S.L., F.N.Z.Inst.; W. Martin, B.Sc.; F. W. Hilgendorf, M.A., D.Sc.; Dr. F. J. Borrie; C. E. Foweraker, M.A. *Representatives on the Board of Governors of the New Zealand Institute*—F. W. Hilgendorf, M.A., D.Sc.; A. M. Wright, A.I.C., F.C.S. *Representative on the Board of Trustees of the Riccarton Bush*—Charles Chilton, D.Sc., M.A., LL.D., F.N.Z.Inst., F.L.S. *Hon. Secretary*—G. E. Archey, M.A. *Hon. Treasurer*—Charles Chilton, D.Sc., M.A., LL.D., F.N.Z.Inst., F.L.S. *Hon. Librarian*—Miss E. M. Herriott. *Hon. Auditor*—J. O. Jameson.

OTAGO INSTITUTE.

At the annual meeting (7th December, 1920) the annual report and balance-sheet were adopted.

ABSTRACT.

Nine meetings of the Council were held during 1920. In addition to the usual routine work of managing the affairs of the Institute in general, the following items of special business were dealt with :—

Fellowship of the New Zealand Institute.—At the request of the New Zealand Institute the Council forwarded a list of eight nominations for the election of four Fellows.

Offer of Yale Telescopes.—Being informed that the Yale University has offered to lend to New Zealand some valuable instruments for charting the heavens, &c., the Council set up a sub-committee to co-operate with delegates from the Otago Expansion League and from the University Council. Ministerial sympathy in the project was aroused, and Dr. Adams, Government Astronomer, has completed a flying survey of the more distant parts. Several sites have been selected for more detailed investigation.

Dr. Tillyard's Visit.—Dr. Tillyard, of Sydney, was invited by the Council of the Institute to visit Otago for entomological research. He was similarly invited by the affiliated societies, and made remarkably successful studies in various parts of the Dominion. He gave two special lectures in Dunedin, under the auspices of the Institute, and reported to the Council at the end of his stay that all those special problems he had set himself to solve had been either solved or were in the process of solution.

Subsequently Dr. Tillyard accepted the position of Biologist to the Cawthron Institute, Nelson, and has recently represented the Dominion at the Entomological Congress in London.

Section for the Study of the Early History of Man.—At the instigation of Mr. H. D. Skinner, the Council agreed to establish a section for the study of the early history of man. A committee, including as co-opted members several prominent citizens and some members of the University staff, was set up to consider the best lines to follow. As a result a circular has been issued to members of the Institute and to others likely to join the section. It is hoped that the movement will be successful.

Appeal for a Larger Interest on the Part of the Public.—In order to popularize the work of the Institute the Council has decided that the ordinary meetings shall be open to the public. A circular has also been issued appealing for a larger membership.

Meetings.—Eight ordinary and three special meetings of the Institute were held. At these meetings the following papers were read, and have since been submitted for publication in the *Transactions* : Dr. R. V. Fulton, "Description of a Stone supposed to have been used by the Maoris for sharpening Weapons"; Professor J. Park, "The Geological History of Eastern Marlborough"; J. M. Fowler (communicated by Professor Park), "On an Ice-striated Rock-surface on the shore of Circle Cove, Lake Manapouri"; Professor W. N. Benson, "Palaeozoic and Mesozoic Seas and Lands in Australasia"; Mrs. D. E. Johnson (communicated by Dr. J. Malcolm), "Food Value of New Zealand Fishes, Part II."

The following addresses were given at the ordinary meetings during the session: Dr. R. V. Fulton, "Pakeha *v.* Maori" (presidential address); Professor J. Malcolm, "Some Experiments on Contraction of Muscle"; D. Tannock, "Climate in Relation to Human Welfare"; Professor W. B. Benham, "The History of the Tuatara"; Professor J. Macmillan Brown, "The Pacific Ocean and its Future"; Professor Dunlop, "Psychology and Industry"; P. Rouse, "The Development of Artificial Fertilizers"; Dr. Adams, Government Astronomer, "Some Observatories and their Work."

Special addresses were given on nights other than the ordinary times of meeting of the Institute. They were: "Dragon-flies and Fossil Insects," two lectures by Dr. Tillyard; and one, "Volcanoes and Volcanology," by Dr. T. A. Jaggar, Government Volcanologist at Honolulu. All these addresses proved very interesting, and were fairly well attended.

Librarian's Report.—The Institute has opened subscriptions to the following new journals and periodicals: *Geographical Journal*, *Journal of the Royal Anthropological Institution* (in continuation), *The Radio Review*, *Wireless*, and to a very interesting publication, *Discovery*, which appeals to the general reader, for it contains articles written by well-known authorities on a great variety of subjects, literary, archaeological historical, classical, as well as scientific subjects. Several new books have been purchased, and a number of volumes have been presented by Dr. Colquhoun to the Anthopological Section.

As reported last year, the University has added considerably to the library in the Museum, especially to the anthropological works. That institution has also received from the Carnegie Research Institute of Washington the series of monographs issued by them, which are housed in the library.

I am glad to be able to report that more use is being made of the library by members than in preceding years.

Membership.—During the year four of the members on last year's list have died and sixteen have resigned. Fourteen new members have joined, so that the list now stands at 152, as against 158 for last year.

Balance-sheet.—The year's transactions show a credit balance of £5 12s. 8d. The gross receipts totalled about £700, including subscriptions amounting to £145, and deposits at call, £462.

Election of Officers for 1921.—President—W. G. Howes, F.E.S. *Vice-Presidents*—Dr. R. V. Fulton and H. Brasch. *Hon. Secretary*—Professor W. N. Benson, B.A., D.Sc., F.G.S. *Hon. Treasurer*—J. C. Begg. *Hon. Auditor*—R. Gilkison. *Hon. Librarian*—Professor W. B. Benham, M.A., D.Sc., F.R.S., F.N.Z.Inst. *Council*—Hon. G. M. Thomson, F.N.Z.Inst., F.L.S., M.L.C.; Professor J. Park, F.G.S.; Professor R. Jack, D.Sc.; Professor W. B. Benham, M.A., D.Sc., F.R.S., F.N.Z.Inst.; H. Mandeno; H. D. Skinner, B.A.; and G. S. Thomson, B.Sc.

TECHNOLOGICAL BRANCH.

During the session the Technological Branch was wound up and its assets transferred to the main account of the Institute.

ASTRONOMICAL BRANCH.

The Astronomical Branch has held only one general meeting (on the 3rd August), at which the following contributions were given: Professor White, "Some Notes on Mars"; J. C. Begg, "A Visit to Lick Observatory"; Professor Jack, "The Offer of Telescopes by Yale University." On the last topic Professor Park, who presided, also read some notes, and a strong case was made out for Central Otago as an ideal site for an observatory.

It was decided to co-operate with the committee of the general Institute in endeavouring to secure the Yale instruments for Otago, and useful records of the night sky at several points in the province have since been obtained from interested local observers.

The branch has also carried on negotiations with a view of securing a commanding site on the Town Belt, and erecting thereon a small observatory to house the Beverly telescope and the transit instrument in its possession.

At the annual meeting, held on the 7th December, the following office-bearers were elected: *Chairman*—R. Gilkison. *Vice-Chairmen*—Professor Park, F.G.S.; Professor R. Jack, D.Sc.; and Professor D. R. White, M.A. *Committee*—Rev. D. Dutton, F.R.A.S.; Dr. P. D. Cameron; H. Brasch; C. Frye; J. W. Milnes; Rev. A. M. Dalrymple, M.A. *Hon. Secretary*—J. C. Begg, Fifield Street, Roslyn.

NELSON INSTITUTE.

The annual general meeting of the Scientific Branch of the Nelson Institute, the first meeting of the present year, was held on the 11th August, 1920, Mr. F. G. Gibbs presiding. Over twenty persons were present, apologies being received from a number of others who were willing to become members.

After some discussion as to the future constitution, it was decided that the work of the branch should continue on the lines previously followed, and the existing constitution was adopted. Gratification was expressed at the large accession of new members, and especially at the willingness of the staff of the Cawthron Institute to take an active part in the operations of the branch.

Three meetings of the committee and three general meetings were subsequently held. Well-attended lectures were given by Professor T. H. Easterfield, on "Colloids," and T. Rigg, on "The Work of the Rothamsted Experimental Station." The following papers were read: R. J. Tillyard, "A New Species of Uropetela"; A. Philpott, "Notes on the Lepidoptera."

The final gathering of the year took the form of an excursion to the Dun Mountain, under the leadership of F. G. Gibbs.

Election of Officers for 1921.—President—Theodore Rigg, M.A., M.Sc. *Committee*—Professor T. H Easterfield, M.A., Ph.D., F.N.Z.Inst.; Miss K. M. Curtis, M.A., D.Sc., D.I.C.; F. G. Gibbs, M.A.; A. Philpott, F.E.S.; F. V. Knapp; and F. L. N. Tuck, B.Sc. *Secretary and Treasurer*—W. C. Davies.

MANAWATU PHILOSOPHICAL SOCIETY.

The annual general meeting was held at the Museum on the 19th November, 1920, when the annual report and balance-sheet were adopted.

Abstract.

Attendance at the monthly meetings has been fairly satisfactory, but, considering the trouble and expense that the society has gone to in providing lectures and papers, the interest of the public leaves something to be desired.

The society in October suffered a grievous loss by the death of Mr. Kenneth Wilson, M.A., who for nearly eleven years had acted as its Hon. Secretary and Treasurer. Mr. Wilson was one of the original founders of the Manawatu Philosophical Society, had occupied every office, and to his untiring and enthusiastic work is due the present satisfactory position of the society, and the finding of his successor will be a difficult matter.

Death also removed two other very old members in the persons of Mr. C. E. Waldegrave and Mr. T. Manson.

Six members resigned, in all cases due to removal from the district, and nine members were elected, the net result for the year being a gain of one in our membership. The financial position of the society is, on the whole, satisfactory, but in view of the heavy expenses attendant upon the holding of the New Zealand Science Congress in Palmerston North special efforts are necessary, and are being made, to meet these extraordinary conditions.

The Museum continues to expand, and the Council is seriously faced with the question of increased accommodation for exhibits; and, our available space being now

fully occupied, it has been found necessary to decline, though with great reluctance, some valuable exhibits. There is good reason to hope, however, that in the new library to be erected by the municipal authorities ample accommodation for the Museum will be provided, and deputations from the Council of the society touching this matter met with a most encouraging reception from the civic body. Meanwhile the fire risk in our present building is causing the Council much anxiety, and this risk, added to the fact of the congestion, were the points most dwelt upon by the speakers at the several deputations. The report of the Curator shows that the average daily attendance was twenty-two, and exhibits were received from thirteen different donors, to whom our best thanks are accorded.

Mr. R. H. F. Grace reported that the attendance at the Observatory has been fair, but no great advantage has been taken of the privilege of school-children attending as a class free; and in view of the very accessible situation of the Observatory and the awakened interest in astronomy their lack of appreciation of the facilities afforded is difficult to explain.

The telescope is in good repair, but the building requires repainting, and, if the opportunity offers, steps should be taken to secure a more modern instrument, as the one we have is not adapted for precise work, and we therefore cannot collaborate in the general work being done in New Zealand. The October eclipse of the moon was, unfortunately, not observable, owing to heavy clouds.

During the year nine general meetings were held, and the following papers were read: Colonel Porter, "Personal Reminiscences of Maori Customs and Superstitions"; Dr. H. Bett, "The Transfusion of Blood"; T. E. Sedgwick, "Population"; R. Edwards, "The Origin of Coal"; Johannes C. Andersen, "Bird-song and the Song-birds of New Zealand"; C. T. Salmon, "The Cosmic Cycle"; "T. Watson, "The Climate as a Factor in Racial Characteristics"; Elsdon Best, "Ancient Maori Lore and Customs."

Your Council commends to your attention the distinction accorded to Palmerston North in being chosen as the location of the 1921 Biennial Science Congress, and earnestly trusts that every effort will be put forth by members of the society and townspeople generally to make the gathering, which is fixed for the last week in January, a notable success.

Election of Officers for 1921.—President—Dr. D. H. Bett, M.B., Ch.B., M.R.C.S., L.R.C.P., F.R.C.S.E. *Vice-Presidents*—A. Whittaker; J. B. Gerrand. *Council*—Miss D. Wilson; R. Ross; R. Edwards; J. A. Colquhoun, M.Sc.; C. Taylor; E. Larcomb; H. J. Canton; A. H. M. Wright; J. Murray, M.A.; W. Park, F.R.H.S.; M. A. Elliot; M. H. Oram, M.A., LL.B. *Officer in Charge of the Observatory*—R. H. F. Grace. *Honorary Secretary and Treasurer*—C. T. Salmon. *Honorary Auditor*—W. E. Bendall, F.P.A.

WANGANUI PHILOSOPHICAL SOCIETY.

Three meetings were held during the year 1920, at which the following lectures were given:—

June: H. E. Segar, "The Dwindling Sovereign."

September: P. Marshall, "The Age of the Earth."

October: R. Dunn, "Coal-tar Chemistry"; P. Marshall and R. Murdoch, "Some Tertiary Mollusca, with Descriptions of New Species," "Fossils from the Paparoa Rapids, on the Wanganui River," "Tertiary Rocks near Hawera."

At the annual meeting the report and balance-sheet were adopted, and the following officers were appointed:—

President—P. Marshall, M.A., D.Sc., F.G.S., F.N.Z.Inst. *Vice-Presidents*—J. A. Neame, B.A., and J. T. Ward. *Council*—T. Allison; C. Palmer Brown, M.A., LL.B.; R. Murdoch; T. W. Downes; H. E. Sturge, M.A.; H. R. Hatherly, M.R.C.S.; C. C. Hutton, M.A. *Hon. Secretary and Treasurer*—R. Murdoch.

APPENDIX.

NEW ZEALAND INSTITUTE ACT, 1908.

1908, No. 130.

An Act to consolidate certain Enactments of the General Assembly relating to the New Zealand Institute.

Be it enacted by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. (1.) The Short Title of this Act is the New Zealand Institute Act, 1908.

(2.) This Act is a consolidation of the enactments mentioned in the Schedule hereto, and with respect to those enactments the following provisions shall apply:—

(*a.*) The Institute and Board respectively constituted under those enactments, and subsisting on the coming into operation of this Act, shall be deemed to be the same Institute and Board respectively constituted under this Act without any change of constitution or corporate entity or otherwise; and the members thereof in office on the coming into operation of this Act shall continue in office until their successors under this Act come into office.

(*b.*) All Orders in Council, regulations, appointments, societies incorporated with the Institute, and generally all acts of authority which originated under the said enactments or any enactment thereby repealed, and are subsisting or in force on the coming into operation of this Act, shall enure for the purposes of this Act as fully and effectually as if they had originated under the corresponding provisions of this Act, and accordingly shall, where necessary, be deemed to have so originated.

(*c.*) All property vested in the Board constituted as aforesaid shall be deemed to be vested in the Board established and recognized by this Act.

(*d.*) All matters and proceedings commenced under the said enactments, and pending or in progress on the coming into operation of this Act, may be continued, completed, and enforced under this Act.

2. (1.) The body now known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as heretofore have been or may hereafter be incorporated therewith in accordance with regulations heretofore made or hereafter to be made by the Board of Governors.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

3. The control and management of the Institute shall be vested in a Board of Governors (hereinafter referred to as "the Board"), constituted as follows:—

The Governor:

The Minister of Internal Affairs:

Four members to be appointed by the Governor in Council, of whom two shall be appointed during the month of December in every year:

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine:

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

4. (1.) Of the members appointed by the Governor in Council, the two members longest in office without reappointment shall retire annually on the appointment of their successors.

(2.) Subject to the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

5. The Board shall be a body corporate by the name of the "New Zealand Institute," and by that name shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

6. (1.) The Board shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) The Board shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3.) The Board shall have power from time to time to make regulations under which societies may become incorporated with the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with; and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property from time to time vested in it or acquired by it; and shall make regulations for the management of the same, and for the encouragement of research by the members of the Institute; and in all matters, specified or unspecified, shall have power to act for and on behalf of the Institute.

7. (1.) Any casual vacancy in the Board, howsoever caused, shall be filled within three months by the society or authority that appointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board.

(2.) Any person appointed to fill a casual vacancy shall only hold office for such period as his predecessor would have held office under this Act.

8. (1.) Annual meetings of the Board shall be held in the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

9. The Board may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute,

at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in New Zealand by any means that may appear desirable.

10. The Minister of Finance shall from time to time, without further appropriation than this Act, pay to the Board the sum of five hundred pounds in each financial year, to be applied in or towards payment of the general current expenses of the Institute.

11. Forthwith upon the making of any regulations or the publication of any Transactions, the Board shall transmit a copy thereof to the Minister of Internal Affairs, who shall lay the same before Parliament if sitting, or if not, then within twenty days after the commencement of the next ensuing session thereof.

SCHEDULE.

Enactments consolidated.

1903, No. 48.—The New Zealand Institute Act, 1903.

NEW ZEALAND INSTITUTE AMENDMENT ACT, 1920.

1920, No. 3.

AN ACT to amend the New Zealand Institute Act, 1908.

[*30th July, 1920.*

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows :—

1. This Act may be cited as the New Zealand Institute Amendment Act, 1920, and shall be read together with and deemed part of the New Zealand Institute Act, 1908.

2. Section ten of the New Zealand Institute Act, 1908, is hereby amended by omitting the words "five hundred pounds," and substituting the words "one thousand pounds."

REGULATIONS.

THE following are the regulations of the New Zealand Institute under the Act of 1903 :—*

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by the New Zealand Institute Act, 1903.

INCORPORATION OF SOCIETIES.

1. No society shall be incorporated with the Institute under the provisions of the New Zealand Institute Act, 1903, unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual

* *New Zealand Gazette*, 14th July, 1904.

revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

Publications.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications :—

(*a.*) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Board of Governors shall determine what papers are to be published.

(*c.*) Papers not recommended for publication may be returned to their authors if so desired.

(*d.*) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e.*) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f.*) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

Management of the Property of the Institute.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

8. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

9. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

10. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

General Regulations.

11. Subject to the New Zealand Institute Act, 1908, and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

12. Upon application signed by the President and countersigned by the Secretary of any society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

13. In voting on any subject the President is to have a deliberate as well as a casting vote.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than the 30th November.

The following additional regulations, and amendment to regulations, were adopted at a general meeting of the Board of Governors of the New Zealand Institute, held at Wellington on the 30th January, 1918, and at Christchurch on the 3rd February, 1919. (See *New Zealand Gazette*, No. 110, 4th September, 1919.)

Regulations governing the Fellowship of the Institute.

20. The Fellowship of the New Zealand Institute shall be an honorary distinction for the life of the holder.

21. The Original Fellows shall be twenty in number, and shall include the past Presidents and the Hutton and Hector Medallists who have held their distinctions and positions prior to 3rd February, 1919, and who at that date are members of the Institute. The remaining Original Fellows

shall be nominated as provided for in Regulation 26 (*a*), and shall be elected by the said past Presidents and Hector and Hutton Medallists.

22. The total number of Fellows at any time shall not be more than forty.

23. After the appointment and election of the Original Fellows, as provided in Regulation 21, not more than four Fellows shall be elected in any one year.

24. The Fellowship shall be given for research or distinction in science.

25. No person shall be elected as Fellow unless he is a British subject and has been a member of one of the incorporated societies for three years immediately preceding his election.

26. After the appointment and election of the Original Fellows as provided in Regulation 21 there shall be held an annual election of Fellows at such time as the Board of Governors shall appoint. Such election shall be determined as follows :—

(*a*.) Each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin may nominate not more than twice as many persons as there are vacancies, and each of the other incorporated societies may nominate as many persons as there are vacancies. Each nomination must be accompanied by a statement of the qualifications of the candidate for Fellowship.

(*b*.) Out of the persons so nominated the Fellows resident in New Zealand shall select twice as many persons as there are vacancies, if so many be nominated.

(*c*.) The names of the nominees shall be submitted to the Fellows at least six months, and the names selected by them submitted to the Governors at least three months, before the date fixed for the annual meeting of the Board of Governors at which the election is to take place.

(*d*.) The election shall be made by the Board of Governors at the annual meeting from the persons selected by the Fellows.

(*e*.) The methods of selection in subclause (*b*) and of election in subclause (*d*) shall be determined by the Board of Governors.

(*f*.) The official abbreviation of the title "Fellow of the New Zealand Institute" shall be "F.N.Z.Inst."

Amendment to Regulations.

Regulation 5 (*a*) of the regulations published in the *New Zealand Gazette* of the 14th July, 1904, is hereby amended to read :—

"(*a*.) The publications of the Institute shall consist of—

"(1.) Such current abstract of the proceedings of the societies for the time being incorporated with the Institute as the Board of Governors deems desirable;

"(2.) And of transactions comprising papers read before the incorporated societies or any general meeting of the New Zealand Institute (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time for special reasons in each case determine to publish, to be intituled *Transactions of the New Zealand Institute.*"

THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

Declaration of Trust.

This deed, made the fifteenth day of February, one thousand nine hundred and nine (1909), between the New Zealand Institute of the one part, and the Public Trustee of the other part: Whereas the New Zealand Institute is possessed of a fund consisting now of the sum of five hundred and fifty-five pounds one shilling (£555 1s.), held for the purposes of the Hutton Memorial Medal and Research Fund on the terms of the rules and regulations made by the Governors of the said Institute, a copy whereof is hereto annexed: And whereas the said money has been transferred to the Public Trustee for the purposes of investment, and the Public Trustee now holds the same for such purposes, and it is expedient to declare the trusts upon which the same is held by the Public Trustee:

Now this deed witnesseth that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purposes upon trust from time to time to invest the same upon such securities as are lawful for the Public Trustee to invest on, and to hold the principal and income thereof for the purposes set out in the said rules hereto attached.

And it is hereby declared that it shall be lawful for the Public Trustee to pay all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed so to do by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year hereinbefore written.

Resolutions of Board of Governors.

Resolved by the Board of Governors of the New Zealand Institute that—

1. The funds placed in the hands of the Board by the committee of subscribers to the Hutton Memorial Fund be called "The Hutton Memorial Research Fund," in memory of the late Captain Frederick Wollaston Hutton, F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the Hutton Memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding £100 shall be expended in procuring a bronze medal to be known as "The Hutton Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as aforesaid as may be approved of by the Board of Governors, and the interest arising from such investment hall be used for the furtherance of the objects of the fund.

5. The Hutton Memorial Medal shall be awarded from time to time by the Board of Governors, in accordance with these regulations, to persons who have made some noticeable contribution in connection with the zoology, botany, or geology of New Zealand.

6. The Board shall make regulations setting out the manner in which the funds shall be administered. Such regulations shall conform to the terms of the trust.

7. The Board of Governors may, in the manner prescribed in the regulations, make grants from time to time from the accrued interest to persons or committees who require assistance in prosecuting researches in the zoology, botany, or geology of New Zealand.

8. There shall be published annually in the "Transactions of the New Zealand Institute" the regulations adopted by the Board as aforesaid, a list of the recipients of the Hutton Memorial Medal, a list of the persons to whom grants have been made during the previous year, and also, where possible, an abstract of researches made by them.

Regulations under which the Hutton Memorial Medal shall be awarded and the Research Fund administered.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct bearing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at any annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

Award of the Hutton Memorial Medal.

1911. Professor W. B. Benham, D.Sc., F.R.S., University of Otago—For researches in New Zealand zoology.

1914. Dr. L. Cockayne, F.L.S., F.R.S.—For researches on the ecology of New Zealand plants.

1917. Professor P. Marshall, M.A., D.Sc.—For researches in New Zealand geology.

1920. Rev. John E. Holloway, D.Sc.—For researches in New Zealand pteridophytic botany.

Grant from the Hutton Memorial Research Fund.

1919. Miss M. K. Mestayer—£10, for work on the New Zealand Mollusca.

HECTOR MEMORIAL RESEARCH FUND.

Declaration of Trust.

This deed, made the thirty-first day of July, one thousand nine hundred and fourteen, between the New Zealand Institute, a body corporate duly incorporated by the New Zealand Institute Act, 1908, of the one part, and the Public Trustee of the other part: Whereas by a declaration of trust dated the twenty-seventh day of January, one thousand nine hundred and twelve, after reciting that the New Zealand Institute was possessed of a fund consisting of the sum of £1,045 10s. 2d., held for the purposes of the Hector Memorial Research Fund on the terms of the rules and regulations therein mentioned, which said moneys had been handed to the Public Trustee for investment, it was declared (*inter alia*) that the Public Trustee should hold the said moneys and all other moneys which should be handed to him by the said Governors of the Institute for the same purpose upon trust from time to time, to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations in the said deed set forth: And whereas the said rules and regulations have been amended by the Governors of the New Zealand Institute, and as amended are hereinafter set forth: And whereas it is expedient to declare that the said moneys are held by the Public Trustee upon the trusts declared by the said deed of trust and for the purposes set forth in the said rules and regulations as amended as aforesaid:

Now this deed witnesseth and it is hereby declared that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purpose upon trust from time to time to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations hereinafter set forth:

And it is hereby declared that it shall be lawful for the Public Trustee to pay, and he shall pay, all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed to do so by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said

Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year first hereinbefore written.

Rules and Regulations made by the Governors of the New Zealand Institute in relation to the Hector Memorial Research Fund.

1. The funds placed in the hands of the Board by the Wellington Hector Memorial Committee be called "The Hector Memorial Research Fund," in memory of the late Sir James Hector, K.C.M.G., F.R.S. The object of such fund shall be the encouragement of scientific research in New Zealand, and such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the said Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding one hundred pounds (£100) shall be expended in procuring a bronze medal, to be known as the Hector Memorial Medal.

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as may be approved by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund by providing thereout a prize for the encouragement of such scientific research in New Zealand of such amount as the Board of Governors shall from time to time determine.

5. The Hector Memorial Medal and Prize shall be awarded annually by the Board of Governors.

6. The prize and medal shall be awarded by rotation for the following subjects, namely—(1) Botany, (2) chemistry, (3) ethnology, (4) geology, (5) physics (including mathematics and astronomy), (6) zoology (including animal physiology).

In each year the medal and prize shall be awarded to that investigator who, working within the Dominion of New Zealand, shall in the opinion of the Board of Governors have done most towards the advancement of that branch of science to which the medal and prize are in such year allotted.

7. Whenever possible the medal shall be presented in some public manner.

AWARD OF THE HECTOR MEMORIAL RESEARCH FUND.

1912. L. Cockayne, Ph.D., F.L.S., F.R.S.—For researches in New Zealand botany.
1913. T. H. Easterfield, M.A., Ph.D.—For researches in chemistry.
1914. Elsdon Best—For researches in New Zealand ethnology.
1915. P. Marshall, M.A., D.Sc., F.G.S.—For researches in New Zealand geology.
1916. Sir Ernest Rutherford, F.R.S.—For researches in physics.
1917. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S.—For researches in zoology.
1918. T. F. Cheeseman, F.L.S., F.Z.S.—For researches in New Zealand systematic botany.
1919. P. W. Robertson—For researches in chemistry.
1920. S. Percy Smith—For researches in New Zealand ethnology.
1921. R. Speight, M.A., M.Sc., F.G.S.—For work in New Zealand geology.

REGULATIONS FOR ADMINISTERING THE GOVERNMENT RESEARCH GRANT.*

All grants shall be subject to the following conditions, and each grantee shall be duly informed of these conditions :—

1. All instruments, specimens, objects, or materials of permanent value, whether purchased or obtained out of or by means of the grant, or supplied from among those at the disposal of the Institute, are to be regarded, unless the Research Grants Committee decide otherwise, as the property of the Institute, and are to be returned by the grantee, for disposal according to the orders of the committee, at the conclusion of his research, or at such other time as the committee may determine.

2. Every one receiving a grant shall furnish to the Research Grants Committee, on or before the 1st January following upon the allotment of the grant, a report (or, if the object of the grant be not attained, an interim report, to be renewed at the same date in each subsequent year until a final report can be furnished or the committee dispense with further reports) containing (*a*) a brief statement showing the results arrived at or the stage which the inquiry has reached ; (*b*) a general statement of the expenditure incurred, accompanied, as far as is possible, with vouchers; (*c*) a list of the instruments, specimens, objects, or materials purchased or obtained out of the grant, or supplied by the committee, which are at present in his possession ; and (*d*) references to any transactions, journals, or other publications in which results of the research have been printed. In the event of the grantee failing to send in within three months of the said 1st January a report satisfactory to the committee he may be required, on resolution of the Board of Governors, to return the whole of the sum allotted to him.

3. Where a grant is made to two or more persons acting as a committee for the purpose of carrying out some research, one member of the said committee shall assume the responsibility of furnishing the report and receiving and disbursing the money.

4. Papers in which results are published that have been obtained through aid furnished by the Government grant should contain an acknowledgment of that fact.

5. Every grantee shall, before any of the grant is paid to him, be required to sign an engagement that he is prepared to carry out the general conditions applicable to all grants, as well as any conditions which may be attached to his particular grant.

6. In cases where specimens or preparations of permanent value are obtained through a grant the committee shall, as far as possible, direct that such specimens shall be deposited in a museum or University college within the province where the specimens or material were obtained, or in which the grantee has worked. The acknowledgment of the receipt of the specimens by such institution shall fully satisfy the claims of the Institute.

7. In cases where, after completion of a research, the committee directs that any instrument or apparatus obtained by means of the grant shall be deposited in an institution of higher learning, such deposit shall be subject to an annual report from the institution in question as to the condition of the instrument or apparatus, and as to the use that has been made of it.

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* In addition to these regulations the Standing Committee is also bound by certain resolutions which appear on page 536 of volume 49, *Trans. N.Z. Inst.*, and which grantees are also bound to observe.

RESEARCH GRANTS MADE DURING THE YEAR ENDING 31ST MARCH, 1921.

Through the Philosophical Institute of Canterbury :—

Professor Evans, £200 and £200 for research on New Zealand brown coals.

Mr. George Gray, £50 for research on the waters of Canterbury.

Professor C. Coleridge Farr, £75 for research on the physical properties of gas-free sulphur.

Dr. F. W. Hilgendorf, £100 on behalf of the Artesian Wells Committee of Canterbury.

Through the Otago Institute :—

Mr. H. D. Skinner, £200 for an ethnographical survey of the South Island.

Professor J. Malcolm, £150 for research into the food values of New Zealand fishes.

Through the Wellington Philosophical Society :—

Sir D. E. Hutchins, £50 for research on the growth of native trees.

Professor E. Marsden, £50 for research on the physical properties of New Zealand timbers.

Through the Nelson Institute :—

Miss K. M. Curtis, £100 for research in parasitic mycology.

THE CARTER BEQUEST.

FOR extracts from the will of Charles Rooking Carter see vol. 48, 1916, pp. 565–66.

NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908.

BOARD OF GOVERNORS.

EX OFFICIO.

His Excellency the Governor-General.
The Hon. the Minister of Internal Affairs.

NOMINATED BY THE GOVERNMENT.

Dr. Charles Chilton, F.L.S., C.M.Z.S., F.N.Z.Inst. (reappointed December, 1918); Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst. (reappointed December, 1919); Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst. (reappointed December, 1919); Dr. Leonard Cockayne, F.R.S., F.L.S., F.N.Z.Inst. (appointed June, 1921).

ELECTED BY AFFILIATED SOCIETIES (DECEMBER, 1919).

Wellington Philosophical Institute ...	Professor H. B. Kirk, M.A., F.N.Z.Inst. Professor T. H. Easterfield, M.A., Ph.D., F.N.Z.Inst.
Auckland Institute	Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst. Professor A. P. W. Thomas, M.A., F.N.Z.Inst.
Philosophical Institute of Canterbury ...	Dr. F. W. Hilgendorf, M.A. Mr. A. M. Wright, F.C.S.
Otago Institute	Hon. G. M. Thomson, F.L.S., F.N.Z.Inst., M.L.C. Professor J. Malcolm, M.D.
Hawke's Bay Philosophical Institute ...	Mr. H. Hill, B.A., F.G.S.
Nelson Institute	Dr. L. Cockayne, F.L.S., F.R.S., F.N.Z.Inst.
Manawatu Philosophical Society ...	Mr. M. A. Eliott.
Wanganui Philosophical Society ..	Dr. P. Marshall, M.A., F.G.S., F.N.Z.Inst.
Poverty Bay Institute	Ven. Archdeacon H. W. Williams, M.A.

OFFICERS FOR THE YEAR 1921.

PRESIDENT: Professor T. H. Easterfield, M.A., Ph.D., F.N.Z.Inst.
HON. TREASURER: Mr. M. A. Eliott.
HON. EDITOR: Mr. Johannes C. Andersen.
HON. LIBRARIAN: Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst.
HON. SECRETARY: Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst.
(Box 40, Post-office, Wellington).

AFFILIATED SOCIETIES.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Wellington Philosophical Society	H. Hamilton, Dominion Museum, Wellington	10th June, 1868.
Auckland Institute ..	T. F. Cheeseman, Museum, Auckland	10th June, 1868.
Philosophical Institute of Canterbury	G. E. Archey, Canterbury Museum, Christchurch	22nd October, 1868.
Otago Institute	Professor W. N. Benson, University, Dunedin	18th October, 1869.
Hawke's Bay Philosophical Institute	C. F. H. Pollock, P.O. Box 301, Napier	31st March, 1875.
Nelson Institute	W. C. Davies, Cawthron Institute, Nelson	20th December, 1883.
Manawatu Philosophical Society	Chas. T. Salmon, P.O. Box 293, Palmerston North	6th January, 1905.
Wanganui Philosophical Society	R. Murdoch, P.O. Box 221, Wanganui	2nd December, 1911.
Poverty Bay Institute ..	John Mouat, Adams Chambers, Gladstone Road, Gisborne	1st February, 1919.

FORMER HONORARY MEMBERS.

1870.

Agassiz, Professor Louis.
Drury, Captain Byron, R.N.
Finsch, Professor Otto, Ph.D.
Flower, Professor W. H., F.R.S.
Hochstetter, Dr. Ferdinand von.
Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., O.M.
Mueller, Ferdinand von, M.D., F.R.S., C.M.G.
Owen, Professor Richard, F.R.S.
Richards, Rear-Admiral G. H.

1871.

Darwin, Charles, M.A., F.R.S.
Gray, J. E., Ph.D., F.R.S.
Lindsay, W. Lauder, M.D., F.R.S.E.

1872.

Grey, Sir George, K.C.B.
Huxley, Thomas H., LL.D., F.R.S.
Stokes, Vice-Admiral J. L.

1873.

Bowen, Sir George Ferguson, G.C.M.G.
Günther, A., M.D., M.A., Ph.D., F.R.S.
Lyell, Sir Charles, Bart., D.C.L., F.R.S.
Pickard-Cambridge, Rev. O., M.A., F.R.S., C.M.Z.S.

1874.

McLachlan, Robert, F.L.S.
Newton, Alfred, F.R.S.
Thomson, Professor Wyville, F.R.S.

1875.

Filhol, Dr. H.
Rolleston, Professor G., M.D., F.R.S.
Sclater, P. L., M.A., Ph.D., F.R.S.

1876.

Berggren, Dr. S.
Clarke, Rev. W. B., M.A., F.R.S.
Etheridge, Professor R., F.R.S.

1877.

Baird, Professor Spencer F.
Weld, Frederick A., C.M.G.

1878.

Garrod, Professor A. H., F.R.S.
Müller, Professor Max, F.R.S.
Tenison-Woods, Rev. J. E., F.L.S.

1880.

The Most Noble the Marquis of Normanby, G.C.M.G.

1883.

Carpenter, Dr. W. B., C.B., F.R.S.
Ellery, Robert L. J., F.R.S.
Thomson, Sir William, F.R.S.

1885.

Gray, Professor Asa.
Sharp, Richard Bowdler, M.A., F.R.S.
Wallace, Sir A. R., F.R.S., O.M.

1888.

Beneden, Professor J. P. van.
Ettingshausen, Baron von.
McCoy, Professor Sir F., K.C.M.G., D.Sc., F.R.S.

1890.

Riley, Professor C. V.

1891.

Davis, J. W., F.G.S., F.L.S.

1895.

Mitten, William, F.R.S.

1896.

Langley, S. P.
Lydekker, Richard, F.R.S.

1900.

Agardh, Dr. J. G.
Avebury, Lord, P.C., F.R.S.
Massee, George, F.L.S., F.R.M.S.

1901.

Eve, H. W., M.A.
Howes, G. B., LL.D., F.R.S.

1906.

Milne, J., F.R.S.

1909.

Darwin, Sir George, F.R.S.

1914.

Arber, E. A. Newell, M.A., Sc.D., F.G.S., F.L.S.

FORMER MANAGER AND EDITOR.

[Under the New Zealand Institute Act, 1867.]

1867–1903.

Hector, Sir James, M.D., K.C.M.G., F.R.S.

PAST PRESIDENTS.

1903–4.

Hutton, Captain Frederick Wollaston, F.R.S.

1905–6.

Hector, Sir James, M.D., K.C.M.G., F.R.S.

1907–8.

Thomson, George Malcolm, F.L.S.

1909–10.

Hamilton, A.

1911–12.

Cheeseman, T. F., F.L.S., F.Z.S.

1913–14.

Chilton, C., M.A., D.Sc., LL.D., F.L.S., C.M.Z.S.

1915.

Petrie, D., M.A., Ph.D.

1916–17.

Benham, W. B., M.A., D.Sc., F.Z.S., F.R.S.

1918–19.

Cockayne, L., Ph.D., F.R.S., F.L.S., F.N.Z.Inst.

HONORARY MEMBERS.

1877.

Sharp, Dr. D., University Museum, Cambridge.

1890.

Liversidge, Professor A., M.A., F.R.S., Fieldhead, Coombe Warren, Kingston Hill, England.

Nordstedt, Professor Otto, Ph.D., University of Lund, Sweden.

1891.

Goodale, Professor G. L., M.D., LL.D., Harvard University, Cambridge, Mass., U.S.A.

1894.

Codrington, Rev. R. H., D.D., Wadhurst Rectory, Sussex, England.

Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Witcombe, Gloucester, England.

1901.

Goebel, Professor Dr. Carl von, University of Munich.

1902.

Sars, Professor G. O., University of Christiania, Norway.

1903.

Klotz, Professor Otto J., 437 Albert Street, Ottawa, Canada.

1904.

Rutherford, Professor Sir E., D.Sc., F.R.S. F.N.Z.Inst., Nobel Laureate, Cambridge, England.

David, Professor T. Edgeworth, F.R.S., C.M.G., Sydney University, N.S.W.

1906.

Beddard, F. E., D.Sc., F.R.S., Zoological Society, London.

Brady, G. S., D.Sc., F.R.S., University of Durham, England.

1907.

Dendy, Dr. A., F.R.S., King's College, University of London, England.

Diels, Professor L., Ph.D., University of Marburg.

Meyrick, E., B.A., F.R.S., Marlborough College, England.

Stebbing, Rev. T. R. R., F.R.S., Tunbridge Wells, England.

1910.

Bruce, Dr. W. S., Edinburgh.

1913.

Davis, Professor W. Morris, Harvard University, Cambridge, Mass., U.S.A.

Hemsley, Dr. W. Botting, F.R.S., Kew Lodge, St. Peter's Road, Broadstairs, Kent, England.

1914.

Balfour, Professor I. Bayley, F.R.S., Royal Botanic Gardens, Edinburgh.

Haswell, Professor W. A., F.R.S, Mimihau, Woollahra Point, Sydney.

1915.

Bateson, Professor W., F.R.S., Merton, Surrey, England.

1916.

Massart, Professor Jean, University of Brussels, Belgium.

1919.

Mellor, Joseph William, D.Sc. (N.Z.), Sandon House, Regent Street, Stoke-on-Trent, England.

1920.

Fraser, Sir J. G., D.C.L., No. 1 Brick Court, Temple, London, E.C. 4.

Gregory, Professor J. W., D.Sc., F.R.S., F.G.S., University, Glasgow.

Hall, Sir A. D., M.A., K.C.B., F.R.S., Ministry of Agriculture, London.

Mawson, Sir Douglas, B.E., D.Sc., The University, Box 498, G.P.O., Adelaide.

Woods, Henry, M.A., F.R.S., F.G.S., University, Cambridge.

ORIGINAL FELLOWS OF THE NEW ZEALAND INSTITUTE.

(See *New Zealand Gazette*, 20th November, 1919.)

Aston, Bernard Cracroft, F.I.C., F.C.S.
*‡Benham, Professor William Blaxland, M.A., D.Sc., F.R.S., F.Z.S.
†Best, Elsdon.
*†Cheeseman, Thomas Frederick, F.L.S., F.Z.S.
*†Chilton, Professor Charles, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.
*†‡Cockayne, Leonard, Ph.D., F.R.S., F.L.S.
†Easterfield, Professor Thomas Hill, M.A., Ph.D., F.I.C., F.C.S.
Farr, Professor Clinton Coleridge, D.Sc., F.P.S.L., Assoc.M.Inst.C.E.
Hogben, George, C.M.G., M.A., F.G.S.
Hudson, George Vernon, F.E.S.
Kirk, Professor Harry Borrer, M.A.
†‡Marshall, Patrick, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.
*Petrie, Donald, M.A., Ph.D.
†Rutherford, Sir Ernest, Kt., F.R.S., D.Sc., Ph.D., LL.D.
Segar, Professor Hugh William, M.A.
Smith, Stephenson Percy, F.R.G.S.
Speight, Robert, M.A., M.Sc., F.G.S.
Thomas, Professor Algernon Phillips Withiel, M.A., F.L.S.
*Thomson, Hon. George Malcolm, F.L.S., M.L.C.
Thomson, James Allan, M.A., D.Sc., A.O.S.M., F.G.S.

FELLOWS ELECTED, 1921.

Cotton, Charles Andrew, D.Sc., A.O.S.M., F.G.S.
Hilgendorf, Frederick William, B.A., D.Sc.
Holloway, Rev. John Ernest, L.Th., D.Sc.
Park, Professor James, M.Am.Inst.M.E., M.Inst.M.M., F.G.S.

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* Past President † Hector Medallist. ‡ Hutton Medallist.

ORDINARY MEMBERS.

WELLINGTON PHILOSOPHICAL SOCIETY.

[* Life members.]

Ackland, E. W., P.O. Box 928, Wellington.
Adams, C. E., D.Sc., A.I.A. (London), F.R.A.S., Hector Observatory, Wellington.
Adkin, G. L., Queen Street, Levin.
Andersen, Johannes C., Turnbull Library, Bowen Street, Wellington.
Anderson, W. J., M.A., LL.D., Education Department, Wellington.
Andrew, R. L., Dominion Laboratory, Wellington.
Anson, Miss J. C., Victoria College.
Aston, B. C., F.I.C., F.C.S., F.N.Z.Inst., P.O. Box 40, Wellington.
Atkinson, E. H., 71 Fairlie Terrace, Kelburn.
Bagley, G., care of Young's Chemical Company, 14 Egmont Street, Wellington.
Baillie, H., Public Library, Wellington.
Bakewell, F. H., M.A., Education Board, Mercer Street, Wellington.
Baldwin, E. S., 215 Lambton Quay, Wellington.
Bateson, H., Dominion Publishing Company.
Beckett, Peter, Paraparaumu.
Bell, E. D., Panama Street, Wellington.
Bell, Hon. Sir Francis H. D., K.C., M.L.C., Panama Street, Wellington.
Bennett, Francis, Headmaster, Berhampore School.
Berry, C. G. G., Railway Buildings, Wellington.
Best, Elsdon, F.N.Z.Inst., Dominion Museum, Wellington.
Birks, L., B.Sc., Assoc.M.Inst.C.E., A.M.I.E.E., Public Works Department, Wellington.
Blair, David K., M.I.Mech.E., 9 Grey Street, Wellington.
Boyes, L. F., care of Messrs. John Duthie and Co. (Ltd.), Wellington.
Bradshaw, G. B., Box 863, Wellington.
Brandon, A. de B., B.A., Featherston Street, Wellington.
Brent, H. C., Laboratory, G.P.O., Wellington.
Bridges, G. G., 2 Wesley Road, Wellington.
Brodrick, T. N., Under-Secretary, Lands and Survey Department, Wellington.
Brown, J., The Bartons, Fairview, Timaru.
Burnett, J., M.Inst.C.E., 31 Moana Road, Kelburn.
Burton, Richard F., Longner Hall, Salop, Shrewsbury, England.*
Cachemaille, E. D., care of Harbour Board, Wellington.
Cameron, Dr. R. A., 148 Willis Street, Wellington.
Campbell, J., F.R.I.B.A., Government Architect, Public Works Department, Wellington.
Carter, W. H., care of Dr. Henry, The Terrace, Wellington.
Chamberlin, T. Chamberlin, Crescent Road, Khandallah.
Chapman, Martin, K.C., Brandon Street, Wellington.
Clarke, J. T., 120 Karori Road, Wellington.
Cockayne, A. H., 71 Fairlie Terrace, Kelburn.
Cockayne, L., Ph.D., F.L.S., F.R.S., F.N.Z.Inst., Ngaio, Wellington.
Cockcroft, T., Bank of New Zealand, Te Aro.
Comrie, L. J., M.A., Cornwall Park Avenue, Auckland.
Cooke, Miss G. F., Sefton Street, Wellington.
Cotton, C. A., D.Sc., F.G.S., F.N.Z.Inst., Victoria University College, Wellington.
Coventry, Mrs. H., Te Rehunga, Dannevirke.
Cowan, J., Department of Internal Affairs, Wellington.
Crawford, A. D., Box 126, G.P.O., Wellington.
Crawford, Miss E. J., Girls' College, Wellington.
Cull, J. E. L., B.Sc. in Eng. (Mech.), Public Works Department, Wellington.
Cumming, E., Land and Income Tax Department, Wellington.
Curtis, H. F., 19 May Street, Wellington.
Darling, J., Kelburn.
Davies, V. C., Westown, New Plymouth.
Donovan, W., M.Sc., Dominion Laboratory, Wellington.
Doré, A. B., Bacteriological Laboratory, Wellington.
Dougall, Archibald, 9 Claremont Grove, Wellington.
Dymock, E. R., F.I.A.N.Z., A.I.A.V., Box 193, Wellington.
Earnshaw, W., 4 Watson Street, Wellington.
Easterfield, Professor T. H., M.A., Ph.D., F.N.Z.Inst., Cawthron Institute, Nelson.
Edwards, W. A., 97 Cuba Street, Wellington.
Ellis, E. McIntosh, Director Forestry Department, Wellington.
Ewen, Charles A., Heretaunga, Upper Hutt.
Ferguson, William, M.A., M. Inst. C. E., M.I.Mech.E., 131 Coromandel Street, Wellington.
Ferrar, H. T., M.A., F.G.S., 38 The Terrace.*
Findlay, Sir John G., K.C., LL.D., 197 Lambton Quay, Wellington.
FitzGerald, Gerald, Assoc.M.Inst.C.E., P.O. Box 461, Wellington.
Fletcher, Rev. H. J., The Manse, Taupo.
Fortune, Alfred, 23 Matai Road, Hataitai.
Fox, Thomas O., Borough Engineer, Miramar, Wellington.
Freeman, C. J., 95 Webb Street, Wellington.*
Frengley, Dr., Hatton Street, Karori.
Furkert, F. W., Assoc.M.Inst.C.E., Public Works Department, Wellington.
Garrow, Professor J. M. E., B.A., LL.B., Victoria University College, Wellington.*
Gavin, W. H., Public Works Department, Wellington.
Gibbs, Dr. H. E., 240 Willis Street, Wellington.
Gifford, A. C., M.A., F.R.A.S., 6 Shannon Street, Wellington.*
Gilbert, Rev. Father T. A., St. Patrick's College, Wellington.
Glendinning, T. A., B.Sc., F.I.C., Watt Street, Wellington.

Goudie, H. A., Whakarewarewa.
Grange, L. I., 38 The Terrace, Wellington.
Gray, W., Mauriceville.
Grimmett, R. E. R., Agricultural Laboratory, Wellington.
Hamilton, H., A.O.S.M., Dominion Museum, Wellington.*
Hanify, H. P., 18 Panama Street, Wellington.
Hansford, George D., Parliamentary Buildings, Wellington.
Hastie, Miss J. A., care of Street and Co., 30 Cornhill, London E.C.*
Hector, C. Monro, M.D., B.Sc., F.R.A.S., 200 Willis Street, Wellington.
Heenan, J. W., Department of Internal Affairs, Wellington.
Helyer, Miss E., 13 Tonks Grove, Wellington.
Henderson, J., M.A., D.Sc., B.Sc. in Eng. (Metall.), Geological Survey Department, Wellington.
Hetherington, Miss J., Training College, Wellington.
Hicks, P. L., Bacteriological Laboratory, Wellington.
Hislop, J., Internal Affairs Department, Wellington.
Hodson, W. H., 40 Pirie Street, Wellington.
Hogben, E. N., Boys' High School, Palmerston North.
Holm, Miss A., 31 Patanga Crescent, Wellington.
Holmes, R. W., M.Inst.C.E., Burnell Avenue, Wellington.
Hooper, Captain G. S., Grant Road, North Wellington.
Hooper, R. H., 6 St. John's Street, Wellington.
Hudson, G. V., F.E.S., F.N.Z.Inst., Hill View, Karori.
Jack, J. W., 170 Featherston Street, Wellington.
Jenkinson, S. H., Railway Department, Wellington.
Jones, A. Morris, 47 Upland Road, Kelburn.
Joseph, Joseph, P.O. Box 443, Wellington.
Kennedy, Rev. Dr. D., F.R.A.S., Greenmeadows, Hawke's Bay.
Kerr, W. J., National Bank, Grey Street, Wellington.
King, G. W., B.E., care of A. H. King, P.O. Box 116, Christchurch.
Kirk, Professor H. B., M.A., F.N.Z.Inst., Victoria University College, Wellington.
Kissell, F. T. M., Public Works Department, Wellington.
Knight, C. Prendergast, 126 Bolton Street, Wellington.
La Trobe, W. S., M.A., Hamilton Road, Karori.
Levi, P., M.A., care of Wilford and Levi, 15 Stout Street, Wellington.
Lomas, E. K., M.A., M.Sc., Training College, Wellington.
Lomax, Major H. A., Araruhe, Aramoho, Wanganui.
Longhurst, W. T. A., Scots College, Wellington.
Luke, John P., C.M.G., M.P., Hiropi Street, Wellington.
McArthur, Captain Charles, Khandallah.
McCabe, Ultan F., care of Richardson and McCabe, 11 Grey Street, Wellington.
McDonald, J., Dominion Museum, Wellington.
McKenzie, C. J., Public Works Department, Wellington.
McKenzie, Donald, care of Mrs. Elizabeth McKenzie, Marton.
Maclaurin, J. S., D.Sc., F.C.S., Dominion Laboratory, Wellington.
MacLean, F. W., M.Inst.C.E., Chief Engineer, Head Office, Railway Department, Wellington.
McSherry, Harry, Box 49, Pahiatua.
Marchbanks, J., M.Inst.C.E., Harbour Board, Wellington.
Marsden, Professor E., D.Sc., Victoria University College, Wellington.
Marwick, J., 38 The Terrace, Wellington.
Mason, J. Malcolm, M.D., F.C.S., D.P.H., Lower Hutt.
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Maxwell, J. P., M.Inst.C.E., 145 Dixon Street, Wellington.
Mestayer, R. L., M.Inst.C.E., 139 Sydney Street, Wellington.
Millar, H. M., Public Works Department, Wellington.
Miller, D., 71 Fairlie Terrace, Kelburn.
Mills, Leonard, New Parliamentary Buildings, Wellington.
Moore, G., Eparaima, via Masterton.
Moore, W. Lancelot, Bank Chambers, Lambton Quay, Wellington.
Moorhouse, W. H. Sefton, 134 Dixon Street, Wellington.
Morgan, P. G., M.A., F.G.S., Director of Geological Survey, 38 The Terrace, Wellington.
Morice, Dr. C. G., 21 Portland Crescent, Wellington.
Morice, J. M., B.Sc., Town Hall, Wellington.
Morrison, J. C., Box 413, G.P.O., Wellington.
Morton, W. H., M.Inst.C.E., City Engineer, Wellington.
Murphy, B. E., M.A., B.Com., LL.B., Victoria College, Wellington.
Myers, J. G., Dominion Laboratory, Wellington.
Myers, Miss P., B.A., 26 Fitzherbert Terrace, Wellington.
Neill, W. T., Lands and Survey Department, Government Buildings, Wellington.
Newman, A. K., M.B., M.R.C.P., M.P., 56 Hobson Street, Wellington.
Nicol, John, 57 Cuba Street, Wellington.
Norris, E. T., M.A., Registrar, University of New Zealand, Wellington.
O'Donoghue, A. J., Blenheim.
Ongley, M., M.A., Geological Survey Department, Wellington.
Orchiston, J., M.I.E.E., 16 Rimu Road, Kelburn.
O'Regan, P. J., Box 807, G.P.O., Wellington.
Orr, Robert, Heke Street, Lower Hutt, Wellington.
Owen, A. C., Box 138, New Plymouth.
Parr, E. J., Education Department, Wellington.

Parry, Evan, B.Sc., M.I.E.E., Assoc.M.Inst. C.E., the English Electric Company (Limited), Queen's House, Kingsway, London W.C. 2.
Paterson, A. J., City Engineer's Office, Town Hall, Wellington.
Patterson, Hugh, Assistant Engineer, Public Works Office, Ngatapa.
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Pilcher, E. G., 225 The Terrace, Wellington.
Pomare, Hon. Dr. M., M.P., Wellington.
Powles, C. P., 219 Lambton Quay, Wellington.*
Ralph, T., 85 Webb Street, Wellington.
Rands, Henry, Wellington Gas Company, Limited, Miramar.
Reakes, C. J., D.V.Sc., M.R.C.V.S., Agricultural Department, Wellington.
Richardson, C. E., P.O. Box 863 (11 Grey Street), Wellington.
Robertson, Professor P. W., Victoria University College, Wellington.
Robinson, I. R., care of Chief Electrical Engineer, Public Works Department, Wellington.
Ronayne, R. H. P., 50 Tinakori Road, Wellington.
Roy, R. B., Taita, Wellington.*
Salmon, Miss O. K., 100 Coromandel Street, Wellington.
Salmond, Sir J. W., K.C., M.A., LL.B., Crown Law Office, Wellington.
Shields, Miss C., Girls' College, Wellington.
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Sommerville, Professor D. M. Y., M.A., D.Sc., F.R.S.E., Victoria University College, Wellington.
Spencer, W. E., M.A., M.Sc., Education Department, Wellington.
Stout, T. Duncan M., M.B., M.S., F.R.C.S., 238 The Terrace, Wellington.
Strachan, J. R., Land Transfer Office, Wellington.
Sunley, R. M., View Road, Karori.
Sutherland, W. S., Whakatomotomo, Pirinoa.
Taylor, C. M., Wellington College.
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Thomas, J., South Wellington School.
Thomson, J. Allan, M.A., D.Sc., F.G.S., F.N.Z.Inst., Dominion Museum, Wellington.
Thomson, John, B.E., M.Inst.C.E., 17 Dorking Road, Brooklyn, Wellington.
Thomson, W. M., M.A., M.B., Ch.B., Hawera.
Tillyard, R. J., M.A., F.E.S., Cawthron Institute, Nelson.
Tolley, H. R., 34 Wright Street, Wellington.
Tombs, H. H., Burnell Avenue, Wellington.
Toogood, H. F., 11 Grey Street, Wellington.
Treadwell, C. H., 4 Panama Street, Wellington.
Turner, E. Phillips, F.R.G.S., Lands and Survey Department, Wellington.
Uttley, G., M.A., M.Sc., F.G.S., Scots College, Miramar.
Vickerman, H., M.Sc., Assoc.M.Inst.C.E., Dominion Farmers' Institute, Featherston Street, Wellington.
Vosseller, F. W., Baker's Buildings, Featherston Street, Wellington.
Waters, R., 71 Fairlie Terrace, Kelburn.
Waterworth, A., 286 Lambton Quay, Wellington.
Webb, E. N., 324 Lambton Quay, Wellington.
Westland, C. J., F.R.A.S., 76 Glen Road, Kelburn.
Widdop, F. C., District Railway Engineer, Thorndon Office, Wellington.
Wilson, F. P., M.A., Victoria University College, Wellington
Wilson, Sir James G., Bull's.
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Wynne, H. J., Railway Department, Wellington.
Young, J. S., Railways, Wellington.

Associate Members.

Bathgate, Miss, Training College, Wellington.
Castle, Miss A., Dominion Museum, Wellington.
Cooke, Miss G. F., Sefton Street, Highland Park, Wellington.
Cotton, Mrs., Plunket Street, Kelburn, Wellington.
Craig, Miss K. M., 122 Molesworth Street, Wellington.
Craig, R. K., 122 Molesworth Street, Wellington.
Haggett, F. G., Trelissick Crescent, Ngaio.
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Harle, Miss, Training College, Wellington.
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Holm, Miss E., Patanga Crescent, Wellington.
Hudson, Mrs. G. V., Hill View, Karori.
Hudson, Miss, Hill View, Karori.
Joyce, Miss, Fitzherbert Terrace, Wellington.
Langdon, C. R., 72 Wellington Road, Kilbirnie.
McKay, A. W., Dominion Museum.
Mestayer, Miss M. K., 139 Sydney Street, Wellington.
Pattle, Miss, Johnsonville.
Pope, Miss, 17 Crieff Street.
Richardson, Miss, Lands and Survey Department, Wellington.
Rump, B., 3 Freeling Street, Island Bay.
Styche, J. E., care of Messrs. Kirkcaldie and Stains, Wellington.
Thomas, H., P.O. Box 199, Wellington.
Topp, J. B., 7 Wellington Road, Kilbirnie.
Tripe, Mrs. J., Selwyn Terrace.

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[* Honorary and life members.]

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Alexander, J., Shortland Street, Auckland.
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Alison, E. W., jun., Bank of New Zealand Chambers, Swanson Street, Auckland.
Alison, Ernest, Takapuna.
Allen, John, Cheltenham Avenue, Devonport.
Allum, John, National Electrical and Engineering Company, Wellesley Street, Auckland.
Ambury, S. J., Greenwood's Corner, Onehunga.
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Bush, W. E., City Engineer, Auckland.
Butler, J., Kauri Timber Company, Customs Street, Auckland.
Butler, Miss, Girls' Grammar School, Auckland.
Buttle, B., Kaiapoi Woollen Company, Elliott Street, Auckland.
Buttle, G. A., Victoria Arcade, Selwyn Road, Epsom, Auckland.
Buttle, J., New Zealand Insurance Company, Queen Street, Auckland.
Cadman, F. P., care of Holland, Gillett, and Co., Customs Street, Auckland.
Caldwell, D. R., Cambridge.
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Carlaw, J., 226 Symonds Street, Auckland.
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Carter, C. M., Lake Town, Takapuna.
Carter, M., Smeeton's Buildings, Queen Street, Auckland.
Casey, W., Hamilton Road, Ponsonby.
Caughey, A. C., care of Smith and Caughey, Queen Street, Auckland.
Caughey, J. Marsden, care of Smith and Caughey, Queen Street, Auckland.
Chambers, S. G., 106 Victoria Arcade, Queen Street, Auckland.
Chatfield, Dr. H. A., Queen Street, Auckland.
Cheal, P. E., Cameron Road, Remuera.
Cheeseman, T. F., F.L.S., F.Z.S., F.N.Z.Inst., Museum, Auckland.
Choyce, H. C., Remuera Road, Remuera.
Clark, A., Wellesley Street, Auckland.
Clark, H. C., Wellesley Street, Auckland.

Clark, M., Wellesley Street, Auckland.
Clark, R. G., care of Robertson Bros., Quay Street, Auckland.
Clarke, S. I., P.O. Box 387, Auckland.
Clay, T. B., care of S. Vaile and Sons, Queen Street, Auckland.
Clayton, C. Z., Ellerslie.
Clayton, D. L., Kauri Timber Company, Customs Street, Auckland.
Cleave, A., High Street, Auckland.
Clinch, J. A., Ph.D., Training College, Auckland.
Coates, T., Orakei.
Coe, James, Mount Eden Road, Auckland.
Colbeck, W. B., New Zealand Insurance Buildings, Queen Street, Auckland.
Cole, Rev. R. H., Gladstone Road, Parnell.
Coleman, J. W., Lower Queen Street, Auckland.
Colwill, J. H., Swanson Street, Auckland.
Coombes, F. H., Victoria Avenue, Remuera.
Cooper, Mr. Justice, Supreme Court, Auckland.
Cooper, A. N., care of Read, Towle, Hellaby, and Cooper, Auckland.
Copeland, M., 97 College Hill, Auckland.
Court, A. J., Karangahape Road, Auckland.
Court, G., Karangahape Road, Auckland.
Court, J., Hamilton Road, Auckland.
Court, J. W., care of J. Court (Limited), Queen Street, Auckland.
Cousins, H. G., Normal School, Wellesley Street, Auckland.
Craig, J. C., care of J. J. Craig (Limited), Queen Street, Auckland.
Crompton, W. J., 3 Mount Pleasant Road, Mount Eden.
Crook, John, 10 Prospect Terrace, Mount Eden.
Cuff, J. C., Emerald Hill, Epsom.
Culling, T. S., Ferry Buildings, Queen Street, Auckland.
Culpan, W., care of Hesketh and Richmond, Wyndham Street, Auckland.
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Davis, Ernest, care of Hancock and Co., Customs Street, Auckland.
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Duder, R. W., Devonport.
Duncan, A., Railway Office, Auckland.
Dunning, James, Lucerne Road, Remuera.
Duthie, D. W., National Bank of New Zealand, Wellington.
Eady, A., Queen Street, Auckland.
Earl, F., K.C., Swanson Street, Auckland.
Edgerley, Miss K., Girls' Grammar School, Auckland.
Edmiston, H. J., care of Champtaloup and Edmiston, Queen Street, Auckland.
Edson, J., Waimarama, Tudor Street, Devonport.
Egerton, Professor C. W., University College, Auckland.
Ellingham, W. R., Customs Street, Auckland.
Elliot, G., Bank of New Zealand Buildings, Swanson Street, Auckland.
Elliot, W., Bank of New Zealand Buildings, Swanson Street, Auckland.
Ellis, A. F., Argyle Street, Ponsonby.
Endean, J., jun., Waitemata Hotel, Auckland.
Entrican, A. J., Customs Street, Auckland.
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Entrican, J. C., Customs Street, Auckland.
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Falla, R. A., Domain Drive, Parnell.
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Farrell, R., Anglesea Street, Auckland.
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Fenwick, R., care of T. and S. Morrin, Auckland.
Ferguson, A. M., care of John Burns and Co. (Limited), Customs Street, Auckland.
Firth, R. W., Wymondsley Road, Otahuhu.
Fisher, F. S., Birkdale.
Fleming, G. H., Remuera Road, Remuera.
Fleming, J., 142 Grafton Road, Auckland.
Florance, R. S., Stipendiary Magistrate, Gisborne.
Fowlds, Hon. G., Queen Street, Auckland.*
Fowlds, G., jun., Queen Street, Auckland.
Frater, J. W., Stock Exchange, Auckland.
Frater, Captain W., Manukau Road, Parnell.
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Garrard, C. W., M.A., Education Offices, Auckland.
George, G., Technical College, Wellesley Street, Auckland.
George, Hon. S. T., St. Stephen's Avenue, Parnell.
Gerard, E., Union Buildings, Customs Street, Auckland.
Gibson, Noel, Dilworth Institute, Remuera.
Gilfillan, H., St. Stephen's Avenue, Parnell.
Gillett, J., care of Hoiland and Gillett, Customs Street, Auckland.
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Girdler, Dr., Khyber Pass Road, Auckland.
Gleeson, J. C., High Street, Auckland.

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Goldie, H., Imperial Buildings, Auckland.
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Gordon, J. B., St. George's Bay Road, Parnell.
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Graham, G., 25 Grafton Road, Auckland.
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Gray, A., Smeeton's Buildings, Queen Street, Auckland.*
Gray, S., Mount Eden Borough Council Offices, Mount Eden.
Gray, W. A., Waitemata Chambers, Auckland.
Greenhough, H. P., 20 Lillington Road. Remuera.
Gribbin, G., Imperial Buildings, Queen Street, Auckland.
Griffin, L. T., Museum, Auckland.
Gulliver, T. V., 503 New Zealand Insurance Buildings, Auckland.
Gunson, J. H., Mayor of Auckland, Church Road, Epsom.
Gunson, R. W., Clifton Road, Takapuna.
Haddow, J. G., Wyndham Street, Auckland.
Haines, H., F.R.C.S., Shortland Street, Auckland.
Hall, J. W., P.O. Box 1048, Auckland.
Hall, Edwin, Seacliff Road, Onehunga.
Hamer, W. H., C.E., Harbour Board Offices, Auckland.
Harbutt, S. J., Selwyn Road, Epsom.
Hardie, J. C., care of Hardie Bros., Queen Street, Auckland.
Harding, E., Dargaville.
Hardley, J. W., Customs Street, Auckland.
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Hazard, W. H., Customs Street West, Auckland.
Heather, H. D., Fort Street, Auckland.
Hemmingway, W. H., Union Buildings, Customs Street, Auckland.
Henning, G., 36 Remuera Road, Auckland.
Herries, Hon. Sir W. H., M.P., Wellington.
Hesketh, H. R., Hesketh and Richmond, Wyndham Street, Auckland.
Hesketh, S., Hesketh and Richmond, Wyndham Street, Auckland.
Hill, J. C., care of Hill and Plummer, Queen Street, Auckland.
Hills, F. M., Arney Road, Remuera.
Holderness, D., Harbour Board Offices, Auckland.
Horton, E., *Herald* Office, Queen Street, Auckland.
Horton, H., *Herald* Office, Queen Street, Auckland
Houghton, C. V., New Zealand Shipping Company, Quay Street, Auckland.
Hovell, S. W., Waihi.
Howey-Walker, A., Queen Street, Auckland.
Hudson, C., Mount Eden Road, Auckland.
Hunter, Ashley, C.E., Swanson Street, Auckland.
Hutchinson, F. R., St. Heliers.
Ick-Hewins, Dr., Howick.
Inglis, Dr. R. T., New Zealand Expeditionary Force.
Isaacs, R. C., St. George's Bay Road, Parnell.
Jackson, J. H., Customs Street, Auckland.
Jackson, Thornton, Jackson and Russell, Auckland.
Johnson, H. Dunbar, 151 Newton Road, Auckland.
Johnson, Professor J. C., M.Sc., University College, Auckland.*
Johnston, Hallyburton, Ngatea, Hauraki Plains.
Johnston, J. B., Stewart and Johnston, Wyndham Street, Auckland.
Johnstone, A. H., Fort Street, Auckland.
Joll, L., Mount Eden.
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Kent, G. S., St. Stephen's Avenue, Parnell.
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Lamb, J. A., Arney Road, Remuera.
Lamb, S. E., B.Sc., University College, Auckland.
Lancaster, T. L., B.Sc., University College, Auckland.
Lang, Sir F. W., M.P., Queenstown Road, Onehunga.
Larner, V. J., Swanson Street, Auckland.
Laurie, B. A., care of W. S. Laurie and Co., Customs Street, Auckland.
Lawson, H. W., National Bank of New Zealand, Queen Street, Auckland.
Leighton, F. W., High Street, Auckland.
Le Roy, E., 42 Queen Street, Auckland.
Lewisham, W. C., care of Robertson Bros., Quay Street, Auckland.
Leyland, S. H., care of Leyland and O'Brien, Customs Street West, Auckland.
Leyland, W. B., care of Leyland and O'Brien, Customs Street West, Auckland.
Leys, Cecil, *Star* Office, Shortland Street, Auckland.
Leys, T. W., *Star* Office, Shortland Street, Auckland.
Lintott, G. S., Customs Street East, Auckland.
Logan, R., Government Insurance Buildings, Queen Street, Auckland.
Long, D., Farmers' Freezing Company, Queen Street, Auckland.
Long, W. H., Woodford Road, Mount Eden.
Lowe, Dr. De Clive, Lower Symonds Street, Auckland
Lunn, A. G., care of Collins Bros., Wyndham Street, Auckland.
Lusk, H. B., King's College, Remuera.

McCullough, Hon. W., Thames.
McDonald, Rev. W., Gardner Road, Epsom.
Macfarlane, J. B., Fort Street, Auckland.
McFarlane, T., C.E., Coromandel.
McGregor, W. R., University College, Auckland.
McIlraith, Dr. J. W., Commercial Hotel, Whangarei.
McIntosh, D. T., 5 Claybrook Road, Parnell.
Mackay, G. J., Queen Street, Auckland.
Mackay, J. G. H., Ellison Chambers, Queen Street, Auckland.
Mackay, P. M., Wellesley Street, Auckland.
Mackellar, Dr. E. D., Manukau Road, Parnell.
McKenzie, Captain G., Devonport.
Mackenzie, Dr. Kenneth, Princes Street, Auckland.
Macky, T. H., care of Macky, Logan, and Co., Elliott Street, Auckland.
McLaughlin, T. M., Phœnix Chambers, Queen Street, Auckland.
Macmillian, C. C., care of Auckland Institute, Auckland.*
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Major, C. T., King's College, Remuera.
Makgill, Dr. R. H., Health Department, Wellington.
Mander, F., M.P., Ranfurly Road, Epsom.
Marriner, H. A., New Zealand Insurance Company, Queen Street, Auckland.
Marsack, Dr., New Zealand Expeditionary Force.
Marshall, J., Te Ataahua, Remuera Road.
Mason, Mrs. F., care of Bank of Australasia, Manaia.
Massey, Right Hon. W. F., M.P., Wellington.
Matthews, H. B., Clonbern Road, Remuera.
Maxwell, L. S., Lower Hobson Street, Auckland.
Mennie, J. M., Albert Street, Auckland.
Miller, E. V., 71 Upland Road, Remuera.
Miller, E. N., Albert Street, Thames.
Milne, J., care of John Chambers and Son, Fort Street, Auckland.
Milne, Miss M. J., Remuera.
Milne, Stewart, care of Milne and Choyce, Queen Street, Auckland.
Milroy, S., Kauri Timber Company, Customs Street West, Auckland.
Milsom, Dr. E. H. B., 18 Waterloo Quadrant, Auckland.
Mitchelson, Hon. E., Waitaramoa, Remuera.
Mitchelson, E. P., Motutara, Waimauku.
Montgomery, Dr. Gladys, Khyber Pass Road, Auckland.
Morrison, A. R., Palmerston Buildings, Auckland.
Morton, E., Customs Street, Auckland.
Morton, H. B., Taumata, Wapiti Avenue, Epsom.
Moses, H. C., No Deposit Piano Company, High Street, Auckland.
Mulgan, A. E , *Star* Office, Auckland.
Mulgan, E. K , Education Offices, Auckland.
Mullins, P., Shaddock Street, Mount Eden.
Murray, G. T., C.E., Public Works Office, Auckland.
Myers, Hon. A. M., M.P., Campbell and Ehrenfried Company, Auckland.
Myers, B., Symonds Street, Auckland.
Napier, W. J., Napier, Luxford, and Smith, A.M.P. Buildings, Queen Street, Auckland.
Nathan, C. J., care of A. H. Nathan and Co., Customs Street, Auckland.
Nathan, D. L., care of L. D. Nathan and Co., Shortland Street, Auckland.
Nathan, N. A., care of L. D. Nathan and Co., Shortland Street, Auckland.*
Neve, B., Technical College, Wellesley Street, Auckland.
Niccol, G., Customs Street West, Auckland.
Nicholson, O., Imperial Buildings, Queen Street, Auckland.
Nolan, H. O., St. Stephen's Avenue, Parnell.
Oliphant, P., 24 Symonds Street, Auckland.
Oliver, W. R. B., F.L.S., H.M. Customs, Auckland.*
Ostler, H. H., care of Jackson, Russell, Tunks, and Ostler, Shortland Street, Auckland.
Owen, Professor G., D.Sc., University College, Auckland.
Parr, Hon. C. J., C.M.G., M.P., Shortland Street, Auckland
Partridge, H. E., Albert Street, Auckland.
Patterson, D. B., 23 Shortland Street, Auckland.
Peacock, T., Queen Street, Auckland.
Perkins, A. W., care of Dalgety and Co., Customs Street West, Auckland.
Petrie, D , M.A., Ph.D., F.N.Z.Inst., "Rosemead," Ranfurly Road, Epsom.
Philcox, T., 11 Fairview Road, Mount Eden.
Philson, W. W., Colonial Sugar Company, Quay Street, Auckland.
Pond, J. A., F.C.S., Queen Street, Auckland.
Porter, A., care of E. Porter and Co., Queen Street, Auckland.
Potter, E. H., P.O. Box 230, Auckland.
Pountney, W. H., Fort Street, Auckland.
Powell, A. W. B., Albany Avenue, Epsom.
Powell, F. E., C.E., Ferry Buildings, Queen Street, Auckland.
Poynton, J. W., 63 Epsom Avenue, Mount Eden.
Price, E. A., Cambria Park, Papatoetoe.
Price, T. G., 109 Queen Street, Auckland.
Pryor, S. H., 26 Pencarrow Avenue, Mount Eden.
Pulling, Miss, Diocesan School, Epsom.
Purchas, Dr. A. C., Carlton Gore Road, Auckland.
Pycroft, A. T., Railway Offices, Auckland.
Ralph, W. J., Princes Street, Auckland.
Rangi Hiroa, Dr., care of Public Health Department Auckland.
Rawnsley, S., Federal Street, Auckland.

Rayner, Dr. F. J., Queen Street, Auckland.
Reed, J. R., K.C., "Cargen," Eden Crescent, Auckland.
Renshaw, F., Sharland and Co., Lorne Street, Auckland.
Rhodes, C., "Ronaki," Remuera.
Richmond, H. P., Arney Road, Remuera.
Robb, J., Victoria Avenue, Mount Eden.
Roberton, A. B., Heather, Roberton, and Co., Fort Street, Auckland.
Roberton, Dr. E., Market Road, Remuera.
Robertson, Dr. Carrick, Alfred Street, Auckland.
Robertson, James, Market Road, Remuera.
Roche, H., Horahora, near Cambridge, Waikato.
Rollett, F. C., *Herald* Office, Queen Street, Auckland.
Rowe, J., Onehunga.
Russell, E. N. A., Russell, Campbell, and McVeagh, High Street, Auckland.
Salt, G. Macbride, University College, Auckland.
Saunders, W. R., Commercial Union Insurance Company, Auckland.
Saxton, A. C., Pyrmont, Sydney.
Scott, D. D., Kempthorne, Prosser, and Co., Albert Street, Auckland.
Scott, Rev. D. D., The Manse, Onehunga.
Segar, Professor H. W., M.A., F.N.Z.Inst., Manukau Road, Parnell.
Shakespear, Mrs. R. H., Whangaparaoa.
Shaw, F., Vermont Street, Ponsonby.
Shaw, H., Epsom.
Shroff, H. R., 108 Victoria Street, Auckland.*
Simmonds, Rev. J. H., Wesley Training College, Epsom.
Simson, T., Mount St. John Avenue, Epsom.
Sinclair, A., Kuranui, Symonds Street, Auckland.
Sinclair, G., care of Pilkington and Co., Queen Street, Auckland.
Skeet, H. M., Pencarrow Avenue, Mount Eden.
Smeeton, H. M., Remuera.
Smith, E., New Brighton, Miranda.*
Smith, H. G. Seth, 88 Victoria Avenue, Remuera.*
Smith, Captain James, Franklin Road, Ponsonby.
Smith, Mrs. W. H., Princes Street, Auckland.
Smith, S. Percy, F.R.G.S., F.N.Z.Inst., New Plymouth.*
Smith, W. Todd, Brooklands, Alfred Street, Auckland.
Somerville, Dr. J., Alfred Street, Auckland.
Somerville, J. M., Birkenhead.
Spedding, J. C., Market Road, Remuera.
Stanton, J., Fort Street, Auckland.
Stevenson, A. G., Gladstone Road, Mount Albert.
Stewart, D. F., care of R. S. Lamb and Co., 32 Jamieson Street, Sydney.
Stewart, J. W., Wyndham Street, Auckland.
Stewart, John A., Kainga-tonu, Ranfurly Road, Epsom.
Stewart, R. Leslie, care of Brown and Stewart, Swanson Street, Auckland.
Streeter, S. C., Enfield Street, Mount Eden.
Suter, A., Loutis, Clonbern Road, Remuera.
Swan, H. C., Henderson.
Talbot, Dr. A. G., A.M.P. Buildings, Queen Street, Auckland.
Thomas, Professor A. P. W., M.A., F.L.S., F.N.Z.Inst., Mountain Road, Epsom.
Thornes, J., Queen Street, Auckland.
Tibbs, J. W., M.A., Grammar School, Auckland.
Tinne, H., Union Club, Trafalgar Square, London.*
Tole, Hon. J. A., Shortland Street, Auckland.
Townson, W., Thames.
Trounson, J., Northcote.
Tudehope, R., Wellesley Street, Auckland.
Tudehope, R. T., 189 Symonds Street, Auckland.
Tunks, C. J., Jackson, Russell, Tunks, and Ostler, Shortland Street, Auckland.
Turner, E. C., care of Turner and Sons, Market Square, Auckland.
Upton, J. H., Bank of New Zealand Buildings, Swanson Street, Auckland.
Upton, P., South British Insurance Company, Queen Street, Auckland.
Upton, P. T., P.O. Box 878, Auckland.
Upton, Selwyn, *Star* Office, Auckland.
Vaile, E. E., Broadlands, Waiotapu.
Vaile, H. E., Queen Street, Auckland.
Veale, P. O., 1 Beresford Street, Auckland.
Vernon, Professor W. S., M.A., University College, Auckland.
Virtue, P., Roller Mills, Quay Street, Auckland.
Wade, Captain, H. L., New Zealand Expeditionary Force.
Wake, F. W., Cleave's Buildings, High Street, Auckland.
Walklate, J. J., Electric Tramway Company, Auckland.
Wallace, T. F., Waihi Gold-mining Company, Shortland Street, Auckland.
Ware, W., Portland Road, Remuera.
Warnock, J. A., 2 King Street, Grey Lynn.
Wells, T. U., Westbourne Road, Remuera.
White, P. C., care of S. White and Sons, Customs Street West, Auckland.
White, R. W., Wellington Street, Auckland.
Whitley, W. S., Albert Street, Auckland.
Whitney, C. A., Colonial Ammunition Company, Auckland.
Whittome, F., Newmarket.
Williams, N. T., National Insurance Company, Queen Street, Auckland.
Williamson, C., Commercial Bank Buildings, Auckland.
Williamson, J. D., Northern Club, Auckland
Wilson, Andrew, District Surveyor, Hangatiki.
Wilson, C. A., P.O. Box 1081, Auckland.
Wilson, F. W., *Herald* Buildings, Queen Street, Auckland.
Wilson, G. A., Wilson and Canham, Ferry Buildings, Auckland.
Wilson, H. W., Town Hall, Auckland.
Wilson, J. A., care of A. Eady and Sons, Queen Street, Auckland.

Wilson, J. M., Portland Road, Remuera.
Wilson, John, New Zealand Insurance Buildings, Queen Street, Auckland.
Wilson, Liston, Upland Road, Remuera.
Wilson, Martyn, Roselle, Lower Remuera.
Wilson, Mrs. R. M., Russell Road, Remuera.
Wilson, W. R., *Herald* Office, Queen Street, Auckland.
Wing, S., Hellabys Limited, Shortland Street, Auckland.
Winkelmann, H., Victoria Arcade, Auckland.
Winstone, F. M., Claude Road, Epsom.*
Winstone, G., Customs Street East, Auckland.
Wiseman, F., Queen Street, Auckland.
Wiseman, J. W., Albert Street, Auckland.
Withy, E., care of Auckland Institute, Auckland.*
Wood, Right Rev. C. J., D.D., Bishop of Melanesia, Norfolk Island.*
Woodward, W. E., Union Bank of Australia, Queen Street, Auckland.
Woollams, W. H., Queen Street, Auckland.
Worley, Professor F. P., D.Sc., University College, Auckland.
Wright, R., care of A. B. Wright and Sons, Commerce Street, Auckland.
Wyllie, A., C.E., Electrical Power Station, Breakwater Road, Auckland.
Yates, E., Albert Street, Auckland.
Young, J. L., Henderson and Macfarlane, Union Buildings, Customs Street, Auckland.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

[* Life members.]

Acland, Dr. H. T. D., 381 Montreal Street, Christchurch.
Acland, H. D., 42 Park Terrace, Christchurch.
Aldridge, W. G., M.A., Technical School, Invercargill.
Alexander, R. E., Canterbury Agricultural College, Lincoln.
Allan, H. H., M.A., F.L.S., High Street, Ashburton.
Allison, H., care of Harman and Stevens, Christchurch.
Alpers, O. T. J., 69 Fendalton Road.
Anderson, Mrs., Murchiston, St. Martin's, Christchurch.
Anderson, J. G., M.Sc., Boys' High School, Invercargill.
Archey, G. E., M.A., Canterbury Museum, Christchurch.
Askew, H. O., B.A., Canterbury College, Christchurch.
Bates, D., Sumner.
Baughan, Miss B. E., Clifton, Sumner.
Beaven, A. W., care of Andrews and Beaven, Moorhouse Avenue, Christchurch.
Beere, Miss M., Public Hospital, Timaru
Bell, E. J., care of Public Library, Christchurch.
Belshaw, Horace, High School, Hawera.
Berry, R. E., 165 Manchester Street, Christchurch.
Bevan-Brown, C. E., M.A., Hackthorne Road, Christchurch.
Bevis, Miss J. F., B.Sc., 286 Madras Street, Christchurch.
Bingham, S. C., 31 Gracefield Street, Christchurch.
Bird, J. W., M.A., Scots College, Wellington.
Birks, L., B.Sc., care of Public Works Department, Wellington.
Bishop, F. C. B., 10 Cranmer Square, Christchurch.
Bishop, R. C., Gas Office, 77 Worcester Street, Christchurch.
Bissett, J. W., Kaiapoi Woollen Company, Christchurch.
Boag, T. D., Bryndwyr.
Booth, G. T., 242 Papanui Road, Christchurch.
Borrie, Dr. F. J., 236 Hereford Street, Christchurch.
Borrie, Miss, 236 Hereford Street, Christchurch.
Bradley, Orton, Charteris Bay.
Brittin, Guy, Riwaka, Motueka, Nelson.
Broadhead, H. D., M.A., Boys' High School, Christchurch.
Brock, W., M.A., Education Office, Christchurch.
Brown, Professor Macmillan, M.A., LL.D., "Holmbank," Cashmere Hills.*
Burnett, T. D., Cave, South Canterbury.
Campbell, J. W., Chancery Lane, Christchurch.
Candy, F. R., care of Tramway Office, Christchurch.
Chilton, Professor C., D.Sc., M.A., LL.D., F.N.Z.Inst., F.L.S., Canterbury College, Christchurch.*
Christensen, C. E., Rotorua.
Clark, W. H., 100 Bealey Avenue, Christchurch.
Cocks, Rev. P. J., B.A., St. John's Vicarage, Christchurch.
Cocks, Miss, Colombo Road South, Christchurch.
Colee, W. C., M.A., Schoolhouse, Waimataitai, Timaru.
Coles, W. R., 446 Wilson's Road, Christchurch.
Collins, J. G., care of Collins and Harman, Christchurch.
Condliffe, Professor J. B., M.A., Canterbury College, Christchurch.
Coombs, Miss, 37 Sherbourne Street, Christchurch.

Cowley, S. R., 156 Antigua Street, Christchurch.
Cradock, Miss F., care of A. Hopkins, Cathedral Square, Christchurch.
Dash, Charles, 233 Norwood Street, Beckenham, Christchurch.
Day, James S., care of Dominion Trust Company, 163 Hereford Street, Christchurch.
Deans, John, Kirkstyle, Coalgate.
Deans, William, Sandown, Waddington.
Dobson, A. Dudley, M.Inst.C.E., City Council Office, Christchurch.
Dorrien-Smith, Major A. A., D.S.O., Tresco Abbey, Scilly, England.
Dougall, J. J., 105 Clyde Road, Christchurch.
Drummond, James, F.L.S., F.Z.S., *Lyttelton Times*, Christchurch.
English, R., F.C.S., M.I.M.E., Gas Office, Christchurch.
Evans, Professor W. P., M.A., Ph.D., Canterbury College, Christchurch.
Everist, W., 69 Dyer's Pass Road, Christchurch.
Fairbairn, A., 53 Fendalton Road, Christchurch.
Farr, Professor C. Coleridge, D.Sc., F.P.S.L., F.N.Z.Inst., Canterbury College, Christchurch.
Ferrar, Miss, 450 Armagh Street, Christchurch.
Ferrar, H. T., M.A., F.G.S., Hackthorne Road, Cashmere, Christchurch.*
Flesher, J. A., 169 Hereford Street, Christchurch.
Flower, A. E., M.A., M.Sc., Christ's College, Christchurch.
Foster, Dr. A., 135 Hereford Street, Christchurch.
Foweraker, C. E., M.A., Canterbury College, Christchurch.
Francis, J. W. H., care of Rhodes, Ross, and Godby, Hereford Street, Christchurch.
Freeman, Dr. D. L., N.D.A., Editor, *Farmer*, Auckland.
Gabbatt, Professor J. P., M.A., M.Sc., Canterbury College, Christchurch.
Garnett, J. B., N.D.A., N.D.D., Technical College, Christchurch.
Garton, John W., Woolston Tanneries (Limited), Woolston, Christchurch.
Garton, W. W., M.A., The School, Pleasant Point.
Gibson, Dr. F. Goulburn, 121 Papanui Road.
Gilling, C. D., The School, Hornby.
Gilling, W. O. R., M.A., B.Sc., 206 Westminster Street, St. Albans, Christchurch.
Godby, M. H., M.A., B.Sc., Hereford Street, Christchurch.
Godby, Mrs. M. D., 12 Holmwood Road, Fendalton, Christchurch.
Goss, W., Peterborough Street, Christchurch.
Gould, George, 4 Fendalton Road, Christchurch.
Gourlay, E. S., 415 River Road, Christchurch.
Gourlay, H., 519 Manchester Street, Christchurch.
Graham, Charles H. E., School, Tai Tapu.
Gray, G., F.C.S., Lincoln.
Greenwood, F., B.A., Agricultural Department, Wellington.
Grigg, J. C. N., Longbeach.
Gudex, M. C., M.A., M.Sc., Boys' High School, Christchurch.
Guthrie, Dr. John, Armagh Street, Christchurch.
Hamilton, W. M., 365 Papanui Road, Christchurch.
Hansen, Dr. D. E., M.A., M.Sc., Technical College, Christchurch.
Haszard, H. D. M., F.R.G.S., Lands Office, Christchurch.
Haynes, E. J., Canterbury Museum, Christchurch.
Hayward, J. R., 48 Peterborough Street, Christchurch.
Herring, E., 28 Paparoa Street, Papanui.
Herriott, Miss E. M., M.A., Canterbury College, Christchurch.
Hewitt, S. J., 234 Selwyn Street, Christchurch.
Hight, Professor J., M.A., Litt.D., Canterbury College, Christchurch.
Hilgendorf, F. W., M.A., D.Sc., F.N.Z.Inst., Canterbury Agricultural College, Lincoln.*
Hill, Mrs. Carey, Clifton, Sumner.
Hitchings, F., F.R.A.S., 69, Durham Street, Sydenham.
Hodgson, T. V., F.L.S., Science and Art Museum, Plymouth, England.
Hogg, E. G., M.A., F.R.A.S., Hackthorne Road, Cashmere, Christchurch.
Hogg, H. R., M.A., F.Z.S., 7 St. Helen's Place, London E.C.
Holford, George, B.Ag., care of Canterbury Farmers' Co-operative, Christchurch.
Holland, H., 108 St. Asaph Street, Christchurch.
Holloway, Rev. J. E., D.Sc., F.N.Z.Inst., Hokitika.
Howard, E. J., care of Trades Hall, Christchurch.
Humphreys, G., Fendalton Road, Fendalton.
Hutton, D. E., 25 Garden Road, Christchurch.
Ingram, John, 39 Mansfield Avenue, St. Albans.
Irving, Dr. W., 56 Armagh Street, Christchurch.
Jameson, J. O., 152 Hereford Street, Christchurch.
Jamieson, A. W., 404 Hereford Street, Christchurch.
Jamieson, W. G., Deans Avenue, Lower Riccarton.
Jobberns, G., B.Sc., Division Street, Lower Riccarton.
Johnston, A. A., M.R.C.V.S., 90 McFadden's Road, Christchurch.
Jones, E. G., B.A., B.Sc., Technical College, Christchurch.
Keir, James, care of P. and D. Duncan (Limited), Christchurch.
Kidson, Lieutenant E. R., M.Sc., care of H. T. Kidson, Van Dieman Street, Nelson.*

Kirkpatrick, W. D., F.R.H.S., M.A., Redcliffs, Sumner.
Kitchingman, Miss, 205 Hackthorne Road, Cashmere.
Knight, H. A., Racecourse Hill.
Laing, R. M., M.A., B.Sc., Boys' High School, Christchurch.
Lester, Dr. G. M. L., 2 Cranmer Square, Christchurch.
Lindsay, Dr. A. B., B.Sc., 243 Hereford Street, Christchurch.
Longworth, H. E., Education Department, Wellington.
Louisson, Dr., M. G., 136 Worcester Street, Christchurch.
Louisson, Hon. C., M.L.C., care of Crown Brewery, Christchurch.
Macartney, R., Tai Tapu.
Macbeth, N. L., Canterbury Frozen Meat Company, Hereford Street, Christchurch.
McBride, T. J., 15 St. Albans Street, Christchurch.
McCallum, Dr. Bella D., M.A., 11 Ramsay Gardens, Edinburgh.
Macleod, D. B., M.A., B.Sc., Canterbury College, Christchurch.
Marriner, H. J., Sumner.
Marsh, H. E., care of Bank of New Zealand, Christchurch.
Marshall, Mrs., 72 Bealey Street, St. Albans.
Martin, William, B.Sc., Education Office, Christchurch.
Meares, H. O. D., Fendalton.
Mills, Miss M. M., M.A., Temuka.
Monro, A. D., B.Sc., Canterbury College, Christchurch.
Morkane, Dr. C. F., 153 Hereford Street, Christchurch.
Montgomery, John, corner Garden and Holmwood Roads, Fendalton.
Morrison, W. G., Hanmer.
Mountford, A. V., F.C.S., care of Labour Department, Wellington.
Murray, Miss F. B., Canterbury College, Christchurch.
Murray, W., "Balgownie," Opawa.
Nairn, R., Lincoln Road, Spreydon.
Neal, N. P., Canterbury College, Christchurch.
Newburgh, W. S., care of Newburgh, Best, and Co., Cathedral Square, Christchurch.
Newton, A. Wells, 58 Brittan Street, Linwood.
Oliver, F. S., care of C. E., Salter, Hereford Street, Christchurch.
Olliver, Miss F. M., M.A., M.Sc., Waimate.
Ollivier, C. M., St. Martin's, Christchurch.
Orbell, N. M., Heaton Street, St. Albans.
Owen, H., care of Cook and Ross, Christchurch.
Overton, Miss, 24 Hereford Street, Christchurch.
Page, S., B.Sc., Canterbury College, Christchurch.
Pairman, Dr. J. C., 21 Latimer Square, Christchurch,
Pairman, Dr. T. W., Governor's Bay.
Pannett, J. A., Cashmere Hills.
Paterson, A. D., care of H. Hobday, 60 Hereford Street, Christchurch.
Pearson, Dr. A. B., Hospital, Christchurch.
Pemberton, O. B., care of A. and P. Rooms, Manchester Street, Christchurch.
Penlington, G., F.N.Z.I.A., Warrington Street, St. Albans.
Polson, J. G., M.A., F.R.E.S., Training College, Christchurch.
Powell, P. H., M.Sc., Canterbury College, Christchurch.
Prudhoe, J. C., 20 Kidson Terrace, Cashmere.
Purchase, J. E., M.A., F.R.E.S., Training College, Christchurch.
Purdie, William C., Agricultural College, Lincoln.
Purnell, C. W., Ashburton.
Purnell, George P., 106 Gloucester Street, Christchurch.
Raymond, S. G., K.C., Heaton Street, St. Albans.
Reece, W., Dyer's Pass Road, Cashmere.
Relph, E. W., care of New Zealand Farmers' Co-operative.
Rennie, J. M., *Sun* Office, Christchurch.
Rhodes, A. E. G., B.A., Fendalton.
Rhodes, Miss B. H. E., 86 Salisbury Street, Christchurch.
Rhodes, Hon. Sir R. Heaton, M.P., Tai Tapu.
Rhodes, J. H., care of Rhodes, Ross, and Godby, Christchurch.
Robinson, R. G., Darfield.
Robinson, W. F., F.R.G.S., Canterbury College, Christchurch.
Ross, R. G., P.O. Box 450, Christchurch.
Rowe, H. V., M.A., Boys' High School, Christchurch.
Ryder, A. R., M.A., Boys' High School, New Plymouth.
Sanders, C. J., care of Dominion Yeast Company, Christchurch.
Sandston, Dr. A. C., Latimer Square, Christchurch.
Scott, G., Manchester Street, Christchurch.
Scott, Professor R. J., M.Inst.C.E., F.A.I.E.E., Canterbury College, Christchurch.
Seager, S. Hurst, F.R.I.B.A., Cathedral Square, Christchurch.
Seth-Smith, B., 1 Garden Road, Fendalton.
Sheard, Miss F., M.A., B.Sc., Girls' High School, Christchurch.
Shelley, Professor J., M.A., Canterbury College, Christchurch.
Simpson, Dr. W., 108 Rugby Street, St. Albans.*
Sims, A., M.A., care of Sims, Cooper, and Co., Hereford Street, Christchurch.
Skey, H. F., B.Sc., Magnetic Observatory, Christchurch.
Skinner, W. H., 3 York Terrace, New Plymouth.
Slater, Dr. F., Sumner.
Slocombe, C., B.Sc., Agricultural Department, Wellington.
Snow, Colonel, Holmwood Road, Christchurch

Speight, R., M.A., M.Sc., F.G.S., F.N.Z.Inst., Canterbury Museum, Christchurch.
Stark, E. E., B.Sc., P.O. Box 526, Christchurch.
Stead, E. F., Ilam, Riccarton.
Steele, G. P., care of Wilton and Co., Christchurch.
Stevens, J. E., Deaf-mute Institute, Sumner.
Stevenson, Dr. J., Fendalton.
Stevenson, James, Flaxton.
St. John, Charles E., 745 Colombo Street, Christchurch.
Stone, T., *Lyttelton Times* Office, Christchurch.
Sullivan, D. G., *Sun* Office, Christchurch.
Symes, Dr. W. H., M.B., B.Sc., 63 Worcester Street, Christchurch.*
Symes, Langford P., 20 May's Road, Papanui.
Tabart, Miss Rose, 97 Papanui Road, Christchurch.
Taylor, A., M.A., M.R.C.V.S., Canterbury Agricultural College, Lincoln.
Taylor, G. J., 440 Madras Street, St. Albans.
Templin, J. R., 10 Wroxton Terrace, Fendalton.
Thacker, Dr. H. T. J., M.P., 25 Latimer Square, Christchurch.
Thomas, Dr. J. R., 29 Latimer Square, Christchurch.
Tripp, C. H., M.A., Timaru.*
Waddell, John, 167 St. Asaph Street, Christchurch.
Wall, Professor A., M.A., Canterbury College, Christchurch.
Waller, F. D., B.A., West Christchurch District High School.
Warren, F. M., 56 Clyde Road, Riccarton.
Way, G. E., 66 Dyer's Pass Road, Christchurch.*
Waymouth, Mrs., care of Mrs. R. M. Hughes, St. Buryan, S.O., Cornwall, England.
Weston, G. T., B.A., LL.B., 152 Manchester Street, Christchurch.
Whetter, Dr. J. P., 211 Gloucester Street, Christchurch.
Whitaker, C. Godfrey, care of Booth, Macdonald, and Co., Carlyle Street, Christchurch.
Widdowson, Dr. H. L., 4 Oxford Terrace, Christchurch.
Wigram, Hon. H. F., M.L.C., 1 Armagh Street, Christchurch.
Wild, L. J., M.A., B.Sc., F.G.S., Canterbury Agricultural College, Lincoln.
Wilding, Frank S., care of Wilding and Acland, Hereford Street, Christchurch.
Wilkins, T. J. C., B.A., Somerfield Street School, Spreydon.
Williams, C. J. R., M.Inst.C.E., 21 Knowles Street, St. Albans.
Wright, A. M., A.I.C., F.C.S., 482 Lincoln Road, Christchurch.
Valentine, J. A., Education Office, Hokitika.
Vowell, C., I.E., Technical College, Christchurch.

OTAGO INSTITUTE.

[* Life members.]

Aldridge, A. P., Power-house, Waipori.
Allen, Hon. Sir James, High Commissioner, London.
Allen, Dr. S. C., 220 High Street.
Angell, S., Commercial Bank of Australia, Princes Street.
Anscombe, E., 171 Princes Street,
Balk, O., 13 Driver Street, Maori Hill.
Barnett, Dr. L. E., Stafford Street.
Barr, Peter, 3 Montpelier Street.
Bathgate, Alex., 85 Glen Avenue, Mornington.*
Beal, L. O., Stock Exchange Buildings.
Begg, J. C., Fifield Street, Roslyn.
Bell, A. Dillon, Shag Valley.*
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Benson, Professor W. N., B.A., D.Sc., F.G.S., University.
Betts, Miss M. W., M.Sc., Museum.
Black, Alexander, 82 Clyde Street.*
Black, James, care of Cossens and Black, 164 Crawford Street.
Bowie, Dr. J. T., London Street.
Bowron, G. W., 426 Moray Place.
Brasch, H., 99 London Street.
Brent, D., M.A., 19 New Street, Musselburgh.*
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Buchanan, N. L., 44 Bronte Street, Nelson.*
Buddle, Dr. Roger, care of Buddle and Button, Wyndham Street, Auckland.
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Cameron, Rev. A., B.A., LL.D., Tweed Street, Roslyn.
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Chamberlain, C. W., 6 Regent Road.
Chapman, C. R., 135 Town Belt, Roslyn.
Church, Dr. R., 257 High Street.
Clarke, C. E., 51 King Edward Road.
Clarke, E. S., Woodhaugh.
Colquhoun, Dr. D., 218 High Street.
Coombs, L. D., A.R.I.B.A., Stuart Street and Octagon.
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Davies, O. V., 109 Princes Street.
Davis, A., Test-room, Cumberland Street.
De Beer, I. S., 75 London Street.
Duncan, P., "Tolcarne," Maori Hill.
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Edgar, James, 286 York Place.
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Fels, W., 84 London Street.*
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Fenwick, Sir G., *Otago Daily Times* Office.

Ferguson, Dr. H. L., C.M.G., "Wychwood," Musselburgh Rise.
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Fitchett, Dr. F. W. B., 8 Pitt Street.
Fleming, T. R., M.A., LL.B., Education Office.
Frye, Charles, Gasworks, Caversham.
Fulton, H. V., Agricultural and Pastoral Society, Crawford Street.
Fulton, Dr. R. V., Pitt Street.
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Gilkison, R., 14 Main Road, North-east Valley.*
Goyen, P., F.L.S., 136 Highgate, Roslyn.
Gray, J. A., 762 Cumberland Street.
Green, E. S., Education Office.
Guthrie, H. J., 426 Moray Place East.
Hall, Dr. A. J., 36 Stuart Street.
Hanlon, A. C., 16 Pitt Street.
Henderson, M. C., Electrical Engineer's Office, Market Street.
Hercus, G. R., 20 Albert Street.
Hoffmann, G., Littlebourne Crescent.
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Johnson, A. G., M.Sc., King Edward Technical College.
Johnson, J. T., 46 Littlebourne Road, Roslyn.
Johnstone, J. A., Driver Street, Maori Hill.
Jones, F. J., Railway Engineer's Office.
Kennedy, A. R., Registrar's Office, Dunedin.
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Lee, Robert, P.O. Box 363.
Loudon, John, 43 Crawford Street.
Lowry, J. M., Public Works Department.
McCurdie, W. D. R., Town Hall.*
Macdougall, W. P., jun., 642 George Street.
McGeorge, J. C., Eglinton Road, Mornington.
McKellar, Dr. T. G., Pitt Street.
Mackie, A., Test-room, Cumberland Street.
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Melland, E., Arthog Road, Hale, Cheshire, England.*
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Newlands, Dr. W., 12 London Street.
O'Neill, Dr. E. J., 219 High Street.
Overton, T. R., Test-room, Cumberland Street.
Park, Professor J., F.G.S., F.N.Z.Inst., University.
Payne, F. W., 90 Princes Street.
Petrie, D., M.A., F.L.S., F.N.Z.Inst., Ranfurly Road, Epsom, Auckland.*
Philpott, A., Cawthron Institute, Nelson.
Pickerill, Professor H. P., M.D., B.D.S., University.
Poppelwell, D. L., Gore.
Price, W. H., 55 Stuart Street.*
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Reid, Donald, jun., 9 Dowling Street.
Riley, Dr. F. R., 6 Pitt Street.
Ritchie, Dr. Russell, 400 George Street.
Roberts, E. F., 128 Highgate, Roslyn.
Roberts, John, C.M.G., Littlebourne.
Robertson, John, B.A., B.Sc., 13 Garfield Street, Roslyn.
Rogers, L. S., Pacific Street, Roslyn.
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Ross, T. C., care of Ross and Glendining (Limited).
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Simpson, George, 98 Russell Street.
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Thomson, Hon. G. M., F.L.S., F.N.Z.Inst., M.L.C., 99 Eglinton Road, Mornington.*
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Wales, P. Y., 2 Crawford Street.
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Waters, Professor D. B., A.O.S.M., University.
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Williams, J., B.Sc., F.C.S., Otago Boys' High School.
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Wingfield, J. E., 663 Castle Street.
Woodthorpe, Ven. Archdeacon, Selwyn House, Cumberland Street.
Young, Dr. James, Don Street, Invercargill.

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Daly, A. J., George Street.
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Hurley, E. O., The Square.
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Stevensen, J. C., High School.
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Sutherland, A., Boundary Road.
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[* Life member.]

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D'Arcy, W. A., 11 Campbell Street, Wanganui.

Downes, T. W., Victoria Avenue, Wanganui.
Drew, Harry, Victoria Avenue, Wanganui.
Duigan, Herbert, Ridgway Street, Wanganui.
Dunn, Richmond, St. John's Hill, Wanganui.
Ford, C. R., F.R.G.S., College Street, Wanganui.
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Jack, J. B., Native Land Court, Wanganui.
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Marshall Professor P., M.A., D.Sc., F.G.S., F.N.Z.Inst., Collegiate School, Wanganui.
Murdoch, R., Campbell Place, Wanganui.
Murray, J. B., St. John's Hill, Wanganui.
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Park, G., B.Ecom., Technical College.
Polson, D. G., St. John's Hill, Wanganui.
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Talboys, F. P., Tramways Manager, Wanganui.
Ward, J. T., Victoria Avenue, Wanganui.*
Watt, J. P., B.A., LL.B., Ridgway Street, Wanganui.
Watt, M. N., St. John's Hill, Wanganui.
Wilson, Alexander, M.D., Wickstead Street, Wanganui.

POVERTY BAY INSTITUTE.

Abbey, Rev. W. H. E., 251 Palmerston Road, Gisborne.
Aitkin, Rev. James, St. Andrew's Manse, Gisborne.
Beale, A. M., Waipiro Bay.
Beere, Major A. G., Clifford Street, Gisborne.
Black, G. J., Kaiti.
Blair, James, Kaiti.
Blake, V. I., Survey Department, Auckland.
Bull, H., Gladstone Road, Gisborne.
Burnard, L. T., Gladstone Road, Gisborne.
Buswell, W. H., Borough Council Office, Gisborne.
Cuthert, A., Gladstone Road, Gisborne.
Florance, R. S., Kaiti.
Foote, F., High School, Gisborne.
Goffe, W. E., Ormond Road, Mangapapa.
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Greer, Miss M., Ormond Road, Gisborne.
Hutchinson, E. M., Waihuka, Gisborne.
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Kinder, J., Gladstone Road, Gisborne.
Lees, E. L., Childers Road, Gisborne.
Lysnar, W. L., Stout Street, Whataupoko, Gisborne.
Mander, M. B., Riverside Road, Gisborne.
Mann, E. H., Lowe Street, Gisborne.
Maunder, G. H., Stout Street, Gisborne.
Mirfield, T., Gladstone Road, Gisborne.
Mouat, John, Gladstone Road, Gisborne.
Muir, A. L., Fitzherbert Street, Gisborne.
Oakley, Mrs., Grey Street, Gisborne.
O'Ryan, William, Waipiro Bay.
Parlane, Rev. James, Stout Street, Gisborne.
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Rowley, F. J., Ormond Road, Gisborne.
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Tiffen, G. W., Gisborne.
Townley, John, Gladstone Road, Gisborne.
Tucker, H. G., Makauri.
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Wainwright, Rev.
Walker, Mrs., Fox Street, Gisborne.
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Journal of Science and Technology.
New Zealand Employers' Federation: *Industrial Bulletin.*
New Zealand Official Year-book.
Polynesian Society: *Journal.*
Statistics of New Zealand.

Australia.

Australasian Institute of Mining Engineers: *Proceedings.*
Australian Antarctic Expedition, 1911–14: *Reports.*
Australian Forestry Journal.
Commonwealth of Australia, Fisheries: *Parliamentary Report.*

New South Wales.

Agricultural Department, N.S.W.: *Agricultural Gazette.*
Australian Museum, Sydney: *Records; Annual Report.*
Botanic Gardens and Government Domains, N.S.W.: *Report.*
Critical Revision of the Genus Eucalyptus.
Linnean Society of N.S.W.: *Proceedings.*
Northern Engineering Institute of N.S.W.: *Papers.*
Public Health Department, N.S.W.: *Annual Report.*

Queensland.

Geological Survey of Queensland: *Publications.*
Queensland Naturalist.
Royal Geographical Society: *Journal.*
Royal Society of Queensland: *Proceedings.*

South Australia.

Adelaide Chamber of Commerce: *Annual Report.*
Department of Chemistry, South Australia: *Bulletins.*
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Royal Society of South Australia: *Transactions and Proceedings.*

Tasmania.

Royal Society of Tasmania: *Papers and Proceedings.*

Victoria.

Advisory Committee: *Report on Brown Coal.*
Department of Agriculture: *Journal.*
Field Naturalists' Club of Victoria: *Victorian Naturalist.*
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Western Australia.

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Board of Agriculture and Fisheries: *Fishery Investigations.*
Botanical Society of Edinburgh: *Transactions and Proceedings.*
British Association for the Advancement of Science: *Report.*
British Astronomical Association: *Journal; Memoirs; List of Members.*
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Geological Survey of Great Britain: *Summary of Progress.*
Handbooks, Commercial Towns, England.
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Institution of Civil Engineers: *Report.*
Leeds Philosophical and Literary Society: *Annual Report.*
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Liverpool Biological Society: *Proceedings.*
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Marlborough College Natural History Society: *Reports.*
Mercantile Guardian, London.
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Royal Society, Dublin: *Economic Proceedings.*
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Royal Society, London: *Proceedings* (Series A, B); *Phil. Trans.* (Series A, B); *Year-book.*
Royal Society of Literature: *Transactions.*
Royal Statistical Society, London: *Journal.*
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Zoological Society of London: *Proceedings and Transactions.*

Belgium.

Académie Royale de Belgique : *Bulletins.*
Librairie Nationale d'Art et d'Histoire : *Les Cahiers belges.*
Société Royale de Botanique de Belgique : *Bulletins.*
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