TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE.

1876.

VOL. IX.

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

BY

JAMES HECTOR, C.M.G., M.D., F.R.S.,

MANAGER.

ISSUED MAY, 1877.

WELLINGTON:
LYON & BLAIR, PRINTERS, LAMBTON QUAY.
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PREFACE.

The present Volume contains only the Transactions of the Institute for the year, comprising a selection from the original papers read before the various affiliated Societies. As they alone occupy more space than any previous issue, the Proceedings, Minutes, and Presidential Addresses and Lectures, heretofore included in the Volume, have been deferred for future publication. For the same reason the publication of the following papers has had to be postponed:—

1. Observations on the Evidences of Recent Change in the Elevation of the Waikato. By James Stewart, C.E.
2. Remarks upon the supposed Pleistocene Glaciation of New Zealand, and Post-Glacial Moas. By J. Cockburn Hood, F.G.S.
3. Notice of a *Senecio*. By J. Buchanan, F.L.S.
4. Observations on Captain Hutton's paper on the Maori Cooking-Places at the Mouth of Shag River (Vol. VIII., "Trans. N. Z. Inst.," pp. 103-8). By Julius von Haast, Ph.D., F.R.S.
5. On a New Fire Grate for Economizing the Combustion of Coals and Lignite, and increasing the Radiation of Heat. By H. Skey.
6. On the Approximate Composition of Winslow's Soothing Syrup. By W. Skey.
7. On the proposed Introduction of the Polecat into New Zealand. By Walter L. Buller, C.M.G., D.Sc.
8. On a Marine Spider found at Cape Campbell. By C. H. Robson.
9. On the supposed Influence of Climate over the Geographical Distribution of the Marine Mollusca. By C. W. Purnell.
10. Notice of a Meteorite. By James Leece.
11. Scientific Instruction in New Zealand. By Professor Bickerton, F.C.S.

The late period at which many of the papers were received has caused some delay in the issue of the Volume, and imposed much extra labour on the Assistant Editor, Mr. Leonard Stowe, to whom the acknowledgments of the Board are due for the efficient manner in which the corrections for the press have been performed.

The Editor has also to recognise the assistance of Mr. R. B. Gore in preparing the Meteorological Statistics appended to the Volume, and of Mr. John Buchanan, F.L.S., by whom most of the Illustrations have been drawn on stone, the printing having been done at the Government Lithographic Establishment by permission of the Hon. the Colonial Secretary.

ERRATA.

PAGE

145, line 19, *for* spar-wheels *read* spur-wheels.
229, *for* Art. XIX *read* XIXA.
326, *for* Walter A. Buller *read* Walter L. Buller.
590, *for* Art. XCII. *read* Art. XCI.

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NEW ZEALAND INSTITUTE.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND, INTITULED "THE NEW ZEALAND INSTITUTE ACT, 1867."

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GAZETTED IN THE "NEW ZEALAND GAZETTE," MARCH 9, 1868.

SECTION I.

Incorporation of Societies.

1. No Society shall be incorporated with the Institute under the provisions of "The New Zealand Institute Act, 1867," unless such Society shall consist of not less than twenty-five Members, subscribing in the aggregate a sum of not less than fifty pounds 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 Chairman 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 tfme be less than £50.

3. The bye-laws of every Society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of its annual 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 Museum and Library of the New Zealand Institute.

4. Any Society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue affixed in manner provided by Rule 3 aforesaid, shall from thenceforth cease to be incorporated with the Institute.

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 may then be published as proceedings or transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

Regulations regarding Publications.

(*a.*) The publications of the Institute shall consist of 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," and of transactions comprising papers read before the Incorporated Societies (subject, however, to selection as hereinafter mentioned), to be intituled, "Transactions of the New Zealand Institute."

(*b.*) The Institute shall have power to reject any papers read before any of the Incorporated Societies.

(*c.*) Papers so rejected will be returned to the Society before which they were read.

(*d.*) A proportional contribution may be required from each Society towards the cost of publishing the proceedings and transactions of the Institute.

(*e.*) Each Incorporated Society will be entitled to receive a *proportional* number of copies of the proceedings and transactions of the Institute, to be from time to time fixed by the Board of Governors.

(*f.*) Extra copies will be issued to any of the Members of Incorporated Societies at the cost price of publication.

6. All property accumulated by or with funds derived from Incorporated Societies and placed in the 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. Subject to "The New Zealand Institute Act, 1867," 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 bye-laws for their own management, and shall conduct their own affairs.

8. Upon application signed by the Chairman and countersigned by the Secretary of any Society, accompanied by the certificate required under Rule 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 rules of the Institute are complied with by the Society.

Section II.

For the Management of the Property of the Institute.

9. All donations by Societies, Public Departments, or private individuals, to the Museum of the Institute, shall be acknowledged by a printed form of receipt, and shall be duly entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

10. Deposits of articles for the Museum may be accepted by the Institute, subject to a fortnight's notice of removal to be given either by the owner of the articles or by the Manager of the Institute, and such deposits shall be duly entered in a separate catalogue.

11. Books relating to Natural Science may be deposited in the Library of the Institute, subject to the following conditions:—

(*a.*) Such books are not to be withdrawn by the owner under six months' notice, if such notice shall be required by the Board of Governors.

(*b.*) Any funds specially expended on binding and preserving such deposited books, at the request of the depositor, shall be charged against the books, and must be refunded to the Institute before their withdrawal, always subject to special arrangements made with the Board of Governors at the time of deposit.

(*c.*) No books deposited in the Library of the Institute shall be removed for temporary use except on the written authority or receipt of the owner, and then only for a period not exceeding seven days at any one time.

12. All books in the Library of the Institute shall be duly entered in a catalogue, which shall be accessible to the public.

13. The public shall be admitted to the use of the Museum and Library, subject to bye-laws to be framed by the Board.

Section III.

14. The Laboratory shall, for the time being, be and remain under the exclusive management of the Manager of the Institute.

Section IV.

Of Date 23rd September, 1870.

Honorary Members.

Whereas the rules of the Societies incorporated under the New Zealand Institute Act provide for the election of Honorary Members of such Societies; but inasmuch as such Honorary Members would not thereby become Members of the New Zealand Institute, and whereas it is expedient to make provision for the Election of Honorary Members of the New Zealand Institute, it is hereby declared—

1st. Each Incorporated Society may, in the month of November next, nominate for election as Honorary Members of the New Zealand Institute three persons, and in the month of November in each succeeding year one person, not residing in the Colony.

2nd. 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 Manager of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

3rd. From the persons so nominated, the Governors may select in the first year not more than nine; and in each succeeding year not more than three, who shall from thenceforth be Honorary Members of the New Zealand Institute, provided that the total number of Honorary Members shall not exceed thirty.

LIST OF INCORPORATED SOCIETIES.

NAME OF SOCIETY.	DATE OF INCORPORATION	
Wellington Philosophical Society	10th June,	1868.
Auckland Institute	10th June,	1868.
Philosophical Institute of Canterbury	22nd October,	1868.
Otago Institute	18th October,	1869.
Nelson Association for the Promotion of Science and Industry	23rd Sept.,	1870.
Westland Institute	21st December,	1874.
Hawke Bay, Philosophical Institute	31st March,	1875.

WELLINGTON PHILOSOPHICAL SOCIETY.

Office-bearers for 1876.—*President*—Dr Buller, C.M.G., F.L.S., F.G.S.; *Vice-Presidents*—T. Kirk, F.L.S., and C. C. Graham; *Council*—W. T. L. Travers. F.L.S., J. C. Crawford, F.G.S., Dr. Hector, C.MG., F.R.S., J. Carruthers, C.E., Hon. W. B. D. Mantell, F.G.S., J. R. George, C.E., J. Marchant; *Auditor*—A. Baker; *Secretary and Treasurer*—R. B. Gore.

Office-bearers for 1877.—*President*—W. T. L. Travers, F.L.S.; *Vice-Presidents*—T. Kirk, F.L.S., J. Carruthers, M.Inst.C.E.; *Council*—Dr. Buller, C.M.G., F.L.S., C. C. Graham, James Hector, M.D., C.M.G., F.R.S., Hon. W. B. D. Mantell, F.G.S., J. C. Crawford, F.G.S., A. K. Newman, M.B., M.R.C.P., C. Rous Marten, F.R.G.S., F.M.S.; *Secretary and Treasurer*—R. B. Gore; *Auditor*—Arthur Baker.

Extracts from the Rules of the Wellington Philosophical Society.

5. Every Member shall contribute annually to the funds of the Society the sum of one guinea.

6. The annual contribution shall be due on the first day of January in each year.

7. The sum of ten pounds may be paid at any time as a composition for life of the ordinary annual payment.

14. The time and place of the General meetings of Members of the Society shall be fixed by the Council, and duly announced by the Secretary.

AUCKLAND INSTITUTE.

Office-bearers for 1876.—*President*—His Honour Mr. Justice Gillies; *Council*—R. C. Barstow, J. L. Campbell, M.D., J. C. Firth, J. Goodall, Hon. Colonel Haultain, T. Heale, Rev. J. Kinder, D.D., G. M. Mitford, Rev. A. G. Purchas, M.R.C.S.E., J. Stewart, C.E., F. Whitaker; *Secretary and Treasurer*—T. F. Cheeseman, F.L.S.; *Auditor*—T. Macffarlane.

Office-bearers for 1877.—*President*—R. C. Barstow, Esq., R.M.; *Council*—J. L. Campbell, M.D., J. C. Firth, His Honour Mr. Justice Gillies, J. Goodall, C.E., The Hon. Col. Haultain, T. Heale, G. M. Mitford, J. A. Pond, Rev. A. G. Purchas, M.R.C.S.E., J. Stewart, C.E., The Hon. F. Whitaker; *Secretary and Treasurer*—T. F. Cheeseman, F.L.S.; *Auditor* T. Macffarlane.

Extracts from the Rules of the Auckland Institute.

1. Any person desiring to become a member of the Institute, shall be proposed in writing by two members, and shall be balloted for at the next meeting of the Council.

4. New members on election to pay one guinea entrance fee, in addition to the annual subscription of one guinea, the annual subscriptions being payable in advance on the first day of April for the then current year.

5. Members may at any time become life members by one payment of ten pounds ten shillings, in lieu of future annual subscriptions.

10. Annual General Meeting of the Society on the third Monday of February in each year. Ordinary Business Meetings are called by the Council from time to time.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

Office-bearers for 1876.—*President*—Ll. Powell, M.D.; *Vice-Presidents*—Dr. J. S. Coward and Professor A. W. Bickerton, F.C.S.; *Council*—Dr. Julius von Haast, Rev. J. W. Stack, Rev. Charles Fraser, G. W. Hall, H. J. Tancred, R. W. Fereday; *Treasurer*—J. Inglis; *Hon. Secretary*—J. S. Guthrie; *Auditors*—T. Palmer and C. R. Blackiston.

Office-bearers for 1877.—*President*—Dr. von Haast, Ph.D., F.R.S.; *Vice-Presidents*—Dr. Powell and Professor Bickerton, F.C.S.; *Council*—Dr. J. S. Coward, G. W. Hall, Professor Cook; *Hon. Treasurer*—J. Inglis; *Hon. Secretary*—J. S. Guthrie.

Extracts from the Rules of the Philosophical Institute of Canterbury.

7. The Ordinary Meetings of the Institute shall be held every first week during the months from March to November inclusive.

25. Members of the Institute shall pay two guineas for the first year of membership, and one guinea annually thereafter, as a subscription to the funds of the Institute.

27. Members may compound for all annual subscriptions of the current and future years by paying ten guineas.

OTAGO INSTITUTE

Office-bearers for 1876.—*President*—R. Gillies; *Vice-Presidents*—H. Skey and J. S. Webb; *Council*—Professor Millen Coughtrey, W. N. Blair, C.E., A. J. Bathgate, J. T. McKerrow, P. Thomson, G. M. Thomson, J. T. Thomson; *Hon. Secretary*—Captain F. W. Hutton, F.G.S.

Office-bearers for 1877.—*President*—The Right Rev. Bishop Nevill; *Vice-Presidents*—R. Gillies and W. N. Blair; *Council*—Dr. Millen Coughtrey, H. Skey, J. S. Webb, G. M. Thomson, P. Thomson, D. Petrie, Dr. Hocken; *Hon. Secretary and Hon. Treasurer*—Professor Hutton; *Auditor*—A. D. Lubecki.

Extracts from the Constitution and Rules of the Otago Institute.

2. Any person desiring to join the Society may be elected by ballot, on being proposed in writing at any meeting of the Council or Society by two members, on payment of the annual subscription of one guinea for the year then current.

5. Members may at any time become life members by one payment of ten pounds and ten shillings, in lieu of future annual subscriptions.

8. An Annual General Meeting of the members of the Society shall be held in January in each year, at which meeting not less than ten members must be present, otherwise the meeting shall be adjourned by the members present from time to time, until the requisite number of members is present.

(5.) The session of the Otago Institute shall be during the winter months, from May to October, both inclusive.

NELSON ASSOCIATION FOR THE PROMOTION OF SCIENCE AND INDUSTRY.

Office-bearers for 1876.—*President*—Sir David Monro; *Vice-President* The Right Rev. the Bishop of Nelson; *Council*—A. S. Atkinson, Leonard Boor, M.R.C.S., Charles Hunter-Brown, F. W. Irvine, M.D., Joseph Shepherd, Geo. Williams, M.D.; *Hon. Treasurer*—Alexr. Kerr, F.R.G.S.; *Hon. Secretary*—T. Mackay, C.E.

Office-bearers for 1877.—*President*—The Right Rev. the Bishop of Nelson; *Council*—A. S. Atkinson, Leonard Boor, M.R.C.S., Charles Hunter-Brown, F. W. Irvine, M.D., Joseph Shepherd, Geo. Williams, M.D.; *Hon. Treasurer and Hon. Secretary*—T. Mackay, C.E.

Extracts from the Rules of the Nelson Association for the Promotion of Science and Industry.

2. The Association shall consist of members elected by ballot, who have been proposed at a monthly meeting of the Society, and elected at the ensuing meeting.

3. Each member to pay a subscription of not less than one pound per annum, payable half-yearly in advance.

4. Ordinary Meetings held on the first Wednesday in each month.

WESTLAND INSTITUTE.

Office-bearers for 1876.—*President*—Hon. James A. Bonar, M.L.C.; *Vice-President*—His Honour Judge Weston; *Council*—Thomas Turnbull, John Crerar, Hermann Meyer, Dr. Dermott, William Todd; *Hon. Treasurer*—William Duncan; *Hon. Secretary*—R. C. Reid.

Office-bearers for 1877.—*President*—His Honour Judge Weston; *Vice-President*—R. C. Reid; *Hon. Treasurer*—E. T. Robinson; *Hon. Secretary*—Charles Ulrich; *Council*—Rev. W. A. Pascoe, M.A., Rev. G. W. Reussell, Rev. G. Marrice, Rev. Father Martin, J. Plaisted, L. G. Reid, W. D. Kerr, Robert Paul, J. H. Greville, D. Osborne, Dr. M'Donald, Robert Walker.

Extracts from the Rules of the Westland Institute.

3. The Institute shall consist:—(1) Of life members, *i.e.*, persons who have at any one time made a donation to the Institute of ten pounds ten shillings or upwards; or persons who, in reward of special services rendered to the Institute, have been unanimously elected as such by the Committee or at the general half-yearly meeting. (2) Of members who pay two pounds two shillings each year. (3) Of members paying smaller sums—not less than ten shillings.

5. The Institute shall hold a half-yearly meeting on the third Monday in the months of December and June.

HAWKE BAY PHILOSOPHICAL INSTITUTE.

Office-bearers for 1876.—*President*—His Honour J. D. Ormond; *Vice-President*—The Right Rev. the Bishop of Waiapu; *Council*—W. Colenso, J. M. Gibbes, H. R. Holder, S. Locke, J. A. Smith, W. I. Spencer, F. W. C. Sturm; *Hon. Secretary and Treasurer*—W. Colenso.

Office-bearers for 1877.—*President*—His Honour J. D. Ormond; *Vice-President*—The Right Rev. the Bishop of Waiapu; *Council*—W. Colenso, J. M. Gibbes, H. R. Holder, S. Locke, J. A. Smith, W. I. Spencer, F. W. C. Sturm; *Hon. Secretary and Treasurer*—W. Colenso.

Extracts from the Rules of the Hawke Bay Philosophical Institute.

3. The annual subscription for each member shall be one guinea, payable in advance on the first day of January in every year.

4. Members may at any time become life members by one payment of ten pounds ten shillings in lieu of future annual subscriptions.

(4.) The session of the Hawke Bay Philosophical Institute shall be during the winter months, from May to October, both inclusive; and general meetings shall be held on the second Monday in each of those six months, at 8 p.m.

TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE,

1876.

I.—MISCELLANEOUS.

Art. I.—*Notes on the Lake District of the Province of Auckland.* By W. T. L. Travers, F.L.S.

[*Read before the Wellington Philosophical Society*, 2nd *September*, 1876.]

There is no part of New Zealand which offers greater points of interest to the traveller, whether scientific or merely in search of the picturesque, than that which is popularly known as the Lake District of the Province of Auckland; and there can be no doubt that, with reasonable facilities for reaching it, it would be visited by very large numbers of persons both from this and the neighbouring Colonies. Indeed, I was much surprised to find, on glancing over the visitors' books kept at the accommodation-houses at Ohinemutu and Wairoa, how many persons, especially from Australia, had already been attracted to it by the fame of the sulphur baths at Ohinemutu, and by the wonders of Rotomahana. Having had an opportunity, during the early part of last month, of making an excursion through parts of this district, I have thought it would be interesting to the Society if I put together, in the form of a paper, a short description of that part of it which the limited time at my command enabled me to visit, and certain facts communicated to me by residents on the spot (which were partly confirmed by my own observation) in reference to the remarkable volcanic phenomena which it everywhere exhibits.

The Lake District comprises the larger lakes named Rotorua, Rotoiti, Rotokakahi, and Tarawera, and a considerable number of smaller lakes in the neighbourhood of these larger ones, of which Okataina, Okareka, Tikitapu, and others, are chiefly remarkable for the picturesque character of their scenery, whilst the Rotomahana, though somewhat deficient in this respect, surpasses them all in the interest and wonder which it excites.

The Lake District may be reached by four separate routes: one from Napier to Tapuaeharuru, on the Waikato, near its outlet from Lake Taupo, and from thence to Ohinemutu, diverging, if the traveller pleases, to visit the wonders of Orakeikorako; or the traveller, by this line of route, might proceed from Napier first to Tokano, on Lake Taupo, and, after enjoying the grand scenery on its southern and western shores, including magnificent views of the volcanic masses of Ruapehu and Tongariro, might proceed from thence by way of Tapuaeharuru to Ohinemutu. Another route is up the Waikato to Cambridge, and from thence by Te Wetu to Ohinemutu. The third and fourth routes would start from Tauranga, from whence Ohinemutu can be reached either by the present coach-road or by way of Maketu, which is about 30 miles to the southward of Tauranga. The direct routes from Napier through Tapuaeharuru, and from Tauranga to Ohinemutu, are both available for carriages, whilst those from Cambridge and Maketu are not so. A carriage-road has been formed from Maketu to Ohinemutu, but has been suffered to fall into disrepair, which is unfortunate for those who can only travel by a carriage, as that road presents scenery of very great beauty, whilst the district through which it passes is one of the most celebrated in the legends and history of the Maori.

I travelled from Tauranga direct to Ohinemutu, making that place the centre from which I visited other parts of the district: and I may here venture to state that, throughout my excursion, I found the accommodation, though somewhat rough, by no means uncomfortable, and received very great civility from all persons with whom I came in contact.

The road from Tauranga passes for about twelve miles over open country of considerable fertility, gradually rising to a place named Orepi, from whence it traverses a tract of forest eighteen miles through. Independently of the beauty of the scenery in the open ground, the traveller is interested by the sight of the celebrated Gate Pah, sections of some of the trenches and rifle-pits occupied by the advanced posts of the Maoris during the assault, being visible in the bank, where the road cuts through the rising ground on which the remains of their fortifications still stand. I had previously visited the Cemetery, at Tauranga, which contains the tombs of many gallant men who fell on that occasion, and I could not but contemplate with sorrow a scene fraught with recollections of the terrible disasters of that battle.

That the native population of the country round Tauranga must, in the past, have been very great, is attested by the numerous extensive fortifications which are visible on the summits of the bolder hills, and the enormous refuse-heaps seen in every direction; but although we cannot feel much regret that a race, so little permanently improvable as the Maori has shown itself to be, when brought into contact with ourselves, should give place to a more civilized one, yet some sympathy must be shown for the decay of a people which, in their ruder state, exhibited a somewhat high standard of character.

The road from Orepi through the forest continues to rise for about twelve miles further, and then descends towards the open country forming the basin of Lake Rotorua. The scenery in parts of the forest is very picturesque; but I may say, parenthetically, without desiring to give offence to those under whose charge the maintenance of the road has been placed, that the picturesque character of the country would be infinitely more enjoyable to the traveller, and the road more suitable for horses and carriages, if the ruts were less than eighteen inches deep, and the roots, logs, and other fragments of trees, with which it is abundantly strewn, were removed from it.

The first impression of Rotorua, as seen from the coach-road, especially on the afternoon of a dull day, is very disappointing, owing, chiefly, to the fact, that the whole country around the lake is covered with fern, the dull, monotonous colour of which gives it a gloomy aspect. On reaching Ohinemutu, however, this impression is somewhat dispelled, the picturesque and remarkable appearance of the village giving life to the foreground, whilst, on the morning after my arrival, as the sun rose above the hills on its eastern side, lighting the landscape with rich and glowing colours, the lake presented an aspect of much beauty. It was evidently, at one time, of considerably greater size than it is at present, for the ground rises gradually all around it, terminating in terraces composed chiefly of stratified pumice sand.

The pah of Ohinemutu is situated on a small peninsula on the western side of the lake, part of it also occupying a rising ground at the back of the peninsula. Though no longer presenting its ancient distinguishing characteristics as a pah, it is still famous for its baths, and is occupied by a considerable number of the Arawa people. In former days, each dwelling was surrounded by its pole fence, and was ornamented with specimens of native carving in wood, generally of the most grotesque character, whilst larger images, erected on lofty poles, stood amongst the general line of the defensive pallisading. In these respects, however, as well as in that neatness which was formerly observed by the natives around their dwellings and enclosures, there is a great falling off; and the remains of ruined whares, fragments of cast-off clothing, broken bottles, kerosine and sardine tins, old pots and kettles, children in ragged shirts or without any at all, half-starved horses, and all kinds of mongrel dogs and squeaking pigs—the latter, as they root amongst the refuse, avoiding, with marvellous ingenuity, the numberless boiling springs and steam-holes which occur over the whole surface—appear to occupy every inch of available space, the scene being completed by Maori women preparing food, naked men and boys lying in the open baths, and ancient females squatted on the warm stones used for drying the berries of the *tawa*. In fact, it is difficult to describe the state of filth and demoralization into which the Maori population of this and the adjacent settlement of Wairau are gradually sliding; and it is certainly to be regretted that the efforts and self-denial of the early missionaries, in their attempts to introduce civilized habits amongst these people, should have been neutralized by the drunkenness and vice into which they have lapsed, as the result of contact with brandy-sellers and Pakeha-Maoris, and from their own abandonment of habits of industry in reliance upon extraneous means of support. In keeping with this lowering of character, is the present appearance of the Rev. Mr. Spencer's once beautiful residence, at Te Temu, formerly kept in order by the members of his Maori flock, but which, in its decay and desolation, appears to keep pace with the degradation of the neighbouring Maori people.

But Ohinemutu, though no longer possessing its former characteristics as a famous Maori pah, still affords to the contemplation of the visitor objects of the very highest interest. There is not a square rod of the lower ground that is not occupied by one or more of the hot springs and fumaroles, which give it so peculiar an appearance when the whole are in high activity. This was the case on the second morning after my arrival there; and as the whares and enclosures, with the people moving about them, were only dimly visible through the dense clouds of steam which rose on all sides, the scene presented a weird appearance to which no mere description can fully do justice. I propose, in the sequel, to refer to these intermittent accessions of activity, without, however, being able to afford any explanation of them; but certainly nothing can be more striking than the difference in the appearance of the settlement when these phenomena are quiescent, and when they are in full, active operation.

I was also much interested by discovering, amongst the ancient carvings which once decorated the palisading of the pah, a couple of grotesque carved figures in the ordinary style of Maori art, but which had, to my surprise, the full complement of fingers and toes. On inspection of the carvings in the Maori House annexed to the Museum at Wellington, and of those to be seen elsewhere, it will be found that, in every case, the number of fingers and toes on the figures is limited to three; and, until I noticed the peculiarity in the figures referred to, at Ohinemutu, I had never seen any Maori carving in which the number of fingers and toes was complete. Upon this subject I do not hesitate to quote the following passage from

Mr. Tylor's elaborate and instructive work, entitled "Researches into the Early History of Mankind and the Development of Civilization:"—

"Hanging and burning in effigy is a proceeding which, in civilised countries at any rate, at last comes fairly out into pure symbolism. The idea that the burning of the straw and rag body should act upon the body of the original, perhaps hardly comes into the mind of any one who assists at such a performance. But it is not easy to determine how far this is the case with the New Zealanders, whose minds are full of confusion between object and image, as we may see by their witchcraft, and who also hold strong views about their effigies, and ferociously revenge an insult to them. One very curious practice has come out of their train of thought about this matter. They were very fond of wearing round their necks little hideous figures of green jade, with their heads very much on one side, which are called *tiki*, and are often to be seen in museums. It seems likely that they are merely images of Tiki, the god of the dead. They are carried as memorials of dead friends, and are sometimes taken off and wept and sung over by a circle of natives; but a *tiki* commonly belongs, not to the memory of a single individual, but of a succession of deceased persons who have worn it in their time, so that it cannot be considered as having in it much of the nature of a portrait.* Some New Zealanders, however, who were lately in London, were asked why these *tikis* usually, if not always, have but three fingers on their hands, and they replied that if an image is made of a man, and any one should insult it, the affront would have to be revenged, and to avoid such a contingency the *tikis* were made with only three fingers, so that, not being any one's image, no one was bound to notice what happened to them."

Although I have asked many Maoris the reason why the number of fingers in the figures is limited to three, I never received the explanation given in Mr. Tylor's book, which, however, a perusal of that work leads me to believe to be a correct one.

I have requested Captain Mair and Mr. Hamlin (the Resident Magistrate at Maketu) to endeavour to acquire these figures, with a view of having them placed in the Wellington Museum, and I have some hopes that this may be done. In other respects, the carvings which I examined there are not very high even in the scale of Maori art.

About a mile from Ohinemutu are the baths of Sulphur Point, to which numbers of persons resort for curative purposes. They appear to be effectual in various forms of cutaneous diseases, and to have given relief even in rheumatic affections. The surface of the ground, over a very large

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* Hale, in U. S. Exploring Exp.; Philadelphia, vol. vi., 1846, p. 23. Rev. W. Yate, "Account of New Zealand" London, 1835, p. 151.

area, is covered with dismal-looking ponds of discoloured water, varying much in temperature, but in every case more or less saturated with sulphurous gases. Solfataras and mud volcanoes are also numerous, the pipes and crevices in the former being lined with crystals of sulphur.

From Ohinemutu, I, in the first place, visited the geysers of Whakarewa, about two miles off, on the right bank of the Puheroa river. As compared with the small springs and fumaroles of Ohinemutu, those at Whakarewa exhibit, in much greater intensity, the effects of volcanic agency. Immediately across the ferry is a nearly circular Ngawha, or pond of boiling water, some twenty feet in diameter, the margin and interior surface of which are composed of silicious sinter, in the beautiful forms which this substance assumes in crystalization. The water of this Ngawha is of a rich mazarine blue, and as clear as crystal, and, when the steam happens to be blown gently from its surface, and the eye is thus enabled to penetrate the depths of the pond, huge masses of the same sinter, in the form of magnificent stalagmites and cascades, are seen to occupy the interior. The water of this Ngawha is rarely disturbed by ebullition, though a considerable rill constantly flows from it into the river. Beyond these are the two great geysers which form the principal feature at Whakarewa; and although I was not fortunate enough to see either of them in full play, I saw enough to afford some idea of the appearance which they would then present. Standing upon the edge of the crater of the smaller of the two, in which the water-pipe is about four feet in diameter, I saw the water gradually rise, with a roaring sound similar to that produced by the escape of steam from the discharge-pipe of a large ship, until it reached the lower surface of the basin. The ebullition then increased in intensity until the basin itself was nearly filled, and then a column of water, three or four feet in diameter, was frequently projected into the air to the height of twelve or fifteen feet, falling back into the basin in showers of steaming spray. The water then receded from the basin and slowly sunk to its former level in the pipe, where it remained in a state of ebullition, but, although I watched it for nearly half an hour, there was no repetition of the more violent effects. A still larger geyser lies in immediate vicinity to the one I have just described; but this had shown no signs of violent activity for some months, and is said to be very capricious in its action. I have little doubt, however, that long-continued and carefully-taken observations will establish as a fact (subject to the singular circumstance to which I shall hereafter refer), that the intermissions in the action of all these springs occur at regular intervals. Both of these greater geysers have formed, by deposit from their waters, rounded but irregular masses of silicious sinter, of a pure white colour and of very considerable extent, the pipes through which the water rises occupying positions almost in the centre of the separate masses. Here, as in other parts of the district where similar volcanic phenomena are exhibited, there is the like variety of effects: beautifully clear springs of almost tasteless boiling water, of the richest blue colour, being found in the closest contiguity to springs of boiling mud and to steaming fissures, emitting sulphurous and other malodorous gases of the most unpleasant kind; whilst, what had once been the surrounding rocks, have been converted, by long-continued exposure to the action of these forces, into masses of many-coloured clays. The low ground on the western side of the lake, upwards of a thousand acres in extent, contains innumerable boiling ponds, and geysers, steam holes and fissures, rendering it dangerous to attempt to pass, except along established tracks, through the fern and manuka scrub with which it is covered, and, singular enough, it is found that by sinking for a few feet almost anywhere on this tract tabular masses of flinty deposit, similar to those which are now being formed by the existing boiling springs, are obtainable, indicating the enormous extent and long duration of the phenomena still exhibited within the same area. I think it not improbable, moreover, that a third stratum of this material is to be found at a still greater depth. During my stay at Ohinemutu I sounded, as well as the difficulty of doing so would permit, one of the boiling mud wells on the flat in question. This well is about four feet in diameter, and the mud in it boils furiously, but does not overflow the surface. I found the depth to be little over 20 feet, and the sinker, except in one particular spot, invariably rested on a hard but apparently flat surface. At the excepted spot there was evidently a small rugged fissure, for whenever the sinker reached it it sank a few inches and occasionally got entangled in it. I observed, also, that there was then a jerky motion in the string which I used, which led me to think that the boiling mud in the well rose through this fissure. On the surface of this well there was a greenish oily matter of which, as well as of the mud itself, I obtained a small quantity by skimming. The ground is so treacherous all round these wells that it was not without difficulty that I succeeded in sounding the one in question, and in obtaining the specimen of oil already referred to. I was informed by Mr. Wilson, the landlord of the hotel at which I stayed, that one of the clear-water ponds on this flat yields a water which removes almost every stain from soiled linen, without any injury to the fabric, and that it is, for this reason, used by all the European residents for washing purposes. In consequence of a heavy fall of rain on the previous day I was unable to visit this pond; but assuming that the water possesses the properties indicated, it would be useful to obtain a quantity of it for analysis, as in all probability its composition could easily be imitated to the great advantage of housekeepers.

My next visit was to the celebrated Rotomahana, and I may say that there is considerable advantage in following the same sequence which I did, inasmuch as the phenomena to be observed ascend in the scale of magnitude. The road from Ohinemutu to Wairoa, at the head of Lake Tarawera, passes over hills composed chiefly of pumice sands, and skirts the shores of Lakes Tikitapu and Rotokakahi. The former has no visible outlet, but was supposed by Dr. Hochstetter to have an underground communication with the latter. I am disposed to differ with this opinion, and to look upon Tikitapu as a mere pot-hole, because its waters are considerably higher in level than those of Rotokakahi. The area of hills which drain into it is not large, and although the water appears to accumulate in it during the rainy season, the evaporation of summer is sufficient to keep it at a certain average height. Rotokakahi is a very pretty lake, but lies exposed to the north-west wind, which blows along it with great violence. The waters of this lake flow into those of Tarawera, about two miles and a half from it, passing on their way through a small tract of level ground at the head of the latter, upon which the Maori settlement of Wairoa stands. Close to this settlement and overlooking the beautiful lake is Te Temu, formerly the residence of the Rev. Mr. Spencer, but now passing rapidly into decay. The Maoris of Wairoa furnish the canoes by which visitors, who travel thither by water, reach the Rotomahana, and I found the crew of the canoe which I hired on the occasion, to be civil and obliging. Lake Tarawera is, in my opinion, one of the most beautiful in the colony. The descent from the flat at Wairoa to the lake is by a somewhat steep path, but at every turn it opens out views of great beauty and grandeur. Its shores, except at spots where small streams enter it, are generally precipitous, and covered with luxuriant masses of the Pohutukawa and other evergreen trees and shrubs, the former of which, when in full bloom, must give an aspect of extreme loveliness to the scene. The route to the Rotomahana leads up an arm of the lake stretching to the northward of the main waters, the splendid mass of the Tarawera mountain, which lies on the left of the route, giving a wonderful charm to the scene. Immediately after rounding the point at which the turn into this arm is taken, each person in the canoe is expected to place upon a large boulder outside the edge of the water, some fragment of fern or other article, as a votive offering to a Taniwha, said to inhabit the rugged wood-covered slopes above it. This custom was duly observed by us, aud under the vigorous paddling of eight Maoris we soon reached the entrance to the small stream which runs from the Rotomahana. Here our passage was, at first, barred, but after some parley the barrier was removed, and the canoe was suffered to pass up the stream. I walked from this point to the outlet of the lake, in order to enjoy the fine view of the Tarata and the hills surrounding, which is obtained from the western side. It is extremely difficult to give any description capable of conveying to the reader an idea of the remarkable character of the scene disclosed to view. Not only from the great geysers of the Tarata, the Ngahapu, and the Ruakiwi, but from every part of the ground composing the hills on the eastern side of the lake steam rises in clouds, after penetrating the superincumbent mass for depths of which we can form no conception.

The Tarata lies at the eastern end of the lake, the base of the terraces projecting into it and into the stream which runs from it to Tarawera. At the summit of the terraces lies a huge cauldron, some 80 to 100 feet in diameter, filled to the brim with boiling water, as transparent as crystal, but of a rich blue color, contrasting most exquisitely with the marvellous tracery at the edges of the basin. The water of this basin is in constant furious ebullition, a column of it being sometimes thrown up to the height of 40 feet. Unfortunately the view of these tremendous jets, as well as of the surface of the cauldron is generally obscured by clouds of steam, but when the ebullition is intense the roaring sound of the escaping steam quite sufficiently attests the power which produces these violent effects. The silicious deposit from the water has given rise to the wonderful series of terraces for which the Rotomahana is so justly celebrated. These terraces are of a pale creamy white, whilst the water flows over them, and in detail of structure are of unsurpassed delicacy and beauty. Amongst these terraces are numerous ponds filled with the water flowing from the basin above, and still retaining its beautiful blue color. As these terraces act the part of a refrigerator of the water from the great basin, which cools as it descends, one is able to enjoy the remarkable sensation of gradual changes from cool to hot in ascending, and from hot to cold in descending it, making it easy to select a bath of almost any desired bearable temperature. The favourite one, however, is about half way up the ascent, the water in it being of sufficient depth to afford the luxury of a swim. It is impossible to describe the delicate beauty of the tracery in these terraces, but they were compared by my wife, who accompanied me during my excursion, to petrified Yak lace and fleecy wool, disposed in the most tasteful folds and pendant masses. There can be no doubt that the whole presents an unparalelled scene, the steaming basin with the dark hills behind it, the rich blue water contrasting with the cream white deposit of the terraces, and with the fleecy clouds of vapour arising from it, combining to produce effects of the utmost beauty. Not far from the Tarata lies the great cauldron at the Ngahapu, its presence indicated by immense columns of vapour and by the roaring noise of a huge steam-hole close to it. In the basin, which is about 40 feet across, the water is also quite transparent, but very dark in color, owing probably to the geyser being shut in between the hill and thickets of high manuka, which almost surround it. Its position, combined with its constant and tremendous state of ebullition, creates a feeling of awe, which is not raised by a contemplation of the Tarata, but which becomes intense when the seething waters now at one point of the basin, and now at another, are projected, with a roar, into the air, creating large waves on the surface, which lash the incrusted margin.

Further to the north, and within ten feet of the lake margin, above which it does not lie more than a foot, is the Takapo geyser, an incrusted basin some ten feet across. Near this the natives have erected a commodious open bath, the degree of warmth being regulated by shutting off or turning on the waters of the basin. Upon a small tract of flat ground close to this geyser they have also established an extensive drying place for the berries of the tawa and the karaka, consisting of tubular masses of sinter laid over steam holes, which keep the stones at a considerable degree of warmth. At this point I pitched my camp, though I found it impossible to obtain a space ten feet by eight entirely free from steaming crevices. Still further to the north lies the geyser named the Ruakiwi, long held *tapu* or sacred, in consequence of a Maori woman having thrown her newly-born infant into the terrible cauldron. This basin lies about 30 feet above the surface of the lake at the head of a little inlet, and the stony deposit, which is peculiarly streaked with reddish and yellow colors—wanting, however, in the elegance and beauty of the Tarata—extends down to and below the surface of the lake. Above Takapo, at the height of about 80 feet from the surface of the lake is a small valley named the Roto Kanepanapana, from the rugged sides of which steam ascends in all directions, whilst the latter contains a level tract occupied by large numbers of steaming fissures, clear boiling springs, cauldrons of seething mud, and mud cones, which similate in their action the play of fire volcanoes. Singularly enough, each of these emits its own peculiar sound, the whole combining to form a discordant noise, similar to that which is heard in a huge iron foundry, when the works are in full blast.

Further to the northward is the deserted settlement of Ngawhana, the abandoned huts lying clustered round a spring of the same name, the waters of which were formerly conducted, as at Takapo, into well-constructed baths. Near this are several remarkable geysers, but the only one which deserves special mention is the Whatapoho, a terrible pit, from which hot steam and sulphurous gases are constantly emitted with a peculiarly horrid sound.

It is impossible, nor would it be interesting, to describe all the wonders to be seen in the hills on the eastern side of the lake, which may be said to be penetrated in every direction with fumaroles, solfataras, and boiling springs, rendering it absolutely unsafe to trespass from the ascertained paths. The rocks of which these hills were formed have been completely decomposed into clays of various colors, from which all vestiges of their original structure have been obliterated.

There are very few traces of existing volcanic action on the southern side of the lake, although the decomposition which the rocks there have suffered indicates that they have been subjected, in times past, to action precisely similar to that which is producing more complete results amongst the rocks of the eastern hills.

On the west shore, occupying a recess or gully in the hills is the terraced fountain, usually termed the Pink Terrace, the native name of which is Otukapuarangi. Singularly enough this geyser is never in a state of ebullition, the water being considerably below boiling point, but clouds of steam perpetually arise from it. The deposit is similar to that of all the other terraces, but is of a pale pink color, and the whole structure, though by no means as remarkable or grand as the Tarata, is, nevertheless, one of extreme beauty and delicacy. The basin is from 60 to 70 feet in diameter, and from 30 to 40 feet deep, and when the steam blows away from the surface, so as to enable the eye to penetrate its recesses, its sides are seen to consist of the most magnificent stalactitic masses, one of which, rising near the centre of the basin, is of stupendous size, and wonderful in the richness of its tracery.

I have thus endeavored to give some idea of the scenes presented around the marvellous Rotomahana—scenes of magic beauty, but awful when we contemplate the forces still in action amongst them, and I will now state a few matters in connection with these phenomena, which were chiefly communicated to me, but which I was enabled, in some degree, to verify by my own observations.

Dr. Von Hochstetter, in his work on New Zealand, says of the Tarata, that he was informed by his native guide " that sometimes the whole mass of water in the basin is suddenly thrown out with an immense force, and that then the empty basin is open to view to the depth of 80 feet, but that it fills again very quickly," adding that " such eruptions only occur during violent easterly gales." The learned doctor then proceeds to comment upon this statement on the assumption of its truth, although a little reflection and observation of the surrounding ground would have satisfied him at once that such an occurrence, if not actually impossible, never had taken place.

As a fact the basin of the Tarata is not unfrequently empty, and this takes place regularly during heavy north-easterly gales, but the water, instead of being violently projected from the basin, gradually sinks, usually taking about six hours to disappear. Many of the other geysers and springs are similarly affected, whilst others again exhibit no change in their action. But independently of this more remarkable effect upon the waters of the Tarata basin, it appears to be well established that similar effects, increasing or diminishing in intensity, occur regularly as the wind passes round southerly from east to north-west, whilst in the case of the Tarata and all the other springs, their activity increases as the wind passes to the northward of east or west, reaching its maximum during warm north-east weather. It seems open to doubt whether any connexion exists between the winds and the concurrent phenomena exhibited by the springs, beyond the fact that they are both due to the same cause; but whatever may be the cause which produces the effect in question upon the geysers, it can only be ascertained, if ascertainable at all, by long continued and carefully taken observations, extended over the whole area of country presenting these remarkable phenomena. The problem thus presented for solution is one of the highest scientific interest, but without some state aid I doubt whether its solution could be attempted by any scientific body in New Zealand.

Another singular and highly interesting fact is that delicate forms of *Confervæ* and *Algæ* are to be found in almost all the rills from these boiling springs, where the waters are not sulphurous; many of the most beautiful forms being found in water sufficiently hot to blister the skin if immersed in it for a few moments. During the visit of the *Challenger* scientific expedition, I was especially requested by Mr. Mosley, one of the staff, to collect these particular plant forms, which are the special study of a gentleman in Dublin, to whom he wished them to be transmitted. I have availed myself of an offer made by Capt. Mair to make collections for me, and have sent him for the purpose a number of phials filled with absolute alcohol, with directions as to the mode in which the plants were to be collected. I have no doubt but that the result will be highly interesting, both as regards the forms of the plants and the degree of heat which may be found to be not antagonistic to the maintenance of vegetable life in these lower forms.

Whether singular or not, I observed that deposits of sulphur rarely took place either from water or from boiling mud. There were small incrustations of sulphur on the marginal flat of the pink terrace, but I am inclined to think that these had been formed by jets of steam, and had not been deposited from the waters, for I found that wherever steam jets occurred they appeared to be more or less associated with sulphurous gases, sulphur being deposited on the edges of the escape holes and on the under surfaces of the rock in communication with the jets.

The time at my command since my return has not permitted my doing more than throwing together this short notice of a district, upon the wonders and picturesque beauties of which a volume might be written; and I can only express a hope that the time is not far distant when the means of reaching it will be more easy, for although there are many scenes in which the active forces of nature may be observed under grander aspects, there are few more calculated to excite our interest than those which are contained within the Lake District of Auckland.

ART. II.—*Notes of the Traditions and Manners and Customs of the Mori-oris.*

By W. T. L. TRAVERS, F.L.S.

[*Read before the Wellington Philosophical Society, 28th October,* 1876.]

THERE are few subjects which excite greater interest amongst those who are engaged in inquiries into the origin and progress of civilization, than authentic accounts of the habits and customs of the lower races of men, especially before these have become modified by contact with civilized peoples; and as it is notorious that modifications resulting from such contact are very rapidly effected, it is important that those who may have opportunities of intercourse with the lower races should make and record their observations at the earliest possible moment. Such inquiries assume a still greater degree of interest when they relate to an uncivilized people which has long occupied an isolated position, remote from chances of intercourse; for if its relationship to any known race, and the period of its separation from the parent stock, can afterwards be established, a comparison of their several existing conditions will be of the highest value in connection with inquiries of the nature alluded to. It is necessary, however, to the correct determination of many of the most important points involved in such inquiries, to note, not merely the habits and customs of the lower types of mankind, but also the physical conditions under which they live; for these conditions must, manifestly, exercise a considerable influence in determining the nature of those habits and customs. This point has not, as I conceive, been sufficiently borne in mind by writers on the history and progress of civilization, when discussing the condition of inferior peoples in their relation to the contemporary state of more advanced branches of the same race. But it is one which cannot be ignored without the certainty of error in the deductions arrived at. I will take an instance: It is more than probable that the Mori-oris, at the time of the invasion of the Chatham Islands by the Ngatitama, in 1835 or 1836, were a mixed race, having a large proportion of Maori blood in their veins. This may, I think, be fairly deduced from what appears in the sequel of this paper, although we have no present means of ascertaining, even with the slighest approach to definiteness, the period at which the admixture took place. But, although we may be justified in assuming that, however remote the period at which this admixture occurred, the then progress of the Maori in some of the arts of civilization had been far greater than that of the earlier inhabitants of the Chathams, we see, nevertheless, in the manners and customs of the present Mori-ori people, very little trace of this greater progress—a circumstance which can, as I conceive, only be accounted for by the different nature of the physical conditions under which the Maori and the Mori-ori respectively lived. Whilst, therefore, on the one hand, we may be justified in assuming that changed conditions of life had produced upon the descendants of the Maori emigrants to the Chatham Islands a degrading effect, we should not, on the other, be justified in concluding that the condition of the Maori in those islands was, at the time of the immigration to the Chathams, as low as that which we now observe in the inhabitants of the latter group. It must not be assumed, however, that I would lay down as a proposition, that the same conditions of life must necessarily produce similar effects upon the habits and customs of all uncivilized peoples exposed to their influence. Indeed, we find the Hottentot, the Kaffir, and the Bojesman, existing under much the same physical conditions, and yet presenting very different states of progress, due, no doubt, to the fact, that each one of these races is, itself, one of the conditions which produces modifications in the others. All I suggest is, that in considering the habits and customs of isolated uncivilized peoples, whose relations to some specific neighbouring race may be well ascertained, but whose habits and customs differ in important respects from those of that neighbouring race, we must take into account, for all purposes of comparison, the physical conditions under which each of them exists. If I am correct in this, it becomes important, when recording observations upon the habits and customs of an isolated uncivilized people, even where its affinity to any known race may not yet be established, that we should also correctly record all we can learn as to the physical conditions of the *habitat* in which we find it.

I do not propose to follow this course in the present paper, simply because the physical geography—including in that term the natural productions of the Chatham Islands—have already been described by several writers, as well as by myself, in papers read before this Society; but these must unquestionably be borne in mind in any comparisons which may be instituted between the Mori-ori and the Maori on the one hand, and between the Mori-ori and any other race between which and it a connection can be traced, on the other.

The notes which I am about to read in relation to the traditions and habits and customs of the Mori-oris, are drawn up chiefly from memoranda furnished to me by my son from notes made during his visits to the Chatham Islands some years ago. They are, unfortunately, imperfect—a defect which is not, however, to be attributed to any want of interest on his part in the subject itself, but partly to the difficulty of interpretation and partly to the still greater difficulty of arousing a sufficient degree of interest in these matters in the few old men who can give information in regard to them. In this connection it must be borne in mind, that for many years after the Maori conquest, the unfortunate Mori-oris were kept in a condition of abject slavery by their conquerors, who looked upon them very much in the light of sheep and oxen, to be killed and eaten as required, a condition of things by no means favourable to the maintenance of traditional lore or to the observance of original habits and customs, more especially if these should be at all obnoxious to the prejudices of the conquerors. Indeed, my son tells me that the Mori-oris have almost entirely abandoned their own customs, and that it is only when a few of the older people get together that they even speak their own language. I have no doubt, however, that with a knowledge of their language—unless it be altogether too late—the notes which he obtained would afford a clue to further knowledge, and it is to be hoped that some opportunity may occur for obtaining it. In former papers (published in the "Transactions of the New Zealand Institute"), some information is to be found as to the manners and customs of the Mori-oris; but I purpose, even at the risk of repetition, to give all that is contained in the memoranda furnished to me by my son.

The Mori-oris themselves say that they are a mixed race, and that the people who occupied the islands prior to the admixture, were larger in stature, and darker in colour, than the present inhabitants, and had very black hair. They state that these aboriginal people traced their descent, at a distance of 30 generations from the arrival of the first immigrants, with whom the admixture took place, to a great chief named Rongomai, whom they looked upon as a godlike man. It will be observed by those who have read the "Traditions of the New Zealanders," and the Rev. Mr. Gill's interesting work, "Myths and Songs from the South Pacific," that in almost every instance the islanders look back to Rongo, or Rongo-mai, or Rongo-ma-toure, as one of their remote ancestors, ascribing to him the powers of a god; and assert that, although he was a younger son, yet, through the craft of his mother, Papa, all the functions of government, the arrangement of festivals, and the right to distribute honours and power, had been secured to him. It is interesting, therefore, to find the elements of the same tradition amongst a people so isolated as the Mori-ori. Moreover, Rongo is always represented as being very dark, and as possessing raven black hair, characters which, as it appears, distinguished the original inhabitants of the Chathams. My son was unable to obtain any definite information as to the parentage of the Rongo-mai of the Chatham Islands, the sole idea being that he was a very great chief, from whom the first inhabitants were descended. They also said that these original people had immigrated from Hawaiki in consequence of constant and devastating wars, a statement similar to that which is made with respect to the first Maori voyagers to New Zealand. At the time of the arrival of the first immigrants, the principal chiefs of the islands were: Marupuka, who lived at Awa-patiki; Rongopapa, who lived at the Wakuru; Mumuku, who lived at Muriroa; Mamoa, who lived at Tikeri; and Tarangi-mahora-whakina, who lived at Pitt's Island. The first strangers are said to have come in two large canoes, one of which was called the Rangimata, under a chief named Mararoa, and the other the Rangihoana, under a chief named Kawanga-koneke. They say that the people who arrived in these canoes were very numerous, and also came from Hawaiki, but no special reason is assigned for their leaving that place. Mr. Gilbert Mair, in a paper read before this Society, in 1870, mentions five canoes, but in other respects his account tallies a good deal with that obtained by my son. He, however, says that the people of these canoes also left Hawaiki in consequence of inter-tribal wars. The second batch of strangers arrived in a canoe called the Oropuke, under a chief named Mohi, and are said to have come from Awatea, or Arapawa, which is supposed to have been New Zealand, and is stated to have been a cool country. The probability is that the latter canoe did come from New Zealand, for the name Awatea, or Aotea, is that which is said to have been given to New Zealand by its first Maori discoverers. The name Arapawa is also common in New Zealand. Further strength is also added to the supposition, that some of the ancestors of the present people had come from New Zealand, by the fact, that Mr. Shand, on one occasion, heard some old Mori-oris singing a "Karakia," or song of gladness, upon the completion of a large fishing canoe, during which they used the words "*totara*," and "*pohutukawa*;" and, on being questioned as to those words, they mentioned that they were the names of trees in the country from which some of their ancestors had come. My son also states, that fragments of green-stone, similar to that used by the New Zealand natives, have been found on the islands, under circumstances which forbid the supposition that they were taken over by the Maori invaders of 1836, one of these fragments having been obtained from soil below the root of a tree of considerable size. It is related that the islands were afterwards visited by another canoe, under a chief named Kakahu, who is said to have resided for a short time at Waitangi, but left because the climate was unfit for the growth of the *kumera*.

The people in the canoes Rangimata, Rangihoana, and Orepuke assumed the name Mori-ori, but were termed by the first inhabitants *Tangata tare* or strangers, whilst the aboriginals called themselves *Tangata whenua*, or people of the soil.

The people in the first two canoes, although said to have been cannibals, settled down peaceably, and soon became incorporated with the original inhabitants. On the arrival of the canoe Orepuke, however, disputes arose, leading to bloodshed and an outbreak of cannibalism, but the wars resulting from these disputes ultimately ceased at the command of a great chief named Numuku, by whom all deadly fighting was prohibited, their feuds being from thenceforth decided by combat with staves only, used, as my son states, in the manner of the quarter-staff, it being understood that the first side which drew blood was to be deemed victorious. Their quarrels appear to have arisen chiefly out of conflicting claims to the possession of valuable *karaka* trees, the fruit of which was a staple and much liked article of food, and my son informs me that nearly all the older *karaka* trees on the island are marked with devices indicating their special ownership—a fact of very great interest. He made drawings of many of these figures, which are very rude, but were evidently sufficient for the purposes of the owners. Copies are appended to this paper.

One of the leading chiefs of the Ngatitama, who was with the invaders in 1835 or 1836, informed me that the Mori-oris were large and powerful men, darker in color than the New Zealanders, and distinguished by hooked noses. Mr. John Amery, in his little work on the Chatham Islands, also mentions this form of nose, adding also that they had almond shaped eyes, and that in features they bore a strong resemblance to the Jewish people. They never tattooed, and indeed are said to have known nothing about it, a circumstance sufficiently remarkable in itself, and indicating the remoteness of the period at which the immigrations from New Zealand took place.

My son informs me that the language of the Mori-oris differs a good deal from that of the Maori, but that it is now rarely spoken, except amongst some of the older people. He observed that almost every sentence concludes with a kind of lisping sound. He also says that gestures are much employed, but I am not in a position to say whether the language is so defective as to require the use of gestures for the purpose of their ordinary intercourse. The point is one of interest, ethnologically, on several grounds, but I think it doubtful whether this was the case amongst the Mori-oris.

Capt. Wilkes, in his narrative of the United States exploring expedition, says :—" Chatham Island, which will probably soon be connected with the English colony of New Zealand, is now considered as a nest of rogues, and several vessels have been robbed there. Its inhabitants have a tradition that they are derived from New Zealand, whence their progenitors came about a century since, having been driven off in their canoes by a storm, and that on landing they had changed their language. The change consisted in reversing the ordinary construction of their phrases and the syllables of words, as for *haremai*, *maihare*, and for *paika*, *kapai*. The natives of Chatham Island are not tattooed, do not wear clothing, and are said to be more intelligent than their progenitors." I should especially recommend this latter statement to those who adopt the views of Archbishop Whately.

They divide the year into four seasons,—Mitorikau, or the eating of the *karaka* ; Tumatahua, or the growing of the *toe toe* ; Tupuku, or the coming of the cuckoo ; and Korahua, or the hot season, each of which was entered upon with special observances, of which, however, my son was unfortunately unable to obtain any intelligible account.

Their food consisted of fern-root, the fruit of the *karaka*, shell and other fish, birds, seals, and the carcases of stranded whales, and their ordinary modes of cooking were similar to those of the Maoris. It appears, however, that when fish was caught in large quantity it was placed in a running stream, and kept there until the flesh separated freely from the bones. This flesh was then pressed into flax baskets, and kept in store for consumption when required. Like all savage people they were gluttonous and improvident, stuffing to-day to hunger to-morrow. Flakes of chert were employed in cutting up the flesh of animals used for food, but my son was unable to ascertain whether, as in the case of the Maoris, particular kinds of chert were applied to particular classes of food. Chert flakes were also used for cutting the hair, the clippings from the head of a chief being held sacred, and placed in some secluded spot. The women always eat apart from the men. Slabs of sandstone, hollowed in the grinding of their stone implements, were used as dripping dishes in which the fat and juices of roasting flesh were collected. It is interesting to note that two dishes, manufactured in the same manner, are amongst the historical relics of the Maoris, and were exclusively used by them for collecting the fat and drippings obtained in cooking the Moa. It appears strange that these were the only instances in which the latter people employed such utensils, although the manufacture was simple and their usefulness apparent.

As a rule the Mori-oris built no huts, being ordinarily satisfied, even during winter, with the shelter of a sloping breakwind, under which they huddled at night. When, however, a permanent settlement was to be formed, circular and V shaped huts were built, the former composed, like the huts of the Kaffirs, of a circle of poles drawn together at the top, and then thatched; and the latter of similar poles ranged along a ridge, one end resting on the ground, and the whole also covered with thatch, in each case a trench being dug to carry off the rain water. Their meeting houses were occasionally decorated with rude carvings, of which specimens were brought over by my son, and placed in the Wellington Museum. These carvings are different in character from, and are much ruder than those of the Maoris, but were made in the same manner.

Their clothing was composed chiefly of seal skins and of garments manufactured from the fibre of the *Phormium tenax*, much in the same manner as those used by the Maoris, but with less elegance in texture or design. Before going into battle the chiefs put on a long narrow piece of close matting, made from the raw leaves of the *Phormium*, and wrapped round the upper part of the body after the fashion of a Scotch plaid, but with one end hanging in front and the other behind. Both sexes wore ornaments made from the flax fibre dyed in black, or red and white, the black color being produced by steeping the fibre in the juice of some bark containing tannin, and then in a swamp, the water of which was impregnated with iron; and the red by wrapping up the fibre with scrapings of the inner bark of the Matipo (*Myrsine chathamica*) and the bruised leaves of the Kawa kawa (*Piper excelsum*), which was then steeped in water, where after remaining for some time it was taken out and dried before a fire, then assuming the red color.

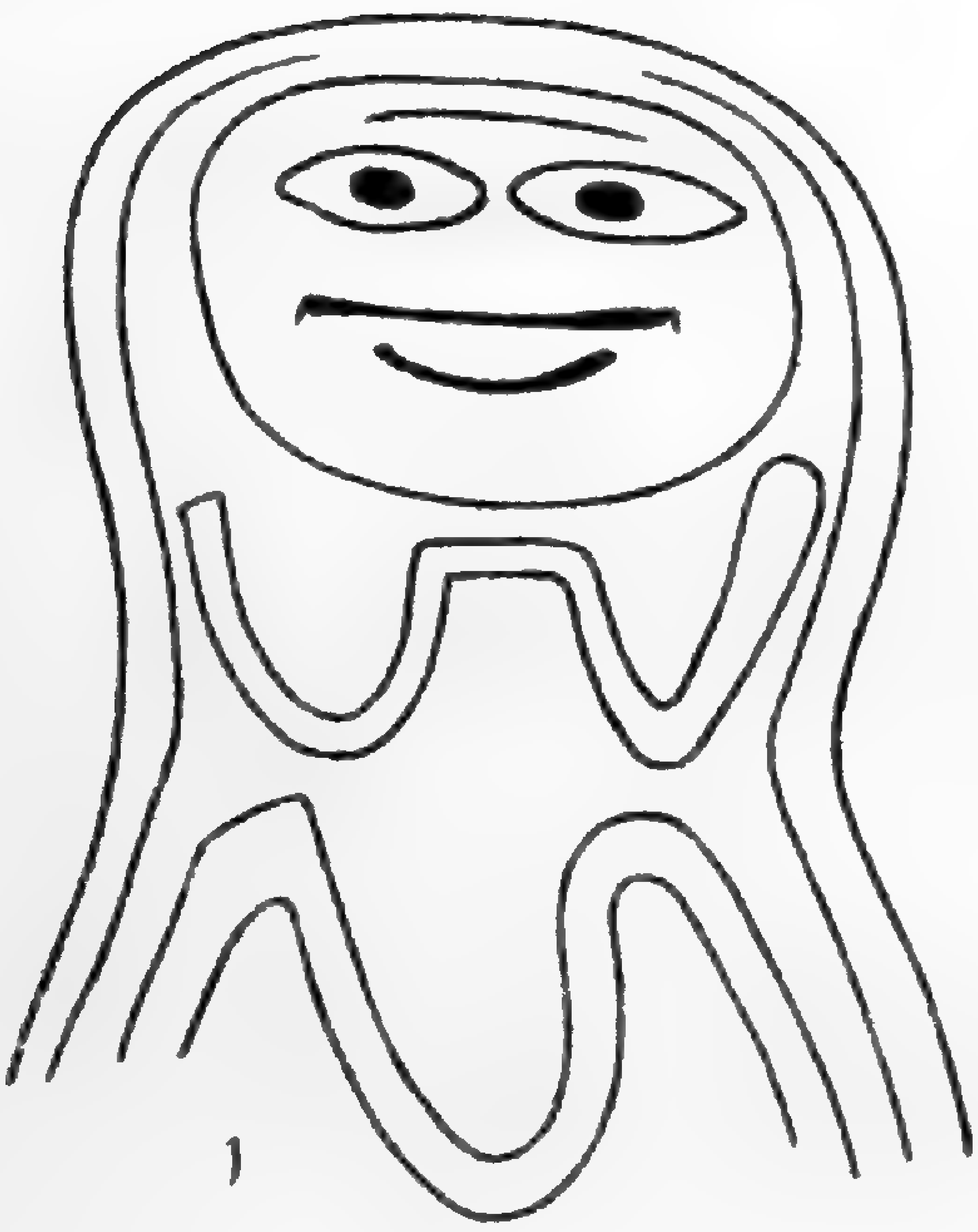
They also used ornaments made from the teeth of the whale, but these were by no means common. My son was unable to find any trace of the use of ornaments made from any form of stone or mineral. The women used combs made from the back-bone of a fish. Stone tools of various forms were used, each of which was sacred to its own particular purpose, one being used in house building, another in cutting wood, a third in carving, and so forth. Some of the axes are peculiar in shape, differing from any of those used by the Maoris. My son discovered some singular shaped stone clubs, evidently of great antiquity, and made from stone different from that used for their ordinary tools. On enquiry he found that these were unknown to the present people, who merely conjectured that they must have belonged to the earlier people already referred to. These clubs are scarce and are usually found buried at some depth in the ground.

Polygamy was common amongst them, and it was usual for a brother to marry a deceased brother's wives. No marriage, however, was originally contracted without the consent of the parents of both parties. When a marriage had been agreed upon it usually took place in the largest house in the settlement, all the people being assembled to partake of the store of food provided for the occasion. A bed of flax leaves mixed with feathers was made in the centre of the house, and after the food had been consumed the couple were placed on the bed, in the centre of the house, a ring made from the fibre of some plant, of which, however, my son could not ascertain the name, being placed round them. The song of marriage was then sung by the assembled people, who immediately afterwards retired, leaving the newly-married couple in the house. The females married very early, the reason given being that it was to prevent fornication. If a man were convicted of the seduction of an unmarried woman he was prohibited ever after from marrying a virgin. Adultery was severely punished, but not with death, beating until blood was drawn being the usual thing.

Children were baptized between the ages of two and three years, and the ceremony bears a striking resemblance to that performed amongst the Maoris. The people of the settlement being assembled at the appointed time and place, the child was brought forth by the priest, and placed in the arms of a chief member of the tribe. If the child's father held a high position in the tribe, a tree was at the same time planted, the growth of which was to be as the growth of the child. During the planting of this tree an incantation song was sung by the priest. This over, the person holding the child advanced towards the priest, who then poured water over it, another incantation song being then sung. A name was then given to the child, and the assembled people at once proceeded to a great feast, which concluded the ceremony. The resemblance in all this to the baptismal ceremony of the Maoris, so well described in Mr. John White's lectures on their manners and customs, is very apparent.

In the Rev. Mr. Gill's "Myths and Songs from the South Pacific" (already alluded to), the following is the account given of the naming of children amongst the islanders of the Hervey Group :—

"At convenient intervals, the principal King of Mangaia, as high priest of all the gods, assisted by the priest of Motoro, summoned the young people to their various family maraes, to be publicly 'named.' Some might be verging on manhood or womanhood, whilst others were scarcely able to walk. Standing in a half circle, two or three deep, the operator dipped a few leaves of a beautiful species of myrtle (*maire*) in the sacred stream flowing past the marae, and sprinkled the assembly ; all the while reciting a song or prayer to the particular god at whose shrine they were worshipping, and who was supposed to be the special protector of those present. At certain pauses in the song, the King, as '*pontifex maximus*,' gently tapped each youngster two or three times on the head or shoulders,



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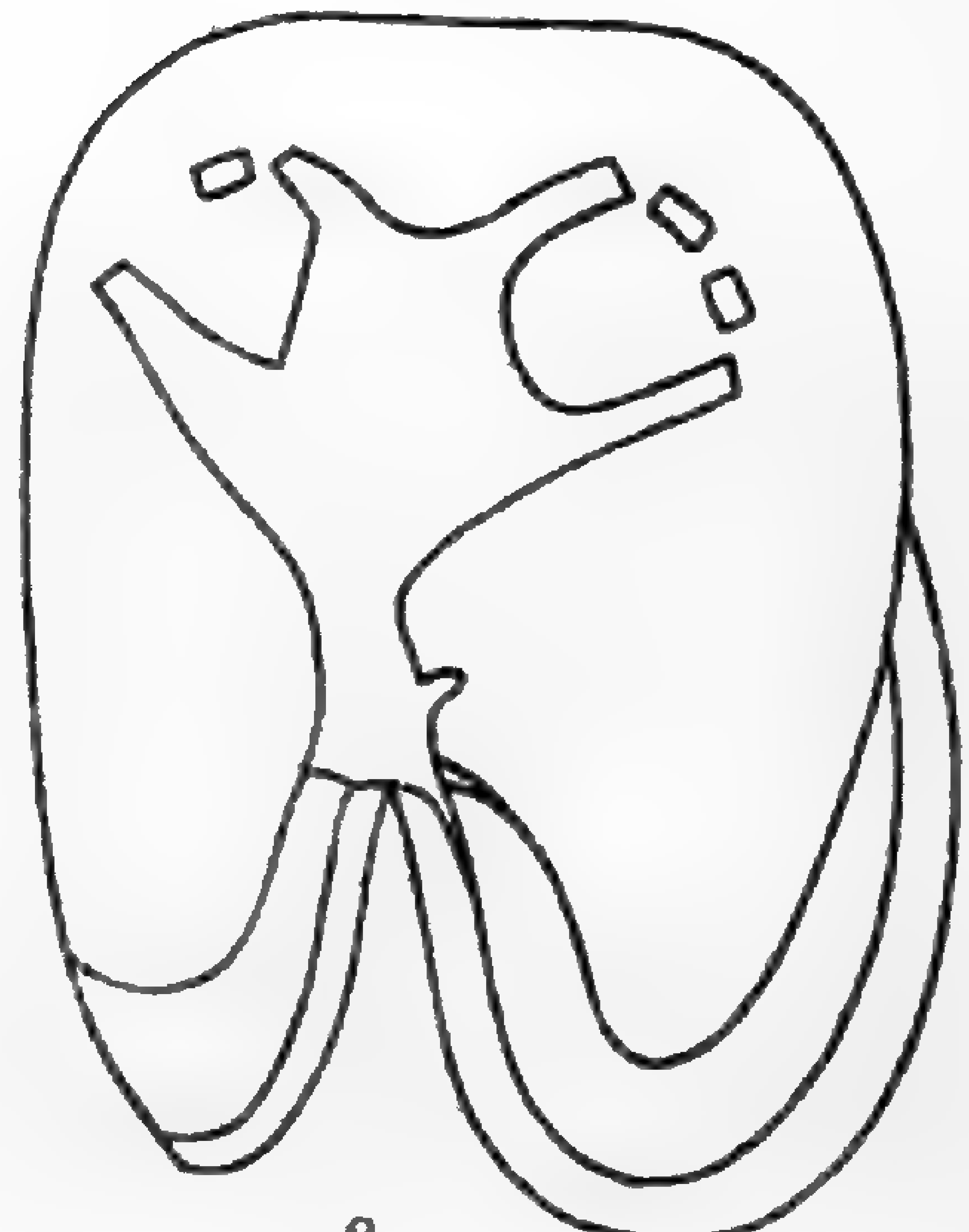

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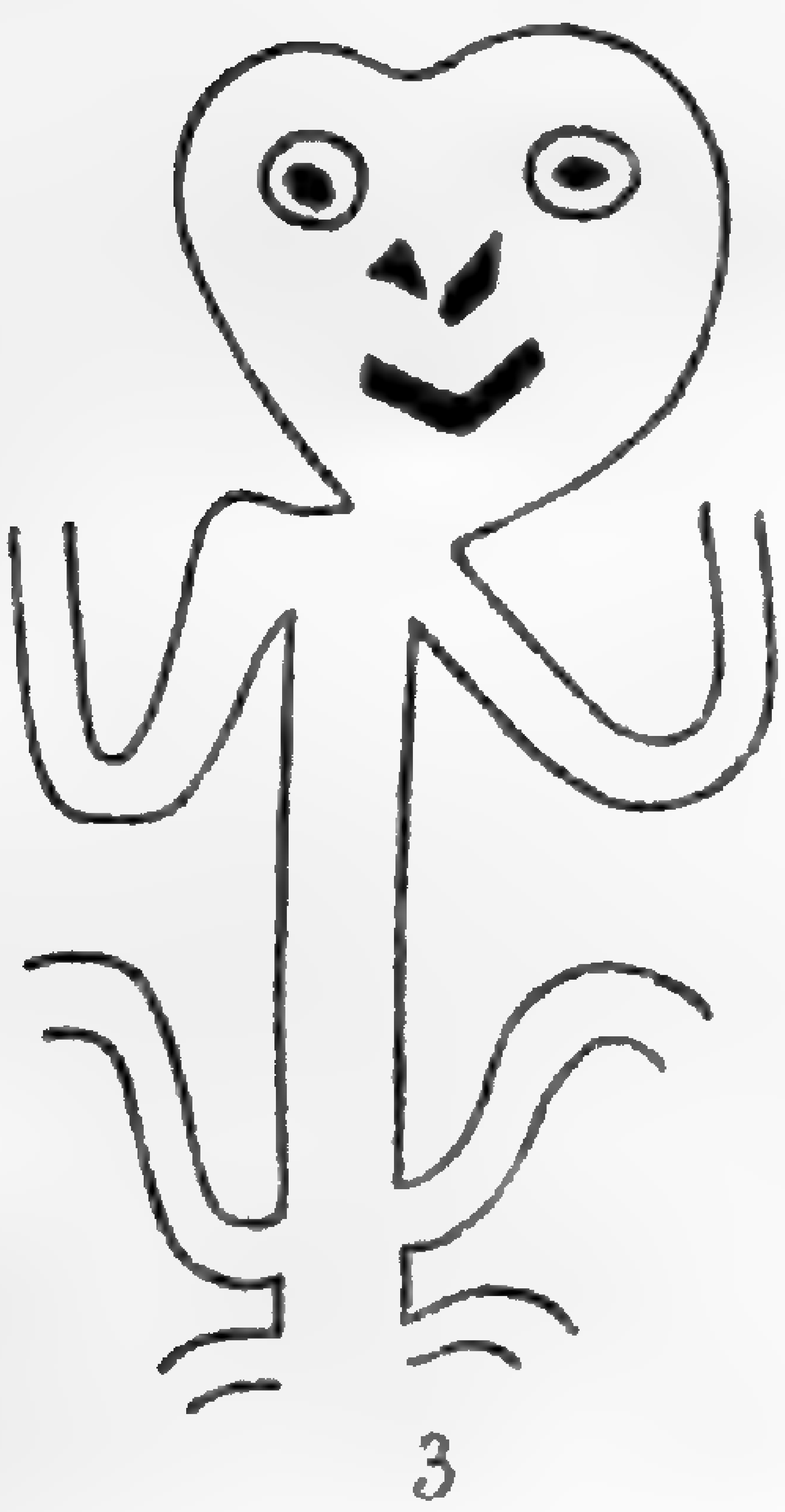

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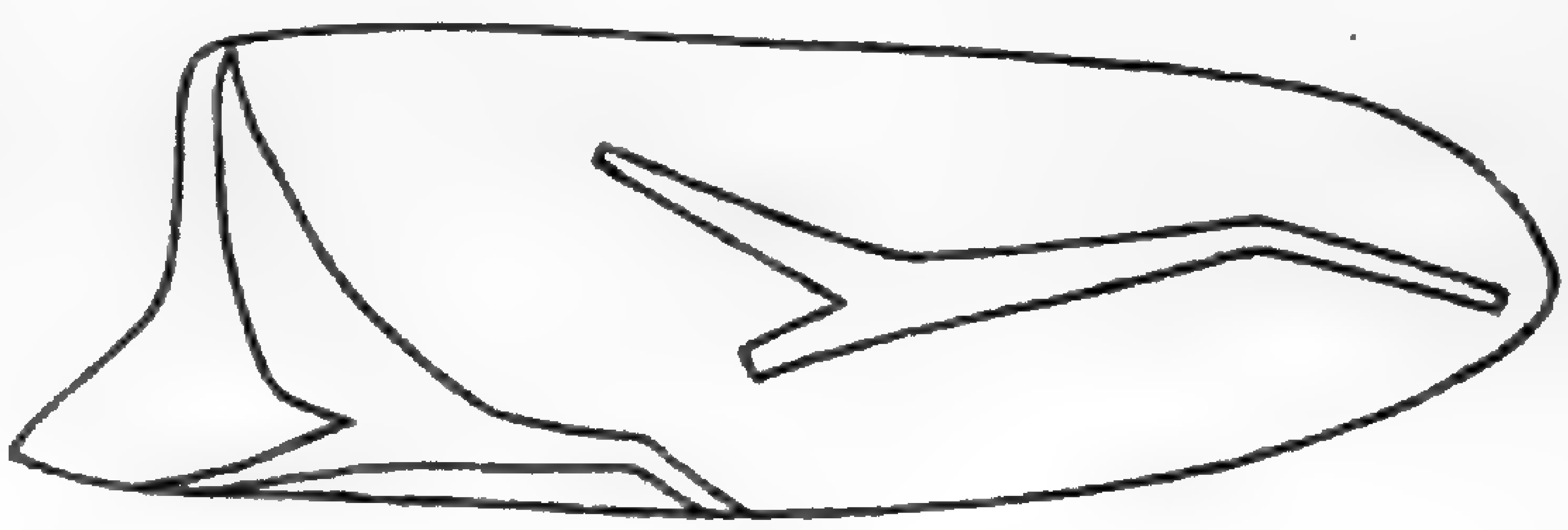

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MORIORI CARVING.

pronouncing his or her name. The idea evidently was to secure a public recognition of the god and clanship of each of the rising generation—for their own guidance in the ceremonial of heathen life, and for the guidance of priests and chiefs afterwards. The greatest possible sin in heathenism was 'ta atua,' *i.e.*, to kill a fellow worshipper by stealth. In general, it might be done in battle. Otherwise, such a blow was regarded as falling upon the god himself; the literal sense of 'ta atua' being, god-striking or god-killing. Such crimes were generally the consequence of ignorance; to prevent the priests and chiefs from such blundering, these occasional 'namings' were appointed. In the event of war, and a consequent re-distribution of lands, the favour of all the principal gods must be secured by favours shown to their worshippers—at least to a selection of a few to keep up the worship of each idol. A great feasting invariably succeeded this ceremony of 'naming.'"

Mr. Mair, in the paper already referred to, says that the Mori-oris had neither songs nor chants; but in this he is undoubtedly in error. Mr. Shand has made, I am told, a considerable collection of their chants, which I hope he will soon publish. It appears, indeed, that in all their principal ceremonies chants, or *karakias*, were used.

Their modes of burial were various. While living, they almost invariably selected their own spot for interment; sometimes on a high hill commanding a view of the sea, some *atua* rock, or the vicinity of their food-yielding *miko*. Others were lashed to young trees, and some were bound in a canoe and sent to sea. The most common mode, however, was this: When a person conceived the approach of death to be near, he would select a long piece of the heart of *ake ake*, about the thickness of a man's wrist, and sharpened at one end. Upon the top he would rudely carve the figure of a bird or a fish. He would then go to a particular spot, and kindle a fire with brushwood. Where the fire died out, he would stick in the *ake ake*, and that was to be the place of his sepulture. When dead, the arms were forced back against the chest, and securely bound there with plaited green flax ropes; the hands were bound together and drawn over the knees, and a stick was then inserted between the arms and knees. This was the orthodox method of trussing a body, and it was sometimes a work of great difficulty; for, when the body became rigid, the efforts of many men were required to bring it into a proper position. This being done, the dead was enveloped in plaited flax matting, and interred as far as the knees, the upper portion of the body being invariably above the soil. To this very day, clearing away land, one frequently lights upon leg and arm bones pointing upwards. Others, again, would be bound to two or three young trees growing closely together, in which case the body would be placed in an erect position, and bound round and round with vines from head to foot, but always looking seaward. Mr. Amery tells that, a few years since, in sawing across a *karamu* tree, something offered unusual resistance to his saw; to his great astonishment he had sawn through the hip bones of a man; he had been lashed against the tree; it had grown and enfolded him in its embrace. Some noted fisherman, again, would direct his remains to be consigned to the waves; in which case, he would be secured, lashed in a *waka korati*, or flax-stem canoe, in a sitting position, as if in the attitude of fishing, a long flax line, with a baited bone hook, and a sinker attached, was suspended over the side, and when the wind or tide was favourable he was launched to sea. A few years since, an American whaler, beating some twenty miles from land, observed one of these canoes with a man apparently sitting in it. Thinking it must be some poor native driven out to sea, a boat was lowered. Upon approaching the canoe it was discovered to contain a dead body. The vessel was making for the South-east Island, so they took the dead man in tow. Upon being boarded by some white men, accompanied by natives, the latter instantly recognised an old companion they had turned adrift, and implored the captain to send him off again, or the *kiko kiko*, or evil spirit, would be exceedingly wrathful; in fact, they should never hear the last of it. Softened by their pathetic appeals, the worthy skipper cut him adrift once more, and away he sped in the direction of Cape Horn. "In my rambles through the bush," (says Mr. Amery), "I have frequently observed a time and weather-bleached skeleton grinning at me from some old tree. Walking one day with an ancient native woman, she suddenly stopped, and commenced an affectionate and whining *korero* with a skull suspended from a branch. I said, 'What old friend is that?' 'Oh, said she, 'it is my first husband; he was a *tane pai*" (a good husband). My wife and I used both entreaties and arguments to break them from such indecent and unholy customs. One day during my absence from home a person was about to be interred in the usual manner. My wife, however, hastened to the spot, and insisted upon having a deep grave dug. She was instantly obeyed, upon which she read an appropriate prayer, and the body was interred with decency. From that time the old custom was never revived. Upon another occasion, a young person was about to be interred in a neat coffin; the prayer had been uttered, and the body was lowered into the grave; at that moment a huge piece of rock, weighing upwards of a ton, rolled from a height into the grave, crushing both corpse and coffin. Upon this the friends and relatives, who had hitherto maintained great decorum, clapped their hands joyfully together, shouting and laughing. They said the *kiko kiko* was killed, and would never come to trouble them now."

When sick their only medicine was water from some particular spring, and *miko*, or cabbage tree, and though the spring was at a distance of 20 miles, it mattered not, it would be brought to the sick person in a flax bucket. Another strange custom was this: the first who should see or touch the body of a person whose death had been caused by accident or violence should abstain from food for three consecutive sunrises and sunsets. They also believed that when a friend died he would send ashore black-fish, or sea leopards, and whenever either happened to be taken they would all muster together to eat the food sent by the dead. Of course the generous action was attributed to the last person deceased. "But of all their customs" (says Mr. Amery) "the most cruel one was to destroy every child that cried during the act of being born, as it was deemed an unlucky one. Upon my first arrival, a Mori-ori child was born during the night. On the following morning I went to enquire about it. They told me that it was "*tamaiti tangi*," *i.e.*, crying child, and they had destroyed it before sunrise. I requested them to show me where they had put it. They led me to a spot, and to my horror and disgust pointed out a poor infant crushed to atoms beneath a huge piece of rock, weighing at least six hundredweight. They appeared to think they had performed a most praiseworthy and meritorious action. I told them they must never do so again. If they did a great curse would be put upon them. Their reply was, that it might be bad for the white men to do so, but that it had been the Mori-ori custom from time immemorial, and therefore it was not wrong in them. It is true they have seen good and evil examples set by white men; nevertheless the contact has been beneficial, inasmuch as it has exercised a humanizing influence. The old customs I have alluded to are now obsolete, but the *kiko kiko* they stick to with great pertinacity."

"Amongst the most fatal diseases," (says Mr. Amery), "are those of a pulmonary nature, the predisposing causes to which are numerous. I believe it to arise from hereditary taint and scrofulous habit; in fact, they are all scrofulous, and the connexion between scrofula and pulmonic consumption is obvious, and generally acknowledged; for, when one disappears from the surface, the other almost invariably falls upon the lungs. Consumptive malady has fearfully increased of late years. They are also subject to cutaneous diseases, engendered by unwholesome food, and neglect of cleanliness. Of such diseases, the *hakihaki*, as it is termed—an aggravated form of itch—first arising in small pimples, is the most distressing and disgusting. I have seen wretched objects literally a mass of sores from sole to crown."

The Mori-ori tradition as to Creation is very similar to that of the Maori, and, indeed, to that of most of the Polynesian race. In the beginning there was darkness, *Rangi*, the heavens, lying close to *kopapa*, the earth. Then *Rangi-tokano*, one of the offspring of *Rangi* and *Kopapa*, sung a powerful incantation song, which caused *Rangi*, the heavens, to rise above the earth, and thereupon light appeared upon the earth. Then *Rangi-tokano* made man out of the earth, and called him *Te-ao-marama*, and from him are descended all the people of the world. *Rangi*, the heavens, sometimes visits his wife, *Kopapa*, such visits being followed by copious dews.

The Mori-oris do not appear to have had any religious feeling in the ordinary acceptation of the term, although they believed in good and evil spirits, both of whom were known by the common name of *Atua*. They were very superstitious; and old and young alike were in the habit, it appears, of telling ghost stories as wild and wonderful as the story of the Cock Lane Ghost. Indeed, they believed that, after death, the spirit of the departed had power to return to earth and haunt the living, and that a person visited by the *kiko kiko* (or evil spirit of the dead), and touched on the head by it, would die very soon after such visitation. To prevent the dead from troubling them, they had a curious custom. As soon as breath had left the body, they would all assemble at midnight in some secluded spot, and proceed to kill the *kiko kiko*. First kindling a large fire, they would sit round in a circle, each person holding a long rod in his hand; to the end of each rod a tuft of spear grass was tied; they would then sway their bodies to and fro, waving the rods over the fire in every direction, jabbering strange and unintelligible incantations. Attempts were made by the first European settlers to wean them from this foolery, but without success; they would persist in the custom, so one of the settlers determined upon the first opportunity to give them a fright. Hearing of the death of a Mori-ori, and that a party were to meet that night in a certain place to kill the *kiko kiko*, he arrayed himself in a white sheet and night-cap, whitened his face, and made himself appear as unearthly as possible, and, going stealthily to the place whilst the ceremony was proceeding, he suddenly appeared before them. With one simultaneous yell they cleared the course, and fled to their huts as if a legion of devils were at their heels. In the morning, their miserable, woe-begone faces plainly indicated a sleepless night, and the horrid *kiko kiko* was the talk amongst them for many months. This experiment, however, succeeded admirably, for their performance was never again repeated. Long after, when they had become more humanized and enlightened, they were told who the *kiko kiko* of that occasion really was. Upon this they looked very serious, shook their heads, and said it was very bad to play with the *kiko kiko*. It was by no means an unusual thing for a person to affirm that he or she had been visited by the *kiko kiko*; in which case, at the slighest approach of sickness, they would resign themselves to death, and that would be the invariable result. This may be accounted for simply by a dream, and the effect of an excited imagination upon a weak, untutored mind.

I do not apologize for the fragmentary nature of the notes which I have thus put together, but I may express a hope that some of those who have had opportunities of inquiry into the same subject, will, as early as possible, place on record the results of their observations.

Appended to this paper are drawings of the private marks on *Karaka* trees, and the Mori-ori and Maori names of some of the indigenous birds and plants.

ART. III.—*Notes on the Influence of Atmospheric Changes on the Hot Springs and Geysers in the Rotorua District.* By Capt. GILBERT MAIR.

[Read before the Wellington Philosophical Society, 28th Oct., 1876.]

FOR many years past, partly from my own observations, and partly from conversations held with intelligent natives, I have been led to believe that some of the hot springs and geysers in the Rotorua and Taupo districts are affected to a remarkable degree by changes in the wind. Latterly I have carefully noted down these changes, and hope at a future time to reduce such observations to some system. But in the hope of drawing attention to this very remarkable phenomenon, I will now give a few instances as they occur to my mind.

Close to my residence at Tekautu, Ohinemutu, there is a large steaming pool 30 by 50 feet wide, and about 60 feet deep, named Tapui. It is situated on a grassy mound, about a hundred yards from Rotorua Lake, and some fifteen or twenty feet above its ordinary level. I have been in the habit of bathing here for some years past, and generally found the water about blood heat.

Since October, 1874, I have observed that immediately the north and east winds (which blow directly across the lake) set in, Tapui fills up four or five feet, a strong outflow takes place, and the temperature rises from 100° to 190° This continues till the wind shifts round to south, south-west, or west, when Tapui resumes its ordinary level and temperature.

In 1875, from January to September, sea breezes or winds from north to east, set in, generally about 9.30, and at noon Tapui would be full and running over, and nearly at boiling point. In the evening, as the wind from the sea died away about six o'clock, the water began to recede, the temperature to lower, and at eight o'clock the water became cool enough for bathing.

This year, however, the prevailing winds have continued to blow from the sea, and Tapui has seldom been fit to bathe in. For many years the natives living at Koutu have observed the rise and fall of this spring, which circumstance has passed into a proverb,—" *Tapui tohu hau* "—(Tapui the wind pointer). They tell me that they have never known it to remain hot for so long a time previously.

At Whakarewarewa, two miles and three quarters from Ohinemutu, there are several hundred mud baths and boiling springs. There are also several fine geysers, which become very active during south-west and westerly winds, frequently throwing water 40 to 60 feet. The principal ones are named Pohutu and Te Horu. They are rarely active in the middle of the day, but generally between seven and nine in the morning, and from three to five in the evening, while Whakaha Rua, or the " Bashful Geyser," is only in a state of violent ebullition after dark.

Perhaps the most singular instance of atmospheric influence is in the case of Te Tarata, the White Terrace, at Rotomahana. The great crater, which is about 90 feet in diameter, is usually full of deep azure blue colored water, occasionally boiling up ten or fifteen feet; but when the keen south wind, or *tonga*, blows, the water recedes, and you can descend 30 feet into the beautifully encrusted crater, which remains empty till the wind changes, when it commences to refill at the rate of three or four feet per hour, boiling and roaring like a mighty engine. When the crater is almost full, grand snow-white columns of water 20 feet in diameter are hurled 60 feet into the air. Blue waves of boiling water surge over the shell-like lips of the crater, and fall in a thousand cascades over the alabaster terraces.

There are many other springs (for example, Ohaki, near Taupo, Whakapoapoa, at Orakeikorako) which, according to Maori legends, are influenced by changes in the wind. There is a great spring called Ketetahi, situated on the western slope of Tongariro, and 1800 feet above the level of Rotoaira Lake, which is only active during westerly winds.

About three miles north of the Waikato River at Niho-o-te-Kiore, and in the middle of Hinemara Plain, are two fine springs, named Waimahana. These pools are circular, each about 25 feet in diameter, and 30 or 40 yards apart. They are situated on a spur which slopes down to the Whangapua River, 180 feet below, on the sides of which the outflow has formed pretty white silica terraces. The northernmost pool slowly bubbles, and the temperature throughout the year ranges from 190° to 200°. In March or April the water in the other pool recedes to ten or fifteen feet below the surface, and remains at blood heat until December, when it fills up, a strong outflow takes place, and the temperature is increased to 204°.

I carefully noted these springs during the years 1870 to 1874 without detecting any deviation from what I have already stated.

In writing these notes I have had to trust entirely to memory: they are therefore not so accurate as might be desired. But I think sufficient evidence has been adduced to justify us in assuming that the coincidence of these changes in the Hot Springs is not merely accidental, but must be attributed to some unexplained cause. Before any correct theory can be arrived at as to the supposed effect of the wind on the Hot Springs, it will be necessary to obtain careful observations extending over a considerable time.

Can it be that the singular phenomena I have alluded to are caused by contraction or expansion of the earth's crust? or are they attributable to barometric pressure? It seems difficult to realize the possibility of their being due to the latter cause, as the orifices of some of the springs I have instanced vary in width from 90 feet to nine inches.

Were these geysers situated at a lower level than the lake, atmospheric pressure, extending over a large water surface, might readily be assumed as a cause; but Te Tarata, and several of the springs I have mentioned, are at a considerable elevation above any water.

Before concluding, I may mention that volcanic action in the Hot Lake District is fast dying out. Many of the finest geysers have dried up during the last twelve years, including the once famous Waikite, at Ohinemutu—so graphically described in Mr. Meade's book—Waikite, at Whakarewarewa, and Te Koingo, or the "Sigh," at Rotomahana; while few new ones ever burst out.

ART. IV.—*On the Draining of Towns.* By W. D. CAMPBELL, Assoc. Inst. C.E., F.G.S.

[*Read before the Wellington Philosophical Society, 4th November,* 1876.]

THE subject of drainage comes before us, in almost every town, either as a question of system or of clarification at the outfall; in England, both of these aspects of sanitary work have of late received a great deal of attention, and many of even the most lethargic towns have been stirred into action by injunctions served upon them by River Conservancy Boards.

The consideration thus bestowed upon drainage has necessarily caused a more methodical grappling with the subject; and the author having been actively engaged for several years upon drainage works, submits to the

Society the following practical considerations, which may be of use in improving the healthfulness of New Zealand towns.

It is proposed to glance at the various systems that should be before the mind of a person who wishes to consider the most judicious manner of draining a town or district.

Two prominent divisions are first noticeable: *First*, we have the midden, pail, and dry-earth systems; *Secondly*, the water-carriage systems.

The midden system is that which has been the first usually adopted. The old-fashioned midden, with a fixed receptacle-trench cut into a porous soil, which is continually absorbing the moisture from the accumulation of the filth, presents the most loathsome combination of bad management. The trench, or pit, is often not covered in, and, when it is, it has still oftener no ventilation except through the seat of the closet.

When no provision is made for the slop water of the house, it is cast out into a channel, which only too often conducts it on to the public street, afflicting the passer-by with disgusting stenches.

When the midden trench is abolished, and a receptacle, such as a tub or pail, substituted, that can be removed weekly or fortnightly, or as occasion might require, then the first requirements of sanitary laws are attained.

A. The various kinds of pail systems, and also the results of the adoption of them in towns, require closer consideration.

The simplest method is, perhaps, that practised in Rochdale and Warrington, in England.

Rochdale has a population of 18,552 persons. It has some 5,600 closets, with pails and ash-tubs, both of which are removed weekly by carts, the whole system of collection being carried out by the Corporation, and under the management of Mr. Alderman Taylor, to whose paper before the Society of Arts I am indebted for these particulars. The refuse is manufactured at the depôt into manure, mortar, cement, or fuel. The collecting of pails is so well managed that the number of omissions has not exceeded thirteen per week. The whole of the refuse collected from an area of 4,000 acres is utilised, and defrays most of the cost of collecting. The death-rate has diminished as the pail system has supplanted the middens. From 1870 to 1875 it averaged 23·57 per 1,000, whereas previously, from 1864 to 1869, it averaged 26·22.

Another kind of pail system is that known as the Gough Absorbent System. Here the pails or containers, are provided with a lining of three or four inches of ash-tub refuse, mixed with a little soot, charcoal, gypsum, etc., and are removed weekly with the ash-tubs.

This system has been in use for several years in Halifax, Woolwich, Sheerness, Aldershot Camp, and Halstead; at the last-named place, the Surveyor asserts that it pays for collection. In Halifax, in Yorkshire, it has been worked for five years by the Gough Company; at first, at the rate of 5s. per closet per annum for a period, and then 12s. per closet, including the collection of ashes. The Corporation offered an additional subsidy of 50 per cent. when the contract ended, in order to induce the Company to continue the working of the system. The Town Corporation, however, have now purchased the plant for £3,500, and work the system themselves. Some 3,000 closets are in use, representing 18,000 of the inhabitants. The population, in 1871, was 65,510, when the death-rate, which had been rapidly increasing, amounted to the alarming height of 31·5 per 1,000; but it has now been reduced to 24·1 per 1,000. The raw manure is sold at 11s. per ton at the Gough depôts. The Gough Company also make a more portable manure, like leaf mould, which is sent out in bags to any part of Yorkshire at £4 per ton, including bags and carriage; ashes, charcoal, soot, and gypsum being added to form this manure.

The price of the closets, in duplicate, with license to use them, is 40 shillings.

At Manchester and Salford, the pail closets have a cinder-sifter attached to them. The sifter is so arranged that the fine ash falls into the pail, while the cinders fall into a bucket, to be used again as fuel.

In Salford, the patent of Mr. C. Morrell is used, the builders purchasing the working closet from the Sanitary and Economic Manure Company, the cost of application, either to new premises or the reconstruction of old closets, varying from £4 to £6 10s. per closet, including apparatus. About 1,000 closets are in use. The collecting per 1,000 is done by two and a-half horses and twelve men. The annual quantity of manure collected is 3,900 tons. The total expenditure for this is stated to be £1,117, including manufacture, so that, when the manure is sold at 5s. 6d. per ton, the expenditure is recouped.

The earth-closets invented by the Rev. H. Moule are largely used in establishments such as schools, barracks, hospitals, and also in the village of Halton, in Buckinghamshire, and at the Broadmoor Asylum they have been used for seven years.

Other forms, invented by Dr. Bond, Messrs. Moser and Gibson, are worthy of mention, and have each their advantages.

The Moule Earth-Closet Company states that three pounds of earth is required for each person per diem, but four and a-half pounds is probably the usual amount used.

From particulars stated by Messrs. Taylor, Mason, and Pearce, the following table has been constructed :—

	Cost per Head.		Cost of Manure, per Ton.	
	For collecting Ash and Manure.	Do., including Manufacture of Manure.	Raw.	Manufactured.
	s. d.	*s. d.*	*s. d.*	*s. d.*
Rochdale	1 3	2 9½	4 6	*11 10
Halifax..	*2 0			
Salford..	3 3	4 4	4 2½	5 7

* Approximate.

In estimating the amount of pail sewage to be removed, one pound may be taken for each individual per diem, or three and a-half hundredweight per annum, and five hundredweight including ash and refuse. About ten tons of pail sewage appears to be necessary to produce one ton of manure, with five or six per cent. of ammonia; so that 62 persons would produce one ton of such manure, and, in such a concentrated form as this, it would be sure to command a market.

In these dry systems, the slop water is taken from the sinks by four or six-inch pipes into the road drains; or, where there is a garden, it should be conducted into a blind drain composed of open-jointed porous pipes two inches in diameter, to form a mode of intermittent filtration, a system which has been found to be most efficacious in dealing with water-carried sewage.

The first outlay in the adoption of one of these dry or pail systems is not large, which forms the great inducement for towns to adopt them; there is also the benefit of an easily manufactured manure that might be made to cover the cost of maintenance.

B. In the second division we will consider the various kinds of water-carriage systems.

The first use made of this method of removing sewage was to conduct the whole into cess-pits, or vertical shafts, lined when necessary with bricks laid without mortar. This was only an enlarged phase of the old midden pits, and open to the same objection. They require to be emptied periodically, causing an intolerable nuisance; and sometimes, as in the case of Sevenoaks, Kent (population 4,250), the whole town was drained into two or three large cess-pits, which overflowed when surcharged by storm water. The subsoil was thus contaminated to such an extent, that almost all towns in England similarly sewered into cess-pits, are endeavouring to abolish them.

The following Table shews the Outlay upon Sewerage Works and the beneficial effects arising from them, and it also shews the varying Cost per Head of Population.

	Population in 1861.	Population in 1875.	Average Mortality per 1000 before Construction of Works.	Mortality in 1875 per 1000.	Saving of Life in one year.	Total Outlay on Works up to 1874.	Annual Cost of Maintenance.	Cost of Works per head of Population.	Proportion of Pail Systems, etc., in use.	Mode of Disposal of Water-carried Sewerage.
						£	£	s. d.		
Banbury ..	10,238	11,718	23·4	19·66	43½	6,000†	5	10 3		Irrigation.
Cardiff	32,954	73,000	33·2	21·26	869	76,000	400	20 10		Drained direct into Bristol Channel.
Croydon ..	30,229	63,000	23·7	21·71	136	77,000†	1,100	24 5		Irrigation and Filtration.
Leicester ..	68,056	95,064	26·4	26·02	36	41,000	1,500	8 7	3,500 Middens, 3,660 Ash Pits, 3,000 Pails	Precipitation by Lime.
Salisbury ..	9,030	12,902	27·5	24·3	41	15,000	700	24 9		Drained direct into River Avon.
Warwick ..	10,570	11,001	22·7	19·1	39½	23,872†	1,187	43 4		Irrigation.

* Mr. Baldwin Latham, M.I.C.E., has attempted to estimate the pecuniary saving effected during thirteen years, since the completion of the Drainage Works of Croydon:—2,439 funerals, which would have cost £12,195; 60,975 cases of sickness prevented, £60,975; value for the labour for six and a-half years of 1,317 adult persons whose lives were extended, £166,930. Total, £240,100.

* See Inaugural Address Society of Civil Engineers. † The cost of land for irrigation not included.

There are two methods of dealing with water-carried sewage: either the whole, together with the rainfall on the streets, can be conveyed by sewers to the outfall, which is the "combined system," or it can be kept separate from the rainfall by a double set of pipes—one for the sewage and one for the rainfall, which is called the "separate system."

The General Board of Health, in England, recommended the latter system, and that the sewer be laid at the backs of houses in order to avoid laying the house-connections under the dwellings from back to front, any leakage from which would render the house unhealthy.

The great advantages are, that pipes can be used to a far greater extent than by the former method, both for the sewers that take the house and yard drainage, and for the drains taking the road drainage. The sewers have then to carry off a regular daily flow, and so can be of much smaller size than they would be if they were to take the rainfall also. The road drains can also be smaller, because they can have as many outfalls as convenient into the nearest watercourse without polluting it and causing a nuisance. In fact, most towns would require only nine-inch pipes laid in the greater portion of the drained area. There is also a regular quantity discharged at the outfall, and, when it is necessary to clarify or deodorize, there is a much more convenient form of sewerage to be dealt with thereby effecting a great saving in the cost of treatment.

In all the best-drained towns of England, the sewers are laid in straight lines, with shafts at their junctions, and at regular distances apart. These shafts are man-holes and lamp-holes, or man-holes and ventilators alternately, both the man-holes and lamp-holes acting also as ventilators. When it is required to inspect a sewer, a lamp is lowered down a lamp-hole, and a man goes down a man-hole, and, by looking along the sewer, can tell whether it is clear or not. If it is not, he places a flushing-board in the man-hole above the blockage, and in a few hours there is sufficient accumulation, and the board is drawn up, and the rush clears away the deposit or obstruction in the pipe.

When a householder finds there is something wrong with his drains, and reports it to the authorities, the public sewer is first inspected, and, it it is proved to be clear, a trench is cut down to the house-connection, and the pipes cleared with rods. A great saving is thereby effected in the maintenance outlay, for, before any expense is incurred at a blockage, it is ascertained to be in either the public or private portions, and all uncertainty and useless excavation is avoided.

The Town Surveyor should be able to refer at once, when necessary, to the block plans sent in when the house-connection pipes are laid, and on which the position of the drains are shown. In some towns, sections, showing their falls, are required by the authorities.

It is to be hoped that in this country the local authorities will be empowered to lay the whole of the house drains, as they are most important portions of a drainage scheme, and, when left to builders or jobbing workmen, are seldom laid properly, and with cement joints when they pass under houses.

The most efficient means of keeping sewer gases from the interior of houses, is to have the sink and soil pipes discharging upon the grating of a small receptacle outside the house, and which is connected with the sewer, or the soil pipe can be continued up to the roof, so as to form a ventilating shaft. Nothing short of complete disconnection will stop the gases. They have been proved by Dr. Fergus, at the meeting of the Social Science Association, in 1874, by experiments, to pass through water-traps. Traps are also constantly getting choked and out of order; but if there is a disconnection of the sink-pipe, any sticks or brushes that have been forced down the pipe by servants are at once intercepted.

The chief defects of a water-carriage system are always in the faulty workmanship of the house-connections. Gas and Water Companies take care that they have the laying down of the house-connections in their hands; and so should that department of work be as carefully done for the sewers as for the gas or water.

Flushing arrangements are required in every town to clear those pipes that have low falls, and are liable to have deposits during the ordinary flow through them. Chambers are built specially for this purpose with penstocks, worked by chains or screws or self-acting counterpoises. It is stated, in the First Report of the Health of Towns Commission, that, on the occasion of one trial, a length of two and a-half miles of sewer was cleaned by one flush, with a four-foot head of water, and carrying 21 yards of sediment away. The cause of sediment is nearly always the road sand that has found its way into the drains from the gullies.

Charcoal baskets have been used to a very great extent in the ventilators to absorb the noxious vapours rising from them, but they are now falling into disuse, as it has been found that free circulation of air through the sewers has a much greater beneficial effect.

The streets and roads are provided with gullies to catch the flow of water along the channels. They are usually four feet deep and three feet by two feet in plan, and are well trapped if they are connected with sewers; but, on the separate system, the road drains would not require that precaution.

In connection with this subject it may be stated that the high proportion of the deaths in New Zealand towns, due to zymotic diseases—viz., dysentery, diarrhœa, enteric and typhus fevers, cholera, etc.—show plainly that there is a fearful loss of life that might be prevented by proper sanitary measures. In 1873, the annual death-rate per 1,000 on the population of 68 of the largest English towns, due to the above cause, was 3·6, while in the rest of the country it was 2·9. In 1875, the corresponding death-rate of seven New Zealand towns, referred to below, was 8·63, while in the country districts it was 3·17.

In Wellington, there would be a saving of 32 lives each year if the mortality was lowered to 23·1 per 1,000—the average of English towns in 1873.

But the most startling fact is, the difference between the proportionate healthiness of the town and country districts in New Zealand compared with that of England.

In England, in 1873, the death-rate of 130 largest towns was 23·1 per 1,000, and in the rest of the country 18·4, giving a proportion of 1·27 deaths in the large towns to 1 in the country. Now, in seven of the largest New Zealand towns the average death-rate was 25·91, and in the rest of the country it was 13·31, or 1·95 deaths in the towns to 1 in the country.

If the New Zealand towns were as healthy, relatively, to the country districts as the English ones are, then their death-rate would be only 16·9, and the saving of life would be as follows :—

1875.	Estimated Mean Population.	Proportion of Deaths per 1,000 of Population.	Number of Lives that would be saved in One Year.	
			If the Death Rate was the same as in average English Towns.	If the Towns were proportionately as Healthy to the Country Districts as compared to England.
Auckland ..	13,084	35·77	166	247
Thames	8,259	18·16	..	10·5
Wellington ..	10,956	26·01	32	100
Nelson	5,805	27·39	26	61
Christchurch ..	10,611	20·44	18	144
Dunedin.. ..	19,153	22·24	..	102
Hokitika.. ..	3,461	21·38	..	15·5
		25·91	302	680·0

In Wellington, I may remark in conclusion, the present mode of construction of sewers is highly objectionable, inasmuch as they are of wood, and cannot be prevented contaminating the subsoil; neither are they so durable as pipes, and are therefore more costly in the long run. They have flat inverts, and so present the least scouring power, and are liable to be infested with vermin. I exhibit a diagram shewing the increase in depth of the same quantity of water in three figures—square, circular, and egg-shaped sewers, all having the same area.

The pail system can never compete in completeness with water carriage, but it would be better than the present one in Wellington. For some portions, such as the suburban and hilly parts of this town, it would be specially advantageous, with water carriage for the remaining parts.

An outfall for the reclaimed and adjacent portions of the town could be formed as far beyond Pipitea Point as money would permit, and the Te Aro end provided with an outfall towards or at Jerningham Point.

The discharge of drains from even a pail system town would not be desirable to have poured into a bay opposite it.

Wellington would do well to protect with jealous care the beautiful bay that is its pride and source of prosperity.

Art. V.—*Speculations on the Physiological Changes Obtaining in the English Race when Transplanted to New Zealand.* By A. K. Newman, M.B.

[*Read before the Wellington Philosophical Society, 30th Sept., 1876.*]

Having studied at odd times the changes produced in English people by a residence in this colony, and also peculiarities in their offspring, an account of the points which interested me, and my speculations on these matters, make up this paper. I regret that I have been unable to weld them into a compact mass, and that consequently this paper is not so continuous as is desirable in a communication to a scientific society.

Science teaches us that all plants and animals are acted upon by the surrounding conditions—in other phrase, by their environment—and that any change in the environment causes many changes in the organism; and therefore, in studying the changes obtaining in an immigrant, it is absolutely necessary that we should possess some knowledge of the environment.

Of the 100,000,000 square miles of water on the globe, 25,000,000 square miles are in the northern, and 75,000,000 square miles—*three times* as much—in the southern hemisphere. From this vast sheet vapour is constantly rising, and the enormous amount of this vapour is demonstrated by the fact that off Cape Horn, and in other parts of the southern ocean, the barometer stands permanently at a low level, ranging between 28° and 29°—*i.e.*, an inch or more below that in the northern hemisphere. Dr. Ballot says that in about 40° N. the average barometric pressure is over 760 millimetres, but in 50° S. it falls to 750 millimetres. These observations are deduced from an immense mass of barometric readings.

In New Zealand we see a steady lowering of pressure from Mongonui, in the north, to Invercargill, in the south, and the presence of this vapour greatly affects the New Zealand climate. Professor Tyndall showed, by elaborate and delicate instruments, that the vapour in the air made it tolerably transparent as regards the transmission of direct rays, but rendered it opaque to the rays reflected from the earth; and he showed, further, that the opacity of the vapour of water was 16,000 times greater than that of pure dry air, and that this vapour acted as a blanket by preventing the escape of heat; therefore, the greater the quantity of vapour, the warmer and more equable the climate, and for this reason the isothermal lines agree more closely with the parallels of latitude in the south than they do in the north.

By means of this vapour, as Maury first suggested, much heat is carried from place to place; this heat, though *latent*, is readily liberated by the condensation of the vapour. When the vapour-laden winds strike the coast of New Zealand, they are forced by the mountain chains to ascend; there cooled, the vapour condenses and falls as rain. By the extraction of the vapour the air is rendered heavy, and it is also warmed by the large amount of liberated heat, His theory explains these phenomena—the raininess of the west of New Zealand as contrasted with the dryness of the east coast, and the fact that on the eastern side, these winds, though tumbling down from cool mountain tops, are yet warm—often hot. This latent heat, when liberated, is a powerful agent in increasing the force and regularity of winds in this hemisphere. Because of the greater dryness of the air on the east coast, the thermometric variations are there much more marked than on the west coast.

Barometric Pressure.

According to Maury, whose statement is founded on an enormous number of barometric readings, the pressure of the atmosphere is, in the southern hemisphere, from 10lb. to 50lb. per square foot less than that in the northern hemisphere. The surface of an average man is 35 square feet, and such a man in England sustains a pressure of 35,560lbs., or nearly 16 tons (" Ganot's Physics "); but in New Zealand the pressure is lightened, and though at any one moment this difference of pressure may seem small and unworthy of notice, yet it is not really so. Ramifying everywhere through the skin are minute blood-vessels; these, the walls of the chest, the air-cells of the lungs, and indeed all the internal organs, are subjected to a lessened pressure. This lessened pressure will slightly change the cerebral circulation, and will therefore also slightly affect the immigrant's thinking powers. The lessening of pressure on the chest walls, though apparently trivial, is not so, because the immigrant respires 19 times a minute; and if, at each respiration, he lifts only *one* pound *less* each time to a given height, yet in the 24 hours he will lift 27,500 pounds (*i.e.*, twelve tons) less than when at home. Though in healthy people it may be difficult to detect many changes arising from these causes, we may see that they really are very powerful. Phthisical patients, after a short residence here, improve (the pathological changes fade out), and often they become robust. A lessened atmospheric pressure is also very beneficial in many acute diseases, and especially in those of the lungs. The fierce New Zealand gales pump air into rooms at high pressures, and thus increase disease and retard recovery. Diminution of atmospheric pressure, too, causes a change in the shape and size of the various organs—*e.g.*, the Aymaras, who inhabit the Andean heights, have long deep chests, with large lungs and short legs; these and other peculiarities of structure in them are directly due to lowered atmospheric pressure.

People who climb lofty mountains soon experience great fatigue because their legs feel so heavy. When walking, our limbs swing freely like pendulums, and feel of little or no weight because of the peculiar formation of the hip, knee, and ankle-joints. If all the muscles and ligaments were cut through which attach the thigh to the trunk it would not fall off, because the atmosphere presses the head of the femur against the acetabulum. This pressure is 25 pounds. In like manner the leg is attached to the thigh by a large joint, the pressure on which is 60 pounds; so with the ankle-joint—thus the weight of each limb, both upper and lower, is much lessened. As in ascending a height, so in any case where the pressure is lessened, the weight of the limbs will increase, and therefore fatigue would a little earlier set in during a long walk in New Zealand than in England.

Yet other altered climatic conditions affect the immigrant. Though the amount of heat received by each hemisphere is exactly equal, yet is its distribution unequal; for, owing to the earth's position, the southern summer is nearly eight days shorter than the northern, and its winter so much longer (Somerville). The solar rays fall more directly on the southern hemisphere, and their heating power is consequently greater by one-eighteenth of their whole intensity; but as solar rays are composed of heat, light, and actinic rays, all three act more directly and more intensely in the southern hemisphere. As each of these varieties powerfully affects all organic and inorganic substances, therefore variations in the amount or intensity, or distribution of all combined, or of each one singly, affects the immigrant both directly and indirectly. In vegetation is easily seen the effect of sunlight—for vegetation grown in the dark is pale, and often sickly. Moreover, Sachs, a German botanist, has shown that, in the sunlight, starch grains travel in ten or fifteen minutes from the stems of plants to the chlorophyll grains in the leaves, and that these and many other changes would not occur if the light and actinic rays were absent. He also shows that carbonic acid (Co_2), the principal food of plants, cannot be decomposed under a lower temperature than 2,500° Fah.; but plants, by the aid of sunlight, easily decompose and utilize it, and to plant-life the presence of abundant light rays is absolutely indispensable; or, as Fiske eloquently expresses it, "The slower undulations penetrating the soil set in motion the atoms of the rootlet, and enable them to shake hydrogen atoms out of equilibrium with the oxygen atoms which cluster about them in the compound molecules of the water. The swifter undulations are arrested by the leaves, where they communicate their motor energy to the atoms of chlorophyll, and thus enable them to dislodge adjacent atoms of carbon from the carbonic acid in which they are suspended." These changes, so poetically described, are greater in New Zealand than in England, and in the internal economy of each individual certain similar changes obtain. The increased heat causes a diminution in the quantity of carbonic acid excreted by each human individual. Vierordt proved that every rise in temperature of 10° Fah. caused the individual to exhale two cubic inches less per minute. According to this scale, the Englishman who at home would excrete eight ounces of carbon in 24 hours by his lungs, would in New Zealand exhale only about seven ounces;—this means that the man in New Zealand would eat less, and would do less work, than when at home.

A popular belief asserts that men can adapt themselves to any climate, and can flourish there. This belief is wrong. It is true that the *genus homo* can endure a cold in Siberia of 109° Fah., or 120° Fah. (*i.e.*, 150° of frost), or, in a Persian desert, a heat of 179° Fah., a difference of 300°; but varieties, or species, of man will not bear transplanting to markedly opposite climates. The Esquimaux and the Fantees would soon die if they changed places. A scanty remnant of the original colony might survive the change for a few years, but the majority would soon perish; and probably, after one or two generations at most, the race would become extinct. Even with less extremes similar results obtain: Englishmen in India, Sierra Leone, and in Guiana die fast, and but for a constant stream of immigration would, in two or three generations, become extinct. So, too, the Dutch in Java are all immigrants from Holland. The climate of New York is fatal to the tropical bred negro.

Of course, the climate of New Zealand is nothing like as hot as in some of these countries, yet the greater intensity and directness of the solar rays, as compared with those in Great Britain, does produce certain marked changes. Experiments very numerous, and conducted on large numbers of persons, prove that all our functions are carried on more quickly in summer than in winter; men and animals gain weight in spring and summer, and lose it in autumn and winter; the hair, too, grows more quickly in summer than in winter. After a short stay here the skin is browned—more tanned—a change arising directly from the greater force of the actinic and light rays acting on the hœmatosine and pigment cells. The hair grows abundantly, and often sooner turns grey. The bright English skin tints are toned down, and there seems a tendency to spareness. Lack of energy, lassitude, and premature ageing are also noticeable features.

The greater warmth will tend to check an imported national vice, and, though it may seem venturesome to give an opinion, it seems pretty certain that drunkenness will not be so prevalent in young New Zealand as among the parent stock. Drunkenness is a form of vice specially suited to cold climates, and one that, perhaps, more than any other vice, is affected by heat and cold. Young Victorians, young Queenslanders, and young New South Walesmen, seem to inherit all the vices of their fathers except drunkenness, and any physiologist who looks at them can at once see, from their general spareness of frame and general lack of vigour, that they as a class must be sober. Young New Zealanders, who are much the same in appearance, look unfit for drunkenness. Many of the changes just enumerated will be continued and multiplied in the offspring. The monotony of the climate, its freedom from great extremes of heat and cold, is an unfortunate thing, for frost and snow, alternating with summer sultriness, stimulates mens bodies, the vital functions are actively carried on, and the lassitude and indolence generated by prolonged summer heat give place to energy. In India, in the Cape of Good Hope, and in Australia the Englishman works less, and for a shorter time, with his muscles and brains than he would have done had he remained at home. The Englishman imports to this colony a stock of energy and a habit of working, but undoubtedly in his offspring may be seen a diminution of this energy, and as generations succeed each other the difference will increase.

Besides the amount and distribution of heat, light, and actinic rays, of calms and storms, of rain and drought, of electricity and magnetism, there are doubtless very many other important conditions which affect the immigrant, but unfortunately our knowledge of the laws of life is too limited to allow us to do more than speculate upon them. For instance, upon the chemical constitution of the soil may depend the success and welfare of a nation. Animal chemistry reveals the startling fact that the amount of phosphorus varies with the amount of mental activity. By analysis of infants' brains, 8 parts in 1,000 are found to be phosphorus. In youths' brains, whose minds are active, it rises to 16 per 1,000; and in adults, when the mind is most active, the amount increases to 18 per 1,000; in the aged, whose minds work little, it falls to 10 per 1,000; and in idiots, it never at any time rises above 8 per 1000, and the amount of brain work done can be roughly measured by the quantity of phosphates excreted. "*Ohne phospher kein gedanke*"—"Without phosphorus no thought"—was the saying of a German philosopher. If therefore the soil be deficient in phosphates, or it be in difficultly disintegratable forms, it must be deficient in the cereals and animal food, and the English immigrant eating such cereals and such meat will lack phosphorus—be wanting in brain power. A nation's greatness depends chiefly on its brain power, and in the fierce struggle for existence it is certain that if the soil of a nation were markedly deficient in phosphorus it would succumb to that nation whose soil contained it largely.

The great geologist Lyell tells us that at the mouth of a land-locked sea a bar was raised, that the water became brackish, and that the oysters and fish grew scarce. As oysters and fish contain large quantities of phosphorus, this elevation of a single strip of land actually affected the thought power of the coastal people.

The quantity of lime in the soil will affect the colonial born, for the bones owe their rigidity to the amount of lime they contain. If this lime be not supplied in proper quantity in the food, the cartilagenous rods bend under the weight of the body, and then are seen the crooked rickety limbs so common among the London poor. On the other hand goitre and cretinism are by learned pathologists attributed to a superabundance of lime in the water, and thus explain it:—At birth the bones of the base of the skull are soft and expand with the growth of the brain, and not till after some years do they become completely ossified, *i. e.*, rendered hard and unyielding. In cretins the temporal sphenoid and occipital bones ossify early, and the brain shut in a rigid case cannot develop, hence cretinism and goitre result.

Last year, at the British Association, a Mr. Cooper showed that the mental condition of nations varied with amount and varieties of inorganic impurities in their drinking water, and that all their social, political, and religious qualities might be changed by these impurities. He goes still further and says that by analyzing fossil bones it would be possible to tell the amount of salts contained in the water they drank. Thus for example, by analyzing and comparing both ancient Maori and English skeletons, we could tell approximately the difference in the chemical impurities of the water of the Waikato or of the Severn. And though Mr. Cooper's theory of impurities in water affect a nation's political, social, and religious life, yet really there is nothing physiologically objectionable in the theory, for we know that certain things, as opium, alcohol, tea, indian hemp, &c., do powerfully stimulate or depress men's brains. Indeed, Sir J. Mackintosh used to say that the difference between one man's mind and another depended solely on the amount of coffee drunk by each.

Young New Zealand.

Though intensely interesting are all questions connected with the immigrants; of equal, if not greater interest are those concerning their offspring; that "every goose thinks its gosling a swan" has passed into a proverb, and old colonists here and in Australia do look with very partial eyes on their offspring. They magnify the good qualities, and are blind to the defects of their succeeding generation. Indeed, many of them loudly assert that young New Zealand is superior physically and mentally to the parent stock. In the Yankees we see the effects produced by a transplantation of our race, and in Victoria and New South Wales already the type is rapidly changing. The epithet "cornstalk" graphically depicts one change. In New South Wales and Victoria the colonial born grow tall and thin, wanting the breadth and robustness of the parent race, in these respects resembling the "slab-sided Yankee." In young New Zealand the same changes obtain: they are spare, wanting in solidity and less of bulk. Other points are noteworthy. The noses and features are more regular. The great variety of noses and the irregular features and amorphous faces so common in an English crowd would be absent in a crowd of colonial born. Uniformity is here the rule.

The doctrine of evolution teaches us that types are not persistent as was formerly thought. That on the contrary, the rule is not persistence but change. The anthropomorphous apes are prognathous, powerful in crushing with their massive teeth. Savages are less prognathous; their jaws are smaller, their crania larger. Civilized men are less prognathous; their jaws smaller, with dwarfed teeth, and the crania bigger, the forehead looms large above the shrinking features. In the Yankees a still further change is going on. The children's jaws are smaller than those of the English, and the teeth appearing in these small jaws want room, jostle, and displace each other. Often, too, the *dentes sapientiæ* are cut late, or not at all. These smaller jaws, with greater width between the rami of the inferior maxilla, give rise to the "lantern" jaws, and, combined with a large forehead, show a further change. In young New Zealand the same changes are apparently to be found. The *symphyses menti* are pointed, the alveolar edge of the maxillæ too small; overcrowding and irregularity of the teeth result. It is probable, too, that the highly carnivorous diet of these persons will increase certain of these changes.

The bright tints of English complexions are in the complexions of young New Zealand, replaced by faded colours, duller hues. It is a curious fact that very few dark complexioned children are born in New Zealand, for, however dark may be the parents—however raven their locks, or black their eyes—their offspring will almost invariably have duller tints. I find it impossible to faithfully paint in words what I consider the distinguishing marks of the young New Zealander. They are most marked in the female. It is, however, very often quite easy to distinguish the colonial born and bred by their looks.

Encouraged by the ardent sun's rays, and unchecked by biting cold, both English plants and English animals here quickly attain maturity. So, too, their offsprings quickly grow, and are early developed. But this early forcing is the precursor of early decay. In Australia, under a fierce sun, the children grow quickly, but like hot-house flowers they early fade, and their mental and physical powers are well nigh exhausted at an age when the Englishman is in his prime. They lack stamina. The New Zealand and colonial youth and young man is physically and mentally weaker than persons of similar age at home. They are less robust; hard work and privations soon affect them. The colonial generation, too, is constitutionally weak. The individuals are often, as they say, "seedy"; any attack of disease quickly prostrates them, and the recoveries are tardy. The women fade, become old and haggard, after rearing a small family. Like the males, they early bloom and quickly fade.

In one of his singularly suggestive and delightful works, Dr. Oliver Wendell Holmes startles the reader by remarking that "the finest women are raised under glass," and then exclaims:—"Good, dry, well-ventilated houses, well-paved streets, every possible comfort, and an absence of hardships are as necessary to produce fine women as a green-house and warmth to exotic flowers." Probably owing to the absence of these things is due some of the defects just mentioned.

The conclusions I draw are these:—Partly owing to the climate, and partly to other changes in the environment, the immigrants' vital capacities diminish, their physical energies deteriorate; and that these alterations are more fully developed in their offspring, and that it is certain that the race would alter much and very decidedly deteriorate, were it not for a constant stream of immigrants.

Art. VI.—*Polynesia.* By J. Adams, B.A.

[*Read before the Auckland Institute, September 13, 1875.*]

About 360 years ago, Magellan, after battling for weeks against contrary winds and currents through the 60 miles of straits that bear his name, got out at last into the great ocean; and steering a N.W. course, sped along with fair winds and favoring currents until he had reached the Ladrone

Islands, which are distant from Cape Horn more than 9,000 miles. From these islands he could have gone with as fair winds, and still more favorable currents, across the North Pacific to the coast of Mexico; because 120 miles south of Guam a strong current is felt, which flows towards Formosa, and when within 120 leagues of that island turns north. At this point the stream is 100 miles wide, of a dark blue color, and twelve degrees hotter than the torpid water on either side. It flows by the islands of Japan at a rapid rate, varying from two miles to four miles an hour, and its waters are so much darker than the rest of the ocean that the Japanese call it the *Kuro-siwo* or black river. As it flows northward it constantly increases in width, so that opposite the Loo Choo Islands it is 500 miles wide, and still further north, in the latitude of the Tsugar Strait, it separates into two branches, one flowing along the coast of Asia and through Behring Straits, and the other branch in a westerly and north-westerly course across the Pacific. The first branch not only raises the temperature of the Kuril Isles and Kamschatka, and keeps the east side of the Behring Straits free from ice during the summer months; but it also piles up drift timber, swept from the shores of Japan, in immense quantities from Norton Bay to Point Barrow in the Arctic Ocean. The second branch, in its westerly course, flows at varying rates from seventeen to forty-eight miles a day, and with a constantly lowering temperature. In 36° N. and 180° W. the temperature is 81°. At this point the current turns north-west, and strews the shores of the Aleutian Isles with drift timber. In latitude 48° N. and 150° W. the temperature is 64°, or 11° hotter than the torpid waters. As the Kuro-siwo approaches nearer the American coast, it meets the cold under current of Behring Strait, and, by it is forced to the west, in latitude 30°, so that the waters revolve from east to west, and form Fleurieu whirlpool. The contest between the currents of warm and cold water is well marked in the North Pacific. The northern branch of the Kuro-siwo forces one cold current from the Arctic close to Kamschatka, and into the sea of Japan, and another is forced along the shores of North America. This current, which is called the Californian, flows south-east towards the equator, and meeting the eastern branch of the Kuro-siwo forces it aside, as has been said, and forms Fleurieu whirlpool. In latitude 20° N., it turns west, and as the North Equatorial current flows right across the Pacific to supply the current of Kuro-siwo.

A similar circuit of ocean currents exists in the South Pacific, but as there is no land to obstruct the cold streams from the Antarctic Ocean, the warm currents are forced nearer to the equator in the South Pacific than in the north. It was a current from the Antarctic that Magellan had to contend against until he got well away from the coast, and entered the left branch of the current which flows along the coast of Chili and Peru, under the name of Humboldt's Current. This immense body of icy-cold water has a great effect on the climate of Patagonia and Chili. Darwin writes that "almost every arm of the sea which penetrates to the interior higher range, not only in Terra del Fuego, but on the coast for 650 miles northward, is terminated by tremendous and astonishing glaciers."

At Conception, in the latitude of Auckland, this cold current so chills the counter trades from the north-west that the forests are always dripping with moisture, and the sky continually cloudy. The effects of this current on the climate is felt as far as the Galapagos, which are situated on the equator. The temperature of the current round these islands is more than ten degrees lower than that of the ocean which hinders the growth of coral on the shores of this Archipelago. The average rate of this current is twelve miles a day, but in some parts it runs far more rapidly, as off the coast of Valparaiso, where it flows twenty-six miles a day. It is of great importance to navigation, as vessels can readily go from south to north. They make a run from Valparaiso to Callao in nine or ten days, and from Callao to Guayaquil in four or five days; but to return from these places occupies weeks, and even months. Humboldt's Current is lost near the Galapagos; part of it returns as an inshore current, southward along the coast, and a part flows west into the South Equatorial. The latter is the current which carried Magellan so rapidly across the Pacific. After crossing the Humboldt, he entered a current of warmer water flowing in the same direction as Humboldt's, which is called Mentor's Drift. This current, on reaching the latitude of 20° south, flows west, and is then called the South Equatorial. When it approaches the Paumotu Group it divides into two streams, one flowing north by the Marquesas and Samoan Islands, north of which a branch flows to the Carolines, and the other south of the Cook and Tongan Groups, until it meets a part of the northern branch west of the Fijis, on the meridian of 179° E. Between these two streams are included the six principal groups of islands with which New Zealand trades: these are, the Paumotu in the east, the Fijis in the west, and between these lie the Society, the Samoan, the Tongan and Cook Islands. For the sake of distinction I will call this division Polynesia, which extends from 128° to 178° west longitude, and lies between the parallels of 8° and 28° south latitude, and is enclosed by the northern and southern branches of the South Equatorial current. East of the Fijis the current divides again—one branch flowing north-west, called Rossell's Drift, and the other south-east towards the shores of Australia. Near Tasmania this warm stream comes in contact with an icy current from the Antarctic, and then is forced to the east, south of New Zealand, and across the Pacific as the south counter current, and near the coast of America forms the Mentor's Drift. This is the southern circuit of ocean currents. The Rossell's Drift, which branches N.E. near Fiji, flows by New Caledonia and the New Hebrides, and the islands of Santa Cruz and others, called inclusively, Melanesia. It continues its north-west course, even against the monsoon which blows from May to September, and flows through Torres Straits and to the west of New Guinea, when it meets the West Australian current; and further north still, a part of the South Equatorial, which branches off north of the Samoan Group. These united streams turn east near the Pelew Isles, and flowing south of the Caroline Group, form the equatorial counter current, which constantly flows east, between the northern and southern circuit currents, at rates varying from three to thirty-eight miles a day.

The ocean currents seem to form six principal divisions of islands. These are, Polynesia, in the South Equatorial; Melanesia, in Rossell's; the Papuan Group, between the latter the West Australian and the South Equatorial; the Gilbert and Ellice islands, which lie between the South Equatorial and the counter current; the Caroline, Marshall, and Ladrone islands, also called inclusively, Micronesia, lie between the North Equatorial and the equatorial counter current; and lastly the Sandwich Group, which is almost the only land in the northern circuit, not quite 6,000 square miles of land in an area of more than 11,000,000 square miles. The entire six divisions do not contain more than a quarter of a million square miles of land, of which Papua alone contains more than 200,000 square miles, and these are scattered over an area of more than 30,000,000 square miles. Widely as these islands are separated from each other, the whole six divisions seem to be inhabited by the same race. A common bond of language unites them, for the names of numerals, of the human limbs, and other common objects, are for the most part identical.

The Papuans are shown by Mr. Wallace to be quite a contrast to the Malays, from whom they are separated by a narrow strait; and to resemble the Maori in language, disposition, and mode of life. Cook and other early voyagers were struck with the resemblance of the Sandwich Islander to the Tahitian; and the Rowditch Islanders to the north of Samoa, who did not know of any other people, when visited by the American expedition in 1840, nevertheless spoke very good Maori.

A study of the prevailing winds and ocean currents accounts for the mild climate of Alaska, compared with that of Greenland in the same latitude. It explains the cause of the extreme cold on the western shores of Patagonia, and the constant rain on the coast of Southern Chile, as well as on that of British America.

The cold Arctic current in the sea of Japan accounts for the excellent fish caught there, whilst those taken from the warm one near the Paumotus are scarcely eatable.

By following the course of the Kuro-siwo vessels can go from Yokohama to San Francisco, a distance of more than four thousand miles, in thirteen days, and the same stream has swept vessels from Japan across the Pacific to America from time immemorial. But neither winds nor currents favor the theory that the Maori came from Malaysia, or the Tahitians from the the Sandwich Isles.

The growth of coral, which forms large reefs near all the Pacific Islands, except the Galapagos, as before mentioned, depends upon the temperature of the water. Where the water is very warm the coral flourishes, but the larger kinds cannot live in a temperature lower than 69° Fah.

For this reason the hardier kinds alone are found near the Sandwich Islands, where the average temperature of the water is 74° Fah., but it grows in its greatest vigour and variety in the Fijian Sea, where the temperature is never lower than 74° Fah., and during the summer months is as high as 85° Fah. The study of the coral polyp has occupied much attention during the last 30 years, and these animals are found to vary as much as the species of the most inclusive order of plants. Some small species live only at great depths; others, like the *astræans*, form immense conical masses; others again grow upward in massive trunks, whilst the most beautiful kinds live either in the sheltered lagoon or on the surface of the reef. Small species have been dredged up from a depth of 190 fathoms; but such kinds do not form reefs. The reef builders cannot live below the depth of fifteen fathoms, and even at this depth, all the reef forming species, cannot live, nor can those forming the base live near the surface. For this reason the *astræans*, who grow into immense spherical masses fifteen or twenty feet in diameter, forming the base of the reef, cannot live nearer the surface than six fathoms deep, so that at a pressure of two atmospheres their upward growth is checked. They however form a suitable basis for *porites* and *mæandrinas*, whose habitat is nearer the surface, and so these kinds continue on the reef, growing upwards in immense tree-like trunks and branches, until they reach their limit, which they cannot pass. Here the lighter kinds *millipores*, *madripores*, and a great variety of sea ferns continue on the structure to the surface, and crown the reef with a shrubbery of every variety of colour. The reef is by no means solid, and the openings left in it are occupied by myriads of other animals, that seek shelter or food between the growing masses. Numerous sea shells and boring shells attach themselves in the crevices. The pearl shell and the immense *treductina* fix themselves securely to the wall; the *echinus* and the *velopus* find here security and abundant food. Then the reef is penetrated by sea worms, and the waves are constantly washing away the lime, and dashing it on again, or hurling into an opening the pieces broken from a projection, and thus forming the conglomerate coral rock.

Thus, the water charged with lime, and the *millipores* or cretaceous plants which grow on the reef, entomb in due time all the animals that sought shelter in the crevices, and form a cemented wall to face the ocean. These animals that raise such barriers against the waves, which are never at rest on account of the trade winds, are the lowest but one in the order of animals. They have the same gelatinous bodies as the sea anemone, the same digestive cavity, the same mode of seeking their food, and also the same roseate appearance when the tentacles are spread; but in one respect they differ, the polypifera secrete lime, and the sea anemones do not. Some of the sea anemones on the shores of Chili are fully fourteen inches in diameter when the tentacles are spread, and some of the species are very beautiful.

The many-tinted tentacles vary in color from bright green to rich purple; the variegated disc and mouth bears a close resemblance to a garden aster, but here the likeness ends, as a sea anemone or *polypi* is as much an animal as a cat or a dog.

So soon as the tentacles come in contact with prey, whether shell-fish or crab, or small fish, they instantly close upon it, and force the captured animal into the mouth, where it soon dies, and when the nutritious parts are extracted, the rest is rejected. The sudden death of the animal is not owing to the tentacles, but to concealed weapons. These are long microscopical threads which are coiled up in cells, either in the tentacles or on the disc, and contain poison cells. These lasso threads are shot out the instant the tentacles touch an object, and the effect is to destroy very quickly the life even of the mollusc or crab that is so unfortunate as to fall or be thrown on the pretty flower. The coral polyp lives in the same way, and is armed with the same weapons, but as his mouth is often not an eighth of an inch in diameter, he must be content with very small animals. From the mouth of the polyp numerous pear-shaped eggs float away through the water, just as the winged seeds of plants are wafted away by the wind. These eggs are furnished with long cellary appendages that float far behind, and bear them along; some of these find at last a suitable resting place—one end becomes attached to the ground, the other becomes depressed, and very shortly the mouth and tentacles appear, and life is begun. The soft partitions in the polyp soon become hardened with the lime it secretes, and after increasing in bulk, the mouth gradually divides into two, and these again divide in a process called fission, and as each mouth is formed the polypifer becomes larger.

This is the mode by which *astræans* increase in bulk. The porites increases by budding, and the bud becomes a mouth and tentacles, and each species has its peculiar mode of growth. The number of animals in one mass, produced from a single polyp, is many millions, and when the many-coloured tentacles are all spread over a surface of living coral, the effect is said to be very beautiful. There is nothing more wonderful in a polyp secreting coral than in an oyster secreting his shell, or the higher animals their bones. All alike are largely, or for the most part, composed of carbonate of lime, whether animal bones, oyster shells, or polyp coral. But that a small gelatinous animal should raise a barrier, in the midst of dashing waves, against the force of an ocean current, is one of the most wonderful examples of the power of vital over the most mighty mechanical force. The polypifera always commence the reef in the neighbourhood of some land;—if the shores are steep, it must build near the shore, but if the land slopes gently, water will be shallow for a good distance from shore, and the reef-builders must therefore commence further from land in water ten or twelve fathoms deep. In due time the distance between the reef and the shore will become almost filled up with the different varieties of coral.

If all coral reefs were of this description they would not have excited so much interest, but by far the greater number of reefs differ very essentially from this description. Instead of the reef being fifteen fathoms thick, it is often 200 fathoms on the ocean side. Instead of being close to a steep shore, it is often many miles away from it; instead of the water within the reef being shallow, it is often more than forty fathoms deep. In order to account for these reefs the most contradictory theories were advanced by naturalists until Mr. Darwin studied the structure of these reefs when he accompanied the English exploring expedition under Captain Fitzroy. After comparing together hundreds of islands with coral reefs, both in the Indian and Pacific Ocean—after taking soundings within the reef and without—after an amount of labour in surveying, mapping, and collecting information that an ordinary person would shrink from, he arrived at a very simple explanation of the scientific problem.

He observed that where islands had not reefs close to the shore or fringing reefs, that the reefs varied in distance from the land, and that, as a rule, the size of the enclosed island diminished in proportion to the distance of the reef; and that the island also became lower in height. Some reefs again surround one solitary rock, as in Nanuka, in the Fijis; others, again, enclose a shoal; and, lastly, similar reefs have been found by sounding to be at present submerged many fathoms deep. It was also observed that where several small islands were close together, as in the Gambier Islands, that a distant reef ran round the whole of the islands, and that these islands were themselves encircled by coral, but that the outer reef was much older than the inner. These are some of the facts that induced him to conclude that the land had slowly subsided.

Thus if the Viti Levu, which has a reef close to the shore, were gradually to subside, that is to say at about one-half foot in 100 years. The coral reefs close to the shore would be raised to the surface by the polypifers during that time, and the distance from the shore would be increased by two or three feet. Supposing the land to sink 7,000 feet, the distance of the reef would then be several miles from shore, and the mountainous parts alone of the island would remain, as in Tahiti. A reef of this kind, which rises from deep water, at a distance from the enclosed island, is called a barrier reef. In case Viti Levu subsided still more, the reef would become more distant from the remaining land, and, in time, the highest peaks alone would remain above the water; each of which, under favorable conditions, would have its own coral reef. The Gambier group furnishes an example of this. The last stage of subsidence leaves a shallow lagoon nearly encompassed by a reef. On this the waves hurl masses of coral broken from the reef, the wind blows together mounds of sand, and the sea birds find a resting place, and thus a soil is formed for plants. A reef of this kind, with patches of pandanus and cocoa nut growing on it is called an atoll. The structure is essentially the same as a barrier reef, even to the patches of vegetation, which also flourish on the latter. The atolls are, however, smaller in extent than barrier reefs, which follows from the statement already made that the subsiding lofty peaks become encircled by reefs. The atolls are thus only the monuments of extensive lands that once formed larger islands, or a vast continent across the Pacific. Even the shape of the land that existed ages ago can still be traced in the trending of barrier reefs. At the Fijis, for instance, a distinct reef surrounds the two large islands of Viti Levu and Vanua Levu, and many small islands which were no doubt forming headlands. This reef encloses more than 10,000 square miles, of which there is now 4,500 square miles of dry land. In the division of islands in the South Equatorial current, which is called Polynesia for distinction, the extent of surface is not much less than the size of Europe, but the habitable land there is not much more than half the area of Auckland province. A great contrast exists between the size of the area enclosed by atolls and the habitable land on them. Thus in the Paumota group, Dana estimates that there are 1,000 square miles enclosed at Dean Island, but only 16 square miles of habitable land. The proportion of land is greater in other atolls, and yet of ten average islands the area enclosed is 1852 square miles, and of this only 76 miles habitable land.

There are altogether 80 of these islands in the Paumotas, of which only nine enclose small islands. The reef does not rise more than eight or ten feet above the sea level, and varies in width from 100 yards to three-quarters of a mile. There is generally an opening on the west side, through which the water constantly flows out, which Sir Charles Lyell regards as a proof of their subsidence. As a rule the vegetation is only on the east side, but in some cases, as at Ascension Island, the vegetation grows round the whole reef.

The beauty of these islands is a constant theme in story books, but there is undoubtedly a great want of variety. There are not more than 30 species of plants found on them, and of these the Cocoa-nut Palm is the most important. This tree grows to a height of 30 feet, and forms dense groves, which can be seen a long way off from ships at sea. It is the staple food, and a great source of the wealth of the natives. The fruit is often their only food; the milk supplies them with drink when fresh water is scarce. The shell is used as a cup; the fibre as cord, and rope, and mats. The timber is used for their huts, and the leaves for thatch. The dried nut, called cobra, or the oil expressed called cobra oil, is also an important article of commerce.

The Pandanus ranks next in importance, and it grows close to the water on the patches of sand on the reefs from the Paumotas to Malaysia. The fruit is grated and made into cakes, which to a European taste like saw-dust; but the fruit is much better in the Gilbert Islands, where it is preferred to cocoa-nut. The leaves are used for roofs of houses, made into sails and mats, and the fibre woven into beautiful and delicate textures. The stem gives off ærial roots, which fix the tree firmly in the sand, and as it gives off bunches of leaves in a spiral form, with large cone-shaped fruit hanging underneath, it has obtained the name of screw pine. This stem is hollow, and the tough wood makes excellent bows. These two trees furnish the natives with food, clothes such as they require, houses, and weapons. There are not more than 28 other species of plants on these islands, and nearly all these like the cocoa-nut and pandanus range from South America to the East Indies. The *Pisonia grandis*, which grows to a height of 40 feet, and sometimes 20 feet in girth, with handsome foliage and large showy flowers, is found on some of the islands from America to India. The same may be said of two *Bœrhavia*, which are only prostrate or creeping plants, of a convolvulus, the *Ipomœa longiflora*, and of a kind of cress, the *Lepidium piscidium*, which is eaten by the natives of New Caledonia as an article of food. I may also mention the *Tournefortea argentea*, an ugly shrub, and the *Asplenium nidus*, a handsome fern, both of which have an equally wide range. The canoes of the islanders are often made from trunks of trees found in the lagoons—a tree which once grew on the submerged land, and is a favorite with the natives of Tahiti and Fiji. The natives of Paumota call the wood *tomano*, and botanists have named it *Calophyllum inophyllum*.

The lagoons of these islands are generally from 20 to 35 fathoms deep; a few like Hinden Island have shallow lagoons, and two at least, Metia and Clermont Tonnere, have been elevated, the former as high as 250 feet. Where, however, the lagoon is moderately deep there is another source of wealth to the island: the natives obtain, by diving, clams and mussels and pearl oysters, which are often their only animal food; the pearl shell is collected for traders, and in many cases valuable pearls are found in it. The chief wealth of the lagoon is the trepang, or *bêche de mer*, called also *holothuria*, an animal closely allied to the sea urchin and star-fish, with the roseate mouth and poisonous lassoes of the polyp. It is about one foot long, and in shape like a cucumber; a great part of the body is buried in the coral sand, and the mouth, in shape like a flower, protrudes. It is said to feed upon the coral polyp, which flourish in great variety of form and colour to a depth of twelve fathoms near the sides of the lagoon. This animal exists in incredible numbers on the protected sides of reefs across the whole Pacific, and Mr. Wallace describes the collecting and curing of it by the natives of Kiliware, near Ceram, in the same manner as it is carried on at the Paumotas for exportation to China. Long before Columbus discovered America, Chinese ships frequented the islands of the Pacific to collect this article of food for their markets. The first European navigators found the trade of Chinese vessels for the tripang as fully established as at present. Both within and without the lagoon there are swarms of fish which feed on the polypifer. In the lagoon they are of various colours, but unfit for food as they are all said to be poisonous.

Another article of trade is in turtle shell;—the animals are generally caught by the natives outside the lagoon, whilst sleeping on the surface of the water. The flesh furnishes them with a feast, and the shells are bartered with traders, and called in commerce, tortoise shell.

A great many of the so-called charms of a lagoon island disappear when we enumerate all the good things they have, and calculate what they have not. There are no hills and valleys, no green fields or flowery meadows, no corn-fields or farmed lands; neither river nor stream, but, on the contrary, a great scarcity of fresh water, which is caught in large holes made in the coral rock during the rainy season, or in the hollowed stumps of cocoa-nut trees. Their only mineral is carbonate of lime, and the animals, if we except the sea birds, are represented by an enormous land crab, that feeds on the cocoa-nut. The inhabitants of such islands, where no forethought is necessary to provide food, nor any necessity for constant work, must have destroyed in them any idea of responsibility, which is the ground-work of morality, and are on account of the necessary poverty of their language, almost precluded from receiving instruction. It is hard to conceive how men, under such circumstances, can be anything but savages.

Sea birds frequent all the islands, but on those uninhabited they assemble in great numbers; nearly twenty varieties congregate on the islands visited for guano. The chief kinds are Gannets and Boobies, Frigate birds, Terns, Noddies, and Petrels, together with some game birds and the Tropic bird. Some lay their eggs in tufts of grass, as the tern, which numbers millions on some islands during the breeding season. The noddy burrows in the ground, and makes a hole for its eggs. The Gannet and Booby make their nests of piles of sticks, and roost on the trees if they can do so. At night the different kinds form separate communities, closely huddled together; but during the day they seek their food to the windward promiscuously.

There is a great contrast between the meagre productions of the coral islands and the abundance and variety of those of older formation, such as the islands of Society, Samoa and Fiji. In these islands there are mountains and valleys, and rivers and streams, and in addition to all the productions of atolls, there are hundreds of species of plants that furnish food, clothes, spices, dyes, scents, timber for ships and houses, and ornamental woods for cabinetmakers. The inhabitants can choose between the yam, the kumara, the taro, the breadfruit, the banana, the plantain and the cocoa-nut, and in addition they have the choicest fruits and medicinal plants. Cotton grows abundantly on all these islands, from the Marquesas to Fiji, and the sugar cane is not only cultivated by Europeans, but is also indigenous to the Tahitian and Fijian islands. In the choice of a special article of diet, the natives of the different island groups differ as much from each other as the inhabitants of the countries of Europe.

The Sandwich Islanders prefer the taro, and with them the cocoa-nut is a delicacy once reserved for the men. In the Society and Samoan Islands the breadfruit is preferred; whilst in the Fijis, where all the products flourish in the greatest perfection, the yam is the staple food. The cultivation of the yam is with the Fijians the great national business, and their calendar of eleven months is based upon the growing, curing, and storing of their favourite food. In reading over their calendar, one is forcibly reminded of the similar influence that the cultivation of wheat had amongst the Jews in marking their seasons and periods of offerings to the priests. Here it may be remarked that neither cereal nor pulse grows to perfection on the islands of Polynesia.

The botanical wealth of the Fijis is only in part known to us, and yet, through the labours of Mr. Seeman, this part of Polynesia is better known than the other groups. That distinguished botanist only describes the botany of the coasts, as he was unable to penetrate any distance into the interior of the larger islands. The vegetable productions seem to unite in the Fijis from all points of the Pacific, claiming relationship with Western Papua by the sago palm, and nutmeg tree; with New Zealand by the kauri; with Tahiti and Samoa by the breadfruit tree; with Paumota by the screw pine; and with the Sandwich Islands and Mexico by the edible arum and American aloe.

The Sago palm, which is the chief food of the people of Ceram, is cut down by the Fijians, ignorant of its value, to make way for their yam plantations. The breadfruit tree grows in large forests, and its fruit ripens in the same months (March and April) as the yam comes to perfection. Its timber is made into canoes and furniture, and its bark into cloth in some islands; the gum also is used for caulking canoes.

The Fijian kauri is fast falling before European woodcutters, both at Kandavau and the large islands, but the wood most highly prized by the Polynesians is that of the Tomano. This tree, *Calophyllum inophyllum*, has a wide range—as far as Ceylon to the west, to Hawaii in the north, and the lagoons of the Paumotus in the east.

It is a handsome tree, growing to a height of 60 feet, and four feet in diameter. The wood is close grained, and resembles mahogany, and is made into canoes and furniture, and is said to be free from the attacks of the *teredo*.

From the seeds is obtained a very valuable oil, called in Fiji *dilo*; in Tahiti, *tomano*; and in India, *cashumpa*, which is used by the natives as a remedy for rheumatism. This tree and the ironwood, *Casuarina equisetifolia* were two of the sacred trees that grew round the ancient Polynesian temples. The list of timber trees that are very abundant is a very long one, and some legend is generally attached to each of the principal ones.

To sum up the productions of Polynesia, of which I have given a mere outline: The atolls supply cocoa-nuts, cobra, and cocoa-nut fibre; pearls, pearl shell, tortoise shell, and sponges; trepang, sharks' fins, and abundance of guano. The Barrier and Fringing reef islands can supply in addition to these products cotton, sugar, coffee, nutmeg, sago, and the choicest fruits in the greatest abundance; sandal wood, excellent timber both for the cabinetmaker and shipbuilder, valuable oils and scents, and medicinal plants.

A great commercial value, that these islands possess, is the number of excellent harbours, that render the products easy of access.

Many of the coral islands have deep lagoons, which a large ship can enter, whilst at the large islands Papiete in Tahiti, Apia and Pangopango, in Samoa, and several harbors in the Fijis are centres of trade, where large ships receive the products of the adjacent islands, which are conveyed thither by schooners and whaleboats.

It has long been a question where the Polynesians came from, and how long they have occupied, the islands of the Pacific. Their traditions were eagerly sought to learn something of their past history, and the great object was to find some legend that would tell how they had come from Malaysia, in spite of contrary winds and currents. But no such tradition was found. On the contrary, the accounts of the wise men of Tahiti, as collected by Mr. Ellis, agreed in stating that, in ancient times there was a large continent (*whenua nui*), where the islands are now scattered, and that this continent was submerged by the anger of the gods; that a few of the inhabitants were saved, and they occupied the sacred places of old times. The island of Racabea was the scene of creation, where Oro, and Tangaroa, and Tane delighted to visit, and this island contained the palaces of their kings, their finest temples, and the chief seat of the priesthood. It was their Delphi and centre of the earth. They refused to believe that they had ever come from other lands, and in this they differ from nearly every other people. These traditions, worthless as they have been thought, agree with the account of the formation of atolls, which is now generally received.

The greater number of atolls lie to the north of a line drawn nearly direct from Pitcairn Island, north of the Society, Samoan, and Solomon to the Pelew group. Of the 204 islands north of this line, there are thirteen high islands. These are Easter Island, eight precipitous islands of Marquesas, and in the Caroline group, Ualan and Hogelan.

This shows the greater subsidence of the land near the American coast to correspond with the gradual elevation of the whole of that continent. The west coast of South America is found to rise, at the rate of nineteen feet in 400 years; but the more extended Pacific area had a much slower subsidence.

As a proof that America has been long occupied by man, the remains of stone houses are found near the summit of the Andes. Fossil remains of pottery and cloth were found on the coast of Chili 85 feet above the sea level. Human remains have been found embedded in a coral reef in Florida, and also in the delta of the Mississipi, sixteen feet beneath the surface, with the remains of four buried forests superimposed. On Easter Island Capt. Cook found statues 27 feet high by 8 feet wide, raised on platforms 30 feet by 16 feet, and from 3 to 12 feet high. These monuments were formed of stone different from any he saw on the island. Of the other high islands, Ponape and Ualan contain remains of temples and fortifications of stone on a very extensive scale, which were the work of a civilized people. Thus while the dwellings of men and tropical vegetation were steadily disappearing beneath the waters of the Pacific, the houses and forests on the coast of America were being raised many thousand feet above the sea level; for not only did Mr. Darwin find the remains of human dwellings on uninhabitable elevations, but he also found fossil trees allied to the Norfolk Island pine at a height of 7000 feet—trees that once flourished on the shores of the Pacific.

Mr. Ellis gives an interesting account of the antiquities of the Society group. Temples were numerous on all the islands;—not buildings such as is generally understood by the name, but rather a kind of pyramid, composed of massive stone blocks, and ascended on the outside by steps, on the top of which was the altar. These temples were secluded by the lofty spreading *tomano*, *camarina* and *thespesia* trees, and the whole enclosed by high walls. One of these temples measured 270 feet in length, 94 feet in width, and 50 feet in height, and was ascended by a flight of steps of which the first was six feet from the ground. On the top, where the sacrifice was offered, it was 180 feet by 6 feet. The description of these temples, and the sacred rites, reminds one of the teocalli of Mexico, which they resembled not only in structure and in the shape of the idols, but also in the cells of the priests and the human sacrifices. Even the terrible drum that roused the Mexicans to pursue Cortes and his followers when they tried to escape from their town at dead of night, had often struck terror into the heart of the Tahitians as its ominous roll from the altar of a neighbouring temple roused them from sleep. Few remains of those temples now exist, as the early converts displayed as hearty zeal in destroying them as the Spaniards did in sweeping away every vestige of Mexican architecture.

Mr. Ellis also mentions remains of stone terraces, stone axes, and other implements found at a good depth from the surface, and he concludes that the islands have been occupied from a very remote period. In the "Transactions of the Royal Geographical Society" I read of a pile of immense stones on the island of Tongatabu, said to be a burial place, although there is not on the island a similar stone as large as a pigeon's egg. In our own "Transactions" a stone fort is described on the island of Rapa, said to be of very remote age.*

Supposing that a great continent once extended across the Pacific, as is maintained by scientific men, and even asserted in native traditions, we

* Hall. "Trans. N.Z. Inst," Vol. I., p. 128. New Ed. Vol. I., p. 75.

should expect to find people some degree removed from barbarism on the Asiatic and American shores; and we do find nations of great antiquity on the west side, namely, China and Japan, whilst on the American side the Spaniards found the Mexicans and Peruvians little behind themselves in civilization, and excelling them in riches and magnificence. But the Spaniards not only found great towns to plunder, but they also discovered the massive ruins of large towns in deserted and wooded regions in Yucatan. In the courts of the houses there are now trees nine feet in diameter, whilst there is a depth of nine feet of mould above the pavements. As a proof that these cities were once the abode of a numerous people, it is remarked that the figure of a tortoise, raised in relief in the court of a temple at Uxmal, is worn nearly smooth by the feet of the crowds that passed over it.

Of the works of art which Cortes sent to Spain, none excited more admiration than the superb garments made from feathers. No such work had been known in the old world, but this same art was practised in the Sandwich Islands and the Fijis. The Spaniards were struck with the copiousness and precision of the Mexican language, and Mr. Ellis makes the same remarks with regard to the Polynesian. What struck him most was the readiness with which boys learned arithmetic, and with regard to their names for numbers he says, " The precision, regularity, and extent of their numbers has often astonished me."

There was for a long time a serious obstacle to learning anything about the islands of Polynesia; I mean the foregone conclusion that the inhabitants came from Malaysia, and that the islands are extinct volcanoes, and the coral raised with the land from the bottom of the sea. The formation of the land and the nature of the polypifer have swept away the last part of the belief; but it is still sometimes asserted that the natives came from Malaysia in spite of winds and currents, and their own traditions and protestations. On the distinction between Malays and Polynesians Mr. Wallace is very clear. He lived with the natives in Malaysia for many years, and he proves that the West Australian current, which flows through the deep but narrow channel of Flores sea and Molucca passage, is the natural line between the two races of Malay and Papuan.

With regard to the distinction between a Papuan and Polynesian he says:—" It is to be especially remarked that the brown and the black Polynesian races closely resemble each other. Their features are almost identical, so that portraits of a New Zealander or Tahitian will often serve accurately to represent a Papuan or Timorese, the darker color and more frizzly hair of the latter being the only differences. They are both tall races. They agree in their love of art and the style of their decorations. They are energetic, demonstrative, joyous, and laughter loving, and in all these particulars they differ widely from the Malay." On the border line, where the two races are in constant communication, the one is quite a contrast to the other, and yet it was long believed that the Polynesian came from Malaysia.

But the difficulty of deriving the joyous islander from apathetic Malay is as nothing compared with covering the islands of the Pacific with vegetation from the same country as the Malay race. Not only trees like the cocoa-nut and sago palm, and sugar cane and cotton tree, which are found in the East Indies, but also trees like the karaka and kowhai, that are not found there. On the authority of Seeman, the Fijians did not know that food could be obtained from the sago palm, and they constantly cut down the tree to clear the ground for yam plantation. Nor did they know how to obtain a strong drink from the unexpanded flower of the cocoa-nut palm. Both of which they would have known had they come from Malaysia.

It is worthy of remark that it is only since we have awakened to the conviction that we do not know all about the origin of the Polynesians, that the present zeal has been shown for collecting their traditions, preserving their works of art, and carefully ascertaining their knowledge of the properties and uses of plants.

Authorities for this Paper :—" Navigation of the Pacific," Capt. A. B. Beecher ; " Coral Reefs ; Naturalist's Voyage," Darwin ; " Corals and Coral Islands," Dana ; " Studies in Animal Kingdom," Agassiz ; " Flora Vitiensis," Berthold Seeman ; " Malay Archipelago," Wallace ; " Researches in Polynesia," Rev. W. Ellis ; " The Conquest of Mexico," Prescott.

ART. VII.—*Civilization of the Pacific.* By MR. COLEMAN PHILLIPS, Auckland.

[*Read before the Wellington Philosophical Society, October 14th, 1876.*]

Preliminary Remarks.

The greater portion of the following paper was read before the Royal Colonial Institute in London in March last. The writer has since slightly altered and added to it in order to bring it down to date. The civilization of the Pacific should be at the present time an interesting subject for discussion. We have lately added Fiji to our colonial dominions. France is acquiring a firm foothold in the South Seas, and is rapidly peopling New Caledonia with convicts. Germany and America are becoming interested in some of the groups of fertile islands. War vessels of all nations are cruising amongst them, ready at any moment to plant the flag of the particular country which they represent, and indelibly mark their name upon the page which the history of the Pacific will occupy in the annals of the world. The Australasian Colonies are agitating for the annexation of the islands to England, whilst at home deputations have waited upon Ministers in order to suggest Imperial action. It may, therefore, be advisable to consider their past and present history.

Geographical Description.

By the Pacific is meant the central portion of the Pacific Ocean, including all those groups of islands lying within 30° north and south of the equator, and stretching eastward from the Pelew Islands to Easter Island. This immense area, commonly called Polynesia, is divided by the equator into the North and South Pacific, which division may be again best divided in Eastern, Central, and Western Polynesia.. The names of the principal groups of islands contained within these divisions, together with their population, area, etc., etc., will be found in Appendix A. *

I include New Guinea in Polynesia, although it is doubtful to which of three divisions it should belong—Malaysia, Australasia, or Polynesia.

Few persons are much acquainted with this portion of the Pacific Ocean or its extent. It is only when we are led to consider the present or future welfare of the islands which it contains that we find ourselves dealing with so vast an area of the earth's surface—something like 20,000,000 square miles. † The importance of this fact, it is necessary to remember, for the water which separates the various groups of islands contains not only many valuable articles of commerce, but, at the same time, is so much a naturally prepared highway for future inter-insular commerce.

Discovery.

The Pacific Ocean was discovered and formally taken possession of for Spain by Vasco Nunez de Balboa, in the year 1513. Crossing the American isthmus, he was the first European who gazed upon it. Descending, he stepped into its waters, and with drawn sword, and in full armour, took possession for his sovereign of all lands and islands the ocean might contain, even unto the Poles. In 1520, Magellan, a Portugese, in the *Victory*, ‡ passing through the straits which now bear his name, was the first to sail across the Pacific (so called by him from the tranquility of his voyage through it, in comparison with the stormy sea he had encountered at and near the straits). Magellan discovered the Ladrone and Philippine Islands.

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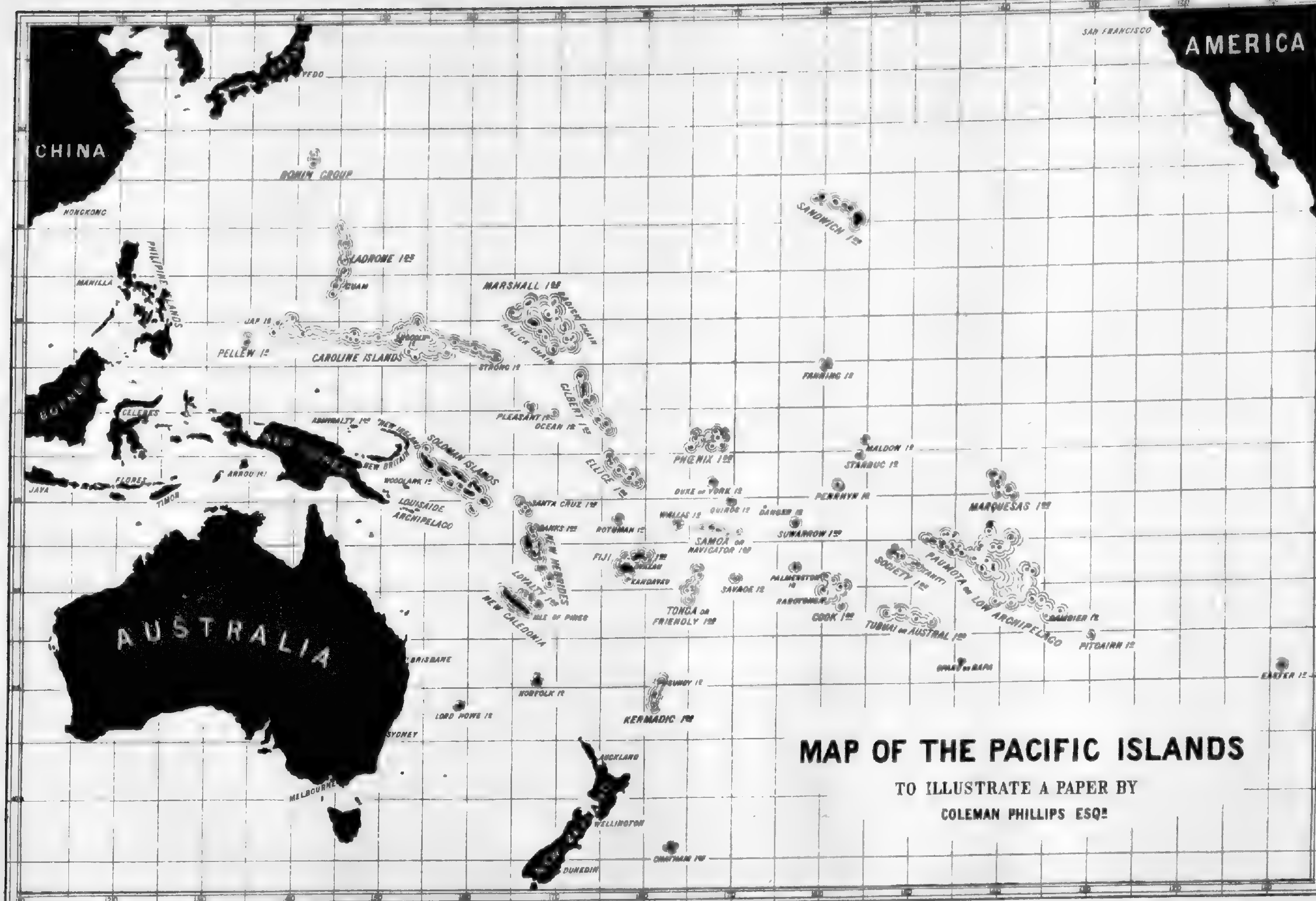
* Melanesia and Micronesia are somewhat indefinite titles given to certain islands inhabited by the Papuan, or black, races. Micronesia principally comprises the Gilbert, Marshall, and Caroline Islands, amongst which, however, many pure Polynesians are found. Melanesia is simply Western Polynesia.

† The Pacific Ocean contains a superficial area of 70,000,000 square miles.

‡ The *Victory* performed the first voyage round the world.


MAP OF THE PACIFIC ISLANDS
TO ILLUSTRATE A PAPER BY
COLEMAN PHILLIPS ESQ^R
CHINA
AMERICA
AUSTRALIA
SAN FRANCISCO
YEDO
HONGKONG
MANILLA
PHILIPPINE ISLANDS
BONIN GROUP
LADRONE IS
GUAM
JAP IS
PELLEW IS
CAROLINE ISLANDS
STRONG IS
MARSHALL IS
RALICK CHAIN
GILBERT IS
PLEASANT IS
OCEAN IS
SANDWICH IS
FANNING IS
PHŒNIX IS
ELLICE IS
MALDON IS
STARBUC IS
PENRHYN IS
MARQUESAS IS
SANTA CRUZ IS
BANKS IS
NEW HEBRIDES
ROTUMAH IS
WALLIS IS
SAMOA OR NAVIGATOR IS
DANGER IS
SUWARROW IS
FIJI
KANDAVU
TONGA OR FRIENDLY IS
SAVAGE IS
PALMERSTON IS
RAROTONGA
COOK IS
SOCIETY IS
TAHITI
PAUMOTA OR LOW ARCHIPELAGO
TUBUAI OR AUSTRAL IS
GAMBIER IS
PITCAIRN IS
EASTER IS
LOYALTY IS
NEW CALEDONIA
ISLE OF PINES
SOLOMON ISLANDS
NEW IRELAND
NEW BRITAIN
ADMIRALTY IS
WOODLARK IS
LOUISIADE ARCHIPELAGO
ARROU IS
CELEBES
BORNEO
JAVA
FLORES
TIMOR
BRISBANE
SYDNEY
MELBOURNE
NORFOLK IS
LORD HOWE IS
KERMADIC IS
AUCKLAND
WELLINGTON
DUNEDIN
CHATHAM IS

Alvaro de Mendana discovered and took possession of the Solomon Islands for Spain. He also discovered the Marquesas and Santa Cruz, which he attempted ineffectually to colonize, and where he died.

The Dutch are represented by Tasman, who, in 1643, discovered the Friendly Islands and Fiji; also by Commodore Roggewein, who, in 1772, named Easter Island, that curious speck of isolated land upon which stand colossal stone images of men. Sailing thence to the East Indies, the Commodore touched upon Samoa, New Britain, and New Guinea.

England, however, mainly achieved the exploration of the Pacific. Many expeditions were fitted out by the British Government during the reign of George III., although I must not pass over in silence the voyages of English navigators of a much earlier period, amongst which stand those of Sir Francis Drake and old Sir Constantine Phipps, first Lord Mulgrave (the founder of the family of his Excellency the Marquis of Normanby, the present Governor of New Zealand), who, in William and Mary's reign, discovered and named the Mulgrave Islands. But of all English navigators in the Pacific, the name of James Cook stands pre-eminent. He discovered New Caledonia (so named from its resemblance to Scotland), Norfolk Island, part of the Society Group, the Sandwich Islands, and many others. He surveyed the New Hebrides, Society, and Friendly Islands; determined the insularity of New Zealand,* explored the then unknown eastern coast of Australia for 2,000 miles, and circumnavigated the globe in a high southern latitude in order to decide the question whether any continent existed north of a certain parallel. Captain Cook performed three voyages. The first expedition left Plymouth in 1768, fitted out for the purpose of observing the transit of the planet Venus at Tahiti. The Society Islands were so named by Cook in honour of the Royal Society, which had induced the Government to fit out the expedition. The second left England in 1772, in order to settle the vexed question of the existence of a southern continent. The third left in 1776 for the purpose of discovering a passage to the Pacific in the direction of Hudson's and Baffin's Bays, or, as Cook preferred, from the Pacific to the Bays. It was at the Sandwich Islands, which he then discovered and named after his patron the Earl of Sandwich, that he met with his death, December, 1778. James Cook was indeed a great navigator and discoverer. The correctness and minuteness of his surveys have won the admiration of the most accomplished seamen who have succeeded him.

Besides Cook, the names of Anson, Byron, Wallis (who, in 1767, discovered and took possession of Tahiti for George III.), Marshall, Gilbert, and other English navigators are indelibly marked on the history of the Pacific.

* New Zealand was formerly supposed to be a portion of a great southern continent.

France is represented in the Pacific by the names of D'Urville, La Perouse, and D'Entrecasteaux, whose expeditions encountered more than ordinary misfortunes.

Missions.

During the latter portion of the last century the accounts published by Wallis, Cook, and other voyagers in the South Seas, the visit to London of Omai, the Society Islander, concerning whom Cowper wrote, the tragic death of the great navigator himself, and the mutiny of the *Bounty*, kept public attention in England fixed upon the Pacific, and the state of the Polynesian Islanders. A strong desire was expressed for the religious improvement of the natives, and the London Missionary Society, at that time but newly formed, gratified that desire by sending away eighteen missionary clergymen to the Society Islands. On March 3rd, 1797, the *Duff*, the first missionary vessel, anchored in Matarai Bay, Tahiti, where Cook, in 1768, had observed the transit of Venus.

When the history of the Pacific is written, the year 1797 will be noted for the actual commencement of civilization therein. Previously to that date the islanders had been taught to fear rather than admire modern civilization. The teachings of the Spaniards can hardly be called civilized. Between 1668 and 1681 the island of Guam, in the Ladrones, was nearly depopulated by them of its 40,000 inhabitants, a notable instance of Spanish dealings in the Pacific. Our missionaries have carried out a totally different policy from that formerly pursued by the Spaniards. From 1797 to the present date, the loss of life has been *always on the missionary side.* Quietly and bravely have English missionaries advanced, reclaiming island after island from barbarism—at what cost only the missionary records can tell—until there are few islands now left which have not yielded to their gentle influence. No monument exists to commemorate this noble work, or to tell of the many lives which it has cost. Cannibalism, immolation, suicide, idolatry, infanticide, tabu, polygamy, domestic slavery, tribal and internecine strife, have all been conquered. The rising generation is almost entirely ignorant of the dark deeds of its predecessors.

The London Missionary Society commenced the work of planting missionaries simultaneously at the Society, Marquesas, and Friendly Islands. The Wesleyan Missionary Society began its labours in the Friendly Islands in 1826, and in Fiji in 1835. The Church of England (or rather the Society for the Propagation of the Gospel) about the year 1850 directed its attention to the Loyalty, New Hebrides, Banks, Santa Cruz, and Solomon groups, or, briefly, Melanesia. In 1820 the American Board of Foreign Mission took charge of the Sandwich Islands. The Presbyterian clergy are endeavouring to Christianize the New Hebrides. Roman Catholic missionaries have spread themselves wherever they thought that their labours were required, and two or three local bodies have been formed for the especial purpose of assisting the cause. It would be unfair to mention conspicuously the name of any single clergyman. All have zealously devoted their energies, and many their lives, to the great work of Christianity and Civilization—Williams, Gordon, Baker, Patteson, are almost household words. Too much praise cannot be bestowed upon missionary labour in the Pacific.

Commerce.

Such is a brief outline of the past history, first discovery, and then missionary zeal. Unlike India, Africa, America, and Australia, wherein discovery was followed by commerce, and then by religious teaching, Polynesia first received religious civilization. Now commerce is stepping in, and we are becoming still more deeply interested in the welfare of the islands. As yet commerce has been of very slow growth, although the exceeding fertility of the islands, their tractable inhabitants, and the general wealth of the Pacific, have long been well known. The great distance of Polynesia from the principal centres of commerce must have been the cause of this slow progress. Steam, however, is lessening the distance; population is flowing over from the Australasian colonies, and a large trade is springing into existence. It was not until some few years since, when the colonies of Australia began to take an interest in the islands, that commerce assumed any degree of importance. The American war, and the suggestions contained in Dr. Seeman's well-known work, turned the attention of those colonists to cotton-growing, and many persons from the colonies commenced to form plantations. Previously to that date a few merchants in the principal groups carried on a small traffic, and one or two associated companies endeavoured to profit by the evident wealth of the islands: the celebrated South Sea Company of the last century, which resulted in what is commonly called the "South Sea Bubble" being the first attempt. There were also, as still there are, many traders, who, fitting out in Australasian ports small vessels with suitable articles of trade, cruised amongst the islands, and bartered with the natives, as the Carthagenians of old bartered with the Africans. (This sort of trading appears to be very suitable to Polynesia, and is likely to increase. When the resources of the islands are better opened up, trading schooners will give place to resident merchants.) Trade, however, is entirely in its infancy. The natives are hardly sufficiently educated to demand much from us. As yet their wants are few. The people of Western Polynesia, and nearly all Central Polynesia, have not sufficient civilization to want at all, a little calico and a few knives being all that is at present required. I do not suppose that the Pacific Islands import more than £700,000 per annum, one half of which is for the use of the resident whites, the other half for native use. As the population of the Pacific, exclusive of New Guinea, must number something over a million, it will readily be seen that trade is in its infancy. Nearly all that we have as yet obtained is the surplus natural production—cocoa-nut oil, *bêche-de-mer*, pearl shell, whale oil, sandal wood, etc. Other productions, such as cotton, coffee, sugar, tobacco, etc., have yet to be raised. An attempt has been made to grow cotton, but the uncertainty of obtaining the necessary labor has almost caused its abandonment. How sadly the Pacific needs protection, and how necessary it is for commerce to be under some sort of regulation, is shown in the fact that immediately an exotic production was attempted to be raised, the poor islanders suffered one of the greatest wrongs which the white race could inflict—the wrong of slavery.

Slavery.

That a species of slavery in the form of kidnapping did exist there is but little doubt. Spanish and Peruvian atrocities, the *Peri* and *Carl* investigations, besides other well authenticated instances, amply prove that fact. I happened to go on board the *Carl*, in Fiji, after her return from her slaving cruise, and I shall never forget seeing the badly obliterated blood-stains and shot-torn timbers of the vessel's hold, in which so many unfortunate natives had lost their lives. The planters of Queensland and Fiji may attempt to exculpate themselves from all blame, but it was not at their suggestion that kidnapping was suppressed. Had the Home Government refrained from interfering, kidnappers would still be gathering their ill-gotten gains. It is true that the Queensland Government, as soon as it recognized the evil, endeavoured to prevent it; but a young colony was powerless to suppress it. Not that any individual planter perhaps, was to blame. Three-fourths of the cotton-growers in Fiji desired the suppression of the traffic, but if any person wanted labourers, and these labourers had "passed the consul," little inquiry was made as to *how* they were originally obtained. Fortunately kidnapping has had but a short reign. On June 27, 1872, the British Parliament passed an Act for "The prevention and punishment of outrages upon natives of the islands in the Pacific Ocean." Our cruisers will see that the Act is enforced, and the disgraceful blot upon the fair face of the Pacific will soon disappear. It still exists in a modified form. Degraded Englishmen can still find sufficient protection *under a foreign flag* to carry out the nefarious practice, and late accounts state that New Caledonia is supplied with kidnapped natives. All labour vessels under a foreign flag should be regarded by our cruisers with the utmost suspicion. The British Government has gained the gratitude of the natives by acting as it has done. The enforcement of the Act has much strengthened the widespread opinion that England is the natural protector of the Pacific. With regard to domestic slavery, I have before stated that this form of servitude yields readily to missionary teaching. Mission history affords numerous instances of this fact.

Inhabitants, whence derived.

The Pacific Islanders appear to be principally derived from two stocks—the Malayan, long-haired and light-coloured, and the Papuan, crisp-haired and dark-coloured. Those islands in close proximity to the Australian continent are principally inhabited by the latter race :—New Guinea or Papua, New Britain, New Ireland, the Solomon, Santa Cruz, Banks, New Hebrides, Loyalty, and New Caledonia groups, or, briefly, Melanesia. The remaining islands of the Pacific, or Polynesia, excepting Fiji and the New Hebrides, in which groups both races appear to combine, are inhabited by the former type. It was formerly supposed that New Guinea was solely peopled by the crisp-haired race, but later travellers inform us of other native types. The origin of the Papuan, Australian, and Polynesian races is a most interesting question. Many of the characteristics of the natives of the Australian continent will be found in New Caledonia. When we become better acquainted with New Guinea we may perhaps be able to discover whether the peculiar features of the Papuan race, dark colour and crisp hair (the Australian natives have long wavy hair), owe their origin to Africa or Madagascar, or simply to the fact of residence upon so large an island situated under the equator. In Ellis's "Polynesia Researches" the following passage occurs :—"The striking analogy between the numerals and other parts of the language, and several of the customs of the aborigines of Madagascar, and those of the Malays who inhabit the Asiatic Islands, many thousands of miles distant in one direction, and of the Polynesian, more remote in another, shows that they were originally one people, or that they had emigrated from the same source." * I imagine that the author, by using the term Polynesia, meant also to include Melanesia, as he must have been acquainted with the difference which exists. In an able paper upon the native ownership of land in Fiji, the Hon. J. B. Thurston remarks :—"The highly elaborate Fijian system of relationship, which resembles in almost every particular that of the Seneca, Iroquois, and other American Indians on the one hand, and that of the people of South India, speaking the Dravidian language (Tamil), on the other, points to a bygone existence of the communal family, a state now regarded with horror and disgust and forbidden by stringent and elaborate laws." Indian writers, also, have often been struck with the resemblance of many Polynesian habits and customs to those of the Hindoos. It will thus be seen that, when fairly investigated, the origin of the Polynesian islanders will not be a very difficult problem to solve. But whatever may be their origin, in future dealings with the natives we have only to consider the marked peculiarities of the two races.

* Vol. II, p. 48.

The inhabitants of Western Polynesia are more treacherous and cruel than the Polynesians proper. We should be more careful in trusting them. Both, however, are much less ferocious than either the Maoris, Malays, or American Indians. I do not think that the whole of the inhabitants of Polynesia will give as much trouble to any colonizing power as New Zealand gave to England.

Colonization.

The actual work of colonization has as yet been small. Tradition does not even give the name or race of the people who cut the stone images on Easter Island, or erected the immense buildings, whose ruins exist upon many islands in the Caroline group, "hundreds of acres in some localities being covered with the remains of walls, canals, and earthworks of the most stupendous character." *

Spain.

Spain was the first colonizing nation in the Pacific, but the attempts of the Spaniards have met with very poor results. They were compelled to abandon many of their settlements. That Government now possesses only the Ladrone and Bonin groups. (The Phillipine Islands belong rather to Malaysia than Polynesia.) The aboriginal inhabitants of the Ladrone Islands have simply been exterminated. We have to congratulate ourselves upon the fact that the Spaniards confined their colonizing efforts to so small a number of islands. Angas' "Polynesia" † supplies the following information:—"It is said that Americans and Sandwich Islanders have been allowed to settle themselves of late years on the island of Agrigan (Ladrone), on condition of acknowledging allegiance to Spain; also, that the island is being peopled with natives kidnapped from other parts of Polynesia. The Bonin Islands have no native population. Japanese junks occasionally visit the group. A few Japanese have established themselves on the northern islands. On some of the others there are British subjects located, for the purpose, it is supposed, of carrying on a contraband trade with Japan." Spain also claims dominion over some of the neighbouring islands in the Pelew and Caroline groups, yet hardly a dozen of her subjects are settled upon them. ‡

* H. B. Sterndale. † 1866 Edition.

‡ The "Statesman's Year Book" for 1875 gives the following information concerning the Spanish possessions in the Pacific:—

Name.	Area, Geographical Miles.	Population.
Phillipine Islands	3,100	4,319,269
Caroline Islands and Palaos	43·1	28,000
Marian Islands (Ladrone)	19·6	5,610
	3,162·7	4,352,879

France.

In 1842 France obtained the sovereignty of the Marquesas by treaty, and established a military colony upon Nukuhiva. In 1859 that experiment was abandoned. A few officials, and a couple of Roman Catholic missionaries, who have given up all hope of converting the natives and taken to planting, alone remain on the group. In 1844 the French Government established a protectorate over Tahiti, or the Society Islands, and consequently over the Paumotas (Low Archipelago), as there has always existed a close connection between the two groups.

In 1854 France took official possession of New Caledonia. With the exception of soiling a fair island with the refuse of her population, France has not made any colonising efforts. The natives are not benefited by the contact, and the resources of the islands are not developed. No matter how anxious the authorities at home may be for the progress of the colonies, French officials abroad alone represent their country—the nation does not appear to follow Government action. French occupation in the Pacific deteriorates but does not improve the native islanders, who are first awed into submission and then demoralised. Religious instruction is supplied by the Roman Catholic missionaries, who can always rely upon the bayonets of the *gens-d'armes* for assistance. France has found it impossible to do anything with the Marquesas, although a finer or more intelligent race of natives does not exist. The immorality of the Tahitians is a standing disgrace to French occupation. The natives of the Loyalty Islands, over whom France, I suppose, claims sovereignty (I have not seen any official notification of the fact), would much prefer our English missionaries to the Roman Catholic missionaries and French bayonets. If the English missionaries would but speak out, what a charge-sheet could they bring against France and the French in the Pacific! Oppression of white industry, bribery, forcible conversion of the natives, kidnapping, etc., etc., would be but a few of the charges. *

* While entertaining every respect for the Roman Catholic religion—for every religion, in my opinion, is entitled to respect—I cannot help stating that in the Pacific its members have been too anxious to extend their particular creed. Surely, when other Catholic missionaries had been striving for years to Christianize the inhabitants of any particular group of islands, Roman Catholic missionaries might well have refrained from interfering. "Go thou to the right, and I will go to the left," might have been a good maxim for their guidance. With the hundreds of millions of Chinese and Japanese almost entirely in their hands, the few thousands of Polynesians might have been left to the Protestant missionaries, especially as they were first in the field. I feel certain that neither Christianity nor civilization has benefited by this interference, for the natives now hardly know which particular creed to respect. It is true that Protestant missionaries sometimes acted antagonistically to Roman Catholic clergymen, but the question is, whether the latter should have given cause for such antagonism.

Whether France claims sovereignty over any other groups of islands is uncertain. Her right to claim anything at all is a matter of dispute. The manner in which the protectorate was established over Tahiti was quite unworthy of a great nation. New Caledonia was taken possession of without even the nominal consent of the native population. They hardly knew anything of the circumstance. The treaty made with Admiral du Petit Thuars, by which France claims the sovereignty of the Marquesas, is no doubt a curious document. Neither were the interests of the many Protestant missionaries, the only foreigners who could well claim any interest, considered. The natives generally knew nothing of France; had never committed any offence against that Government, and did not desire its interference. They had been accustomed to regard England and the English as their friends, and next to England, America. English missionaries, English men-of-war, and English traders were always beside them, and many American whalers. Of France they were utterly ignorant; but they were powerless. The English Government did not think it necessary to support the Queen's subjects resident in the islands, and France acted as she pleased. It must be very mortifying to our missionaries to see so much of their labour completely thrown away. After devoting many years to the Loyalty Group—after rendering those islands habitable—France steps in and reaps the advantage. Our clergymen have to leave the group, for although France professes the greatest religious tolerance, their stay is useless. The Roman Catholic missionaries will not work amicably with Protestant clergymen, and as the first receive the active support of the Government, the second had better leave the field. The New Hebrides are about 150 miles from New Caledonia. Nearly every island in the group has been stained with the blood of English missionaries. Sydney and New Zealand traders have opened up the resources of the group, and a few Englishmen are settled there. France may claim the New Hebrides, and the English Government may allow her to quietly take possession of that which British energy has rendered valuable; but England would be hardly acting fairly either to the natives or to English subjects.

In the case of New Caledonia, the action of the home Government is scarcely to be admired. In 1774, as I have already remarked, New Caledonia was discovered by Cook, who so named it in consequence of its resemblance to Scotland. It was duly taken possession of for George III., and was at one time included either in the commission of the Governor of New South Wales, or in that of Sir George Grey's commission as Governor of New Zealand. In 1854 the French took possession. Hearing that military barracks, etc., were being erected, Sir George Grey went down and informed the French Admiral that New Caledonia was British territory.

On his return to New Zealand he reported the circumstance to the Colonial Office, and the matter ended by his commission being cancelled so far as it concerned New Caledonia. The Government of the time did not wish to go into the question. The Sydney papers of the day bitterly lamented the inaction of the home authorities.

With regard to Tahiti, French occupation means absolute authority. Now, the British public contributed thousands of pounds to the cause of civilization in this group, and the records of the London Missionary Society testify to the loss of life which the work entailed. For nearly fifty years the head-quarters of our missionaries in the Pacific were established in the group; yet the French were quietly allowed to add it to their Colonial possessions by the establishment of a nominal protectorate. In the petition for protection, which certainly is a most curious document, it will be seen that the poor Queen had to especially stipulate for the English missionaries to be allowed to pursue their calling unmolested. That the clause was necessary is shown in the fact that our clergymen, since that date, have been expelled from the group, only one remaining. I believe, however, that it is their intention to return.

Writing upon the civilization of the Pacific, one is almost inclined to say that the advent of the French drove the true civilizers—English missionaries—from the field. Is it not time that this portion of international law should be looked into, especially as regards the Pacific? English missionaries are also British subjects. Surely no foreign power has the right to occupy lands in which they reside without paying some deference to their interests. If any nation has acquired a vested interest in the Pacific, England, through her missionaries, planters, and traders, has most assuredly done so. Certainly no foreign power ought to occupy any such islands without at least informing the British Government of its intention so to do.

I purposely use the word occupy, as it possesses a peculiar meaning. Colonies are acquired by conquest, cession, or occupation. No power, with the exception of Spain, has acquired a colony in the Pacific by conquest; neither does any power wish to do so. Cession and occupation appear to be the favourite modes of acquiring possession therein. In a ceded group of islands, such as Fiji, the voice of all interested is taken, and no injury to any foreign interest is committed. France, however, chooses to occupy certain islands—viz., New Caledonia and the Loyalty Groups—whereby that Government greatly injures all foreign interests, besides ignoring the native population. In my opinion, the only fair and international mode of acquiring these islands is by cession. Civilized nations ought to treat the Pacific islands somewhat differently to their usual customs. It must be remembered that the islanders can make use of all their islands. There are no vast tracts of unused land in the Pacific, such as there were, and still are, in Australia and New Zealand, upon which the surplus population of Europe can find place. Every acre of land in Polynesia has an owner, and every man knows his land. The manner in which the Middle Island of New Zealand was taken possession of was, I suppose, international, but certainly most undignified : two war-vessels, belonging to two Great Powers, almost racing to see which should first raise the flag of the country which they represented, and by that simple operation claiming the land. International law, so far as regards this portion of the globe, sadly requires some little alteration. The nation whose subjects have devoted many years to the civilization of any particular spot, or whose protection is sought for, is the one entitled to the sovereignty of the land. No disinterested power, at the caprice of a moment, has the right to raise its flag and occupy the land. That proceeding partakes more of conquest than occupation. France by nominally fair means has acquired Tahiti, the Paumotas, and the Marquesas, and by actual might New Caledonia. Our Government should not acknowledge her right to any other islands. If a notification were sent to the French Government that British subjects have certain vested interests in the Loyalty, New Hebrides, and other groups of islands near to French possessions, a great deal of trouble may hereafter be prevented.*

It appears to me that the entire action of the French Government in the Pacific was taken for the purpose of establishing a good convict station, and at the same time obtaining good naval stations. England was making use of Australia and Tasmania for a similar purpose, and France desired to do likewise in the Pacific, the civilization of the natives being the last consideration. England forestalled France in the acquisition of New Zealand,

* The "Statesman's Year Book" for 1875 affords the following information concerning French possessions in the Pacific:—

Name.	Date of Acquisition.	Area, Square Kilometres.	Population.
I. Colonies—			
New Caledonia	1854	17,400	29,000
Loyalty Islands	1864	2,147	15,000
Marquesas	1841	1,244	10,000
		20,791	54,000
II. Protected Colonies—			
Tahiti and Dependencies	1841	1,175	13,847
Paumota Islands..	1844	6,600	8,000
Gambier	1844	30	1,500
Toubouaï and Varau	1845	103	550
		7,908	23,897

and so saved that colony from being a French convict station. French official documents testify that neither Marquesas nor Tahiti was considered suitable for the purpose. New Caledonia was chosen, and there are now many thousand convicts on the island. The official notification of the act of taking possession was made in the presence of the officers of the corvette "*Le Phoque*" and the French missionaries. The Admiral was compelled to build a block-house for the protection of the veryflag which he erected.

With regard to the convicts at present upon the island, they will no doubt, in time, gradually extend themselves over Australasia and the Pacific. It can hardly be said that they will be of any advantage to the cause of civilization therein; rather the opposite. I sincerely trust that the Australasian Colonies will endeavour to prevent any other European power following in the footsteps of France. Every country should maintain its own degraded citizens. Colonising from a convict root may be a problem, but the time has gone by for its solution. It is, in my opinion, almost an imperative duty for the Australian Colonies to discourage by every means in their power the continuance of the convict station at New Caledonia. If France requires a colony in the Pacific, so near to our own, let the colonies see, for their own benefit and for the benefit of the Pacific, that free emigrants are sent, no matter how poor.

Germany.

Germany is principally represented in the Pacific by the well-known firm of Messrs. Godefroy and Co., of Hamburg, who in 1858 established their head-quarters at Samoa. From Samoa they have "pushed their agencies southward into the Friendly Archipelago (Tonga) and other islands; northward, throughout the whole range of the Kingsmills and the isles in their neighbourhood, that is to say Tokelau, the Ellice, and Gilbert Groups, and the Marshalls or Rallicks, through the Carolines and to Yap, a great island at the entrance of the Luzon sea, where they purchased 3,000 acres of land, formed a settlement, and established a large depôt intended as an intermediate station between their trading posts at the Navigator Islands (Samoa) and their old-established agencies in China and Cochin. Between Samoa and Yap (one of the Pelew Islands), a distance of 3,000 miles, the firm have, or had lately, an agent at every productive island inhabited by the copper-colored race (Malay), upon which the natives are as yet sufficiently well disposed to permit a white man to reside." *

The Germans make good settlers, although mere traders. It is doubtful whether they have added much to the colonization of the Pacific. They barter a certain quantity of fire-arms, or so much calico, for an equivalent

* H. B. Sterndale.

in cobra (dried cocoa-nut, from which the oil is extracted after its arrival in Hamburg). In order to obtain a monopoly of this material one of the principal instructions to their agents is to oppose the missionary. The minds of Polynesian chiefs are systematically poisoned against missionary teaching. If it were possible, German traders would keep the natives in their present savage state in order to profit by their labour. Of course, the missionary prevents this. The result of German opposition to missionary teaching even in Samoa is lamentable, civil war amongst the native tribes being constant. The Germans fan the flames by supplying the belligerents with arms. In Fiji the German residents strongly supported Maafu in his opposition to King Thakambou, and the desire of the chiefs to cede the country to England. Had we not taken possession, Maafu, with German aid, would have been King of Fiji. The German settlement in Apia (Samoa) consists of some 25,000 acres of land, purchased at about ninepence per acre, and paid for by arms and ammunition. What this implies anyone acquainted with natives can easily understand. It is a pity that so enlightened a firm as Messrs. Godefroy should thus oppose the advance of civilization. A present profit may be made out of the civil war among the natives, but it will be of no advantage in the end, when Samoa becomes depopulated. As to the missionary, Messrs. Godefroy should remember that had it not been for his teaching they would not now be established where they are, and also the fact that every year the missionary is opening up new fields for commerce. The Germans treat their labourers well, but are not very particular as to how they are obtained. A German man-of-war occasionally visits the Pacific in order to look after the interests of the colonists. German policy at the present time is not a colonizing policy, otherwise Samoa would long since have fallen under their flag. At any moment, however, Germany may take possession of the group.

America.

America is but slightly interested in the Pacific. There are a few merchants in the Sandwich Group, and a few whalers amongst the islands. The masters and crews of American whalers have done much harm during the past fifty or sixty years. They have been the cause of a great many of the atrocities which have occurred. Wantonly did the ignorant captains murder and wrong the natives, who revenged themselves upon the next vessel which happened to touch their shores. Luckily a better and more educated class of merchant seamen now sail over these waters. Numerous acts of cruelty on the part of the islanders must be excused; all accounts prove that they have generally acted from a spirit of revenge. The whites, and especially the American whites, must bear a great part of the blame.

At the same time, it is only fair to state that there are many whaling captains who treated the natives in a Christianlike manner. Of late years the whaling industry has greatly fallen off. Whether the United States Government will claim any portion of the Navigator Group is an open question. On February 17, 1872, Maunga, Pango chief of Pango, Tutuila, signed a treaty or agreement with Commander Meade, of the United States s.s. *Narragansett*, granting the exclusive right to the United States Government of using that harbour as a coaling and naval station for a private line of steamers running between San Francisco and New Zealand, and their own ships of war, and binding himself not to grant a like privilege to any other power. This agreement was made to depend upon its ratification by the United States Government. In the same year the chiefs of Samoa petitioned President Grant for protection. No action has yet been taken by the Senate in either of these matters.

England.

Until October, 1874, English action in the Pacific was confined to private energy and enterprise. The Imperial Government paid no attention to the hoisting of ensigns and taking possession of islands in England's name by discoverers and captains of men-of-war; Pitcairn Island, however, being an exception. On November 29, 1838, Captain Elliot, in H.M.S. "*Fly*," took possession of this island, memorable for having afforded refuge to the mutineers of the *Bounty*. A brief account of the matter may be interesting. Captain Bligh stated that the original cause of the mutiny was the connection formed by the crew, while at Tahiti, with the Tahitian women; but the islanders flatly deny the assertion, and attribute it to his own perverse temper and tyrannical conduct. Putting Bligh and seventeen of the crew in an open boat, off Tofoa, one of the Friendly islands, April 28, 1789, the mutineers sailed for Toubouai, where they attempted to establish themselves, but the natives were too hostile. Returning to Tahiti, some of the mutineers landed, but the remaining (Christian and eight men), keeping their place of destination secret, took the vessel on to Pitcairn Island, where they burnt her, January 23, 1790. Those who remained at Tahiti were picked up by the "*Pandora*," which frigate was sent out in search as soon as Bligh returned to England. In 1808 the American ship "*Topaz*" discovered the retreat of the mutineers, and in 1814 H.M. ships "*Britain*" and "*Tagus*" touched at the island. In 1838 it was taken possession of by England, and in 1850 the greater number of the inhabitants, at their own request, were removed to Norfolk Island, having outgrown their diminutive home.

Norfolk Island is also British territory, the English Government having twice used it as a convict station. Captain Cook was its discoverer. Until 1788 the island had remained uninhabited, but in that year a small number of convicts, with a party of marines, were sent there from Australia. It was finally abandoned in 1855, and is now the head-quarters of the Melanesian Mission, and the residence of the Pitcairn islanders. Norfolk Island is included in the commission of the Governor of New South Wales.

In 1864 the inhabitants of Rarotonga, the principal island of the Hervey or Cook's Group, petitioned Her Majesty, through the Governor of New Zealand, for protection, but the prayer was not granted.

On October 10, 1874, Fiji was unconditionally ceded to the British Crown. Want of space forbids my referring to the history of this cession.

A few private individuals, British subjects, claim certain islands by right of purchase or occupation. For example, Messrs. Houlder Brothers, of London, own three small guano islands in Eastern Polynesia; Mr. Brander, of Tahiti, Palmerston Island, in Central Polynesia; one Eli Jennings owns and lives upon Quiros Island; and Messrs. Godefroy and Co. claim and own many others. There are hundreds of similar uninhabited islands in the Pacific, which may thus be acquired. In what manner the title to such acquisitions will be treated by the Great Powers is a question for the purchaser or occupier to consider.

At the present time, therefore, Spain actually possesses and occupies the Ladrone and Bonin groups, together with a few islands in the Pelew and Caroline Groups; France, Tahiti and a few of the Georgian Islands, the Paumotas, Marquesas, Toubouai, and New Caledonia Groups; England, the Fiji Group, Pitcairn, and Norfolk Islands; and America has, or has not, a certain claim upon the Navigator Group, according to the decision of the United States Government.

Native Governments.

The other islands are under the rule of their native chiefs. Three of the principal groups aim at possessing certain forms of constitutional government—the Sandwich, Navigator, and Friendly Islands. This movement has been brought about by the influence of the resident whites, principally Englishmen. Many other islands have also certain forms of monarchial government, such as Rarotonga and Huahine, together with fair codes of laws framed by the missionaries.

In 1863 the reigning chief of the Sandwich Islands, King Kamehamha V., granted his subjects a new constitution (the first constitution of 1840 was granted by Kamehamha III.), based upon the English model—King, Lords, and Commons.

I may be allowed to make a slight digression in order to explain the position of America with regard to the Sandwich Islands and Samoa. The United States, it appears, cannot protect foreign lands without altering certain clauses of the Republican Constitution which are antagonistic to the

Government despotically ruling foreign possessions. The President is very anxious to protect Cuba, San Domingo, the Sandwich Islands, and perhaps Samoa; but protection means annexation, and the Senate will pause before breaking down the fundamental principles of the Constitution. Cuba may be admitted into the Union as a new State, as it very nearly approaches the standard of landed area and population required to constitute a State; but the other three places will require different treatment. Indirectly, American citizens are being encouraged to take such action as will afford the Senate an opportunity of publicly endorsing national claims over these particular spots should it at any time wish to do so. The cordial reception at Washington of any member of the reigning family of the Sandwich Group, the Samana Bay Company in San Domingo, Commodore Meade's action with respect to Pango Pango harbour, Samoa, and the appointment of an American citizen (Colonel Steinberger) to the chief administrative post in that group, are instances of this movement, all of which, I believe, receive the private support of the President, who is a very strong protectionist, or annexationist. There is very little doubt but that the Sandwich Islands will eventually fall under the American flag.

The Friendly Archipelago, or Tonga, is ruled by a native king and council of chiefs;—this group possesses the best native Government in the Pacific. King George Tabou administers the greater portion of the executive duties of the Government personally, and he administers them well. His power is almost absolute. The laws are simple and well framed, the king paying much attention to the advice of the missionaries, who, having no direct interest in commerce, can best advise him upon questions of a conflicting nature. There are many English planters upon the islands, and more flocking in. The group is becoming very valuable. One great trouble is looming before it—the succession to the crown. The king is over 70 years of age, and the heirs-expectant are beginning to talk of his successor. In the Pacific there are always many claimants for the chief authority, and they have each their supporters. The question is generally settled by war, and these wars of succession are most cruel and devastating, might usually overcoming right. A similar war is likely to happen in Tonga. The real well-wishers of Tonga hope that England will interfere and prevent the dark cloud from bursting, for it most assuredly will devastate the island, and cost hundreds of lives.

The Tongese are a most warlike race, and the most daring navigators in the Pacific. Their sympathies are entirely English, and their chiefs have steadily assisted the work of the Wesleyan missionaries; indeed, but for them, Fiji would still be a land of cannibals. The Tongese for more than a century have had much influence in Fijian matters, their warriors playing the part of powerful mercenaries to the quarrelling chieftains. Maafu, a Tongan, carved out for himself a chieftainship in the Windward Islands of that group, and would have ousted Thakambou had it not been for our interference. He is the most likely man to succeed King George in Tonga, although he has no just right to the crown. Maafu is a great chief, and his friendship is worth cultivating. He rules his subjects well ;—white settlers upon his islands can plant and trade in perfect safety.

The action of Sir Hercules Robinson, in inviting Thakambou to Sydney, is highly to be commended. It would be a great advantage if similar hospitality were extended to Maafu. Is it not advisable for the Australian Colonies to pay some such attention to the principal Polynesian chieftains ? The practical lesson of civilization would be a great one, and the bond of friendship between the islands and the colonies much strengthened.

The Navigator Group, or Samoa, is also desirous of obtaining some representative form of government, but matters are in a very unsettled condition. Colonel Steinberger, U.S.A. (a special Commissioner sent by President Grant to investigate and report upon the petition for American protection made by the chiefs) was very lately appointed Prime Minister for life. He did not, however, long hold the appointment. It is a difficult matter for any man to endeavour to control the affairs of both natives and foreign residents in the Pacific. The interests are too diverse. The captain of a British man-of-war may view in a very different light actions which may have been prompted for the sole benefit of the native population. I believe that Colonel Steinberger—and I had many conversations with that gentleman—acted as he considered for the good of the Samoan people, but in doing so he fell under the ban of the foreign residents. On February 8, 1876, Captain Stevens, of H.M.S. "*Barracouta*," at the request of King Malietoa, removed Colonel Steinberger from Samoa. The native chiefs objected, however, to the interference of Captain Stevens, and I think they were quite right in doing so. An affray ensued between the natives and our men, in which a few of our sailors lost their lives. The Admiralty has consequently ordered an investigation into the whole business, and we shall shortly be placed in possession of the actual facts of the case. Steinberger's reign was a short one—landing in March, 1875, removed in February, 1876. His mode of settling the dispute between the rival claimants of the crown (Malietoa the old, and Malietoa the younger) was somewhat peculiar. It was provided that each should reign for four years alternately, while Steinberger himself should be Premier for life.

The Samoan Parliament consists of two bodies—the Tainua and Faipule. The Tainua are the sixteen nobles of Samoa, and the Faipule the elected body, one member being elected for every two thousand of the inhabitants.

The desire of these little communities to possess some form of government which can administer internal affairs, and be recognised by foreign powers, is very laudable; but it is doubtful whether any of them will long maintain the position which they have assumed. They will find themselves far better off under the rule of some great power than under their own. Representative constitution is quite unsuitable to them. Democracies cannot exist within the tropics. The great body of the natives implicitly obey the orders of their chiefs.

Previously to the cession of Fiji, the native Government passed an Act allowing manhood suffrage to both natives and Europeans. The consequence would have been that the power of nominating and returning the whole of the representatives would have fallen into the hands of about four chiefs. Our form of Government—Queen, Lords, and Commons—is not found to work well in the West Indies, neither will it in the Pacific. The people may eventually be taught to exercise the power of election, but at present they cannot be entrusted with it. Neither is the aristocratic form of government—King elected and Chiefs—suitable, as the white settlers must possess a powerful voice in the administration. In my opinion, the only form of government suitable is an absolute monarchy, the crown being assisted by a mixed council of native chiefs and influential white residents, this being analagous to one of our pure Crown colonies.

In such tropical islands as these there can only be two classes—labourers, and employers of labour; there cannot, for many generations to come, be a middle class. Employers of tropical labour must, therefore, be rulers, unless a power steps in to protect the labourer; that power, for the benefit of all concerned, must rule absolutely or not at all. Wherever coloured labour is used, the white employers look upon it as degrading. The planters require to be held in check just as much as the natives. The whites in Fiji utterly ignored the existence of the native population except as consumers of imported goods, possible labourers, and payers of a tyrannical poll-tax. In many other islands the same feeling prevails. It is to be hoped that white settlers will be more liberal in their ideas, and recognize the advantage of absolute government. It is not at all unlikely that many other groups of islands will set up certain forms of government.

Islands still retaining Old Customs.

The following are those islands which still follow their old forms of government, or rather old customs:—In the North Pacific, the Caroline, Marshall, and Gilbert or Kingsmill Groups; a few islands in Eastern Polynesia: the Phœnix and Ellice Groups in Central Polynesia; all the isles of Western Polynesia, with the exception of New Caledonia; and the numerous small islands which lie scattered amongst all the principal groups. In most of these islands the missionary clergyman alone represents the bright side of modern civilization, and tempers the savage habits of the chiefs. In Western Polynesia, however, it is hardly yet safe for a missionary to land, or a trader to leave his vessel. New Guinea is a *terra incognita*, and its inhabitants are but little known. New Britain and New Ireland, the Admiralty and the Louisade Islands are almost in a similar position.

From some of these islands the principal portion of the labour employed in Queensland and the Pacific was, and still is, obtained. Possessing no government, nor any power which the whites could respect, the simple inhabitants were at the mercy of those who resorted to their shores. Luckily, our cruisers will now be some protection to them.

Labour Trade.

Placing upon one side the painful incidents connected with kidnapping, I am inclined to believe that the employment of native labour by cotton-planters and others has been beneficial, especially the employment of labour foreign to any particular locality. The mere fact of seeing other islands, other tribes, and a higher civilization, has led thousands of natives to reconsider and abolish their barbarous customs, and to listen more readily to missionary teaching. Anyone who has seen a large number of natives collected from perhaps ten different islands of Western Polynesia, or those near the equator, upon a well-ordered plantation, would hardly doubt that the lesson those natives received during their three or five years' residence upon that plantation tended to make them better members of the human family on returning to their respective homes. Official papers concerning the annexation of Fiji testify that Polynesian labourers upon Fijian plantations are far better off, as far as regards food, clothing, and house accommodation, than when upon their native islands.

On the other hand, the Melanesian Mission Report for 1873 totally disagrees with this opinion. The report states, with reference to the New Hebrides and Banks Islands, "that the labour trade is depopulating them, and that the returned labourer does not convey back the knowledge of any useful art, or even anything of civilization. It is therefore the business of those who carry on the mission to do all they can to prevent and oppose a traffic, the effects of which they see to be pernicious." In this I think that the mission is decidedly in the wrong. Bishop Patteson himself never demanded the entire suppression of the traffic; he only demanded its proper regulation. Neither do I think that the trade, except in one or two minor instances, is depopulating the islands. It may lessen the population of any particular spot, but only for a time. When the report above referred to was written, there were many hundreds of New Hebridean and Banks islanders in Queensland and Fiji, waiting to be returned to their different homes. His Excellency Sir Arthur Gordon has since returned them. That the labourer returns without having gained any knowledge of civilization or useful arts is a statement which can only be excused on the ground of missionary zeal. It is to be hoped that the clergy will not oppose the labour traffic, but suggest proper rules for its management, and lend their aid in seeing them carried out. The extension of commerce and the employment of labor will assist rather than retard missionary work. The Presbyterian report for 1873, concerning the mission in the New Hebrides, contains the following significant statement:—"We expected to find a people who would at least hear the Word of God and receive instruction, but, on the contrary, the great majority of those among whom we are stationed literally close their eyes, and refuse to be taught anything either sacred or secular." When it is remembered that thirty-five years of missionary labour have been devoted to this group, such a statement is very significant.

Missionaries cannot ascribe this to the labour traffic, for that has only been in operation of late years. In my opinion, it results from the fact that commerce does not properly support missionary teaching. In Eastern and Central Polynesia commerce has followed in the footsteps of the missionary, and the natives are now orderly and well-conducted; but in the New Hebrides commerce has no footing, and the natives listen to nothing, either sacred or secular. It is true that a few natives return to their islands somewhat demoralised. If they carry back a gun and a little ammunition they are not slow in using them against their old enemies, but they would do the same with bows and arrows. It is a question whether even the vices of civilization are not more tolerable than their own previous savage customs—unfortunately they are apt to add the two together. Still, missionaries cannot expect to keep the islands closed until they have evangelized the natives; commerce must spread, and the first step is to take advantage of native labour. When the excitement connected with kidnapping has passed away, it will be found that the employment of labour has been beneficial, especially in spreading the power and superiority of the white race among the islands yet unvisited by the missionary clergymen.

Will the Native Population Die Out?

Whether the native population will die ont is an important question. The labour traffic may have somewhat thinned the population of a few islands; not from rough usage at the plantations, but from the mere fact of a certain number of natives being unable to stand the change of climate. Change of residence may, or may not, be good, but that question is subordinate to the great one before us—Whether the natives generally will survive the contact with the white race? I believe they will. The idea that native races die out upon the appearance of the white race is true only in a limited sense. In my opinion the statement only applies to lands situate in temperate or cold zones, which happened to possess, or do still possess, an aboriginal population; it does not apply to tropical, or semi-tropical, lands—they are beyond its influence. Thus the Indians in some parts of America, and the Maoris in New Zealand, are certain to die out, being unable to survive the contact in temperate zones with the more fitting white race. The American Indians are being gradually driven into the central portion of the continent, which is their proper residence. They will for a time range free over the southern portion of the continent, because circumstances are still favourable for their habitation. The Maoris are gradually dying out because it was an error for any portion of the Malayan race to wander so far south. Certain climates kill native races just as surely as contact with the white race. We found very few Maoris or Malays in the Middle Island of New Zealand; they could not exist there. The American Indians have also much Malayan blood in their veins; their place is within the tropics. Tropical races cannot compete with the more fitting races beyond the tropics, and white races cannot compete with native races within the tropics. No one could possibly maintain that the white race will extinguish the East Indian, the Chinese, or the Malayan, neither will it the Polynesian. I am well aware that the aboriginal inhabitants of the West India Islands have nearly disappeared, but in the first instance they were almost exterminated by the Spaniards. I do not think that it is for our interest to exterminate the Polynesians. When the epidemic of measles was lately devastating Fiji, I heard many well-informed persons remark that if 50,000 natives, more or less, died off; the less trouble would be given to the Colonial Government. Now, a greater mistake could not possibly be made. Every native dying is a loss to the Government. It is to be hoped that not only the health, but the natural increase of the Fijians will be carefully looked after.

Figures purporting to show the decrease of any particular island cannot be relied upon. It was formerly supposed that the Sandwich Islands contained a population of 400,000 inhabitants, and New Zealand 200,000. Later calculations inform us that they now contain respectively 58,000 and 35,000. It is doubtful whether the first ever numbered more than 100,000, or the second 60,000. Captain Cook, generally so correct, was sadly out in his estimate of native population.

As soon as certain sanitary regulations are attended to, and infanticide put a stop to, I believe the population of the Pacific will increase. That of Java has nearly quadrupled itself since 1816, and it is a curious fact that the few remaining aboriginal inhabitants of the West India islands are of late years increasing in numbers.

Imported Labour.

I have before stated that the true wealth of the Pacific, and indeed of all tropical countries, does not rest in the soil nor in its productions, but in the amount of resident voluntary labour obtainable to cultivate the soil. To prove this statement it is only necessary to refer to the West Indies. Immediately after the emancipation of the slaves, estates which were worth £50,000 would hardly realise £5,000; the liberated negroes refused to work, and the planters were ruined. It is therefore the primary task of any Government to superintend and supply the demand for labour if it desires to advance the prosperity of tropical lands.

Hitherto the labour supply has been conducted by private individuals, and the evils which have arisen to both labourers and employers prove the necessity of Government interference. In Fiji, Samoa, and Tahiti the greater portion of the labour used has been imported from the neighbouring islands, but the supply is uncertain and very small. It may almost be said that there is no labour to be obtained in the Pacific. The removal of a few natives from one group of islands to another, whereby the first group becomes depopulated for a time, is not a supply—it is doubtful whether such a transfer is advisable either for the sake of economy or for health; neither is any certain supply to be found in the resident population.

The existence of 140,000 men, women, and children upon 7,400 square miles of tropical land, as is the case in Fiji, affords no supply: hardly twenty to the square mile. Java contains a population of 337 to the square mile, and Ceylon 87. My general estimate of the population of the Pacific (*vide* chart) is 1,200,000 upon a superficial area of 98,000 square miles, giving about twelve to the square mile. Tropical lands admit a far denser population, and the Pacific must look either to the natural increase of the population, or to foreign countries, in order to obtain a fair supply of labour. The natural increase will be found much too slow a process, and the only remaining alternative will be to import labour from abroad under Government superintendence. In South-eastern Asia there exists a labour market able to supply the world. China and India contain a population which is commencing to burst the bounds that have so long restrained them within certain limits. That population is beginning to emigrate, and soon a flood of Asiatics will pour through the long-closed gate of South-eastern Asia, and scatter themselves over the eastern and western tropical and temperate zones.

Now, the Pacific Islands lie close at hand, and a little regulation will direct a stream of labour which will amply supply any demand. This simple fact, this proximity to India and China, renders the Pacific Islands the most valuable within the tropical belt. The cost of passage (a very great consideration) will be small compared with that to the West Indies. A two or three years' contract with the Asiatic labourer will pay in the Pacific, whereas a five or six years' contract will hardly pay in the West Indies. Employers of tropical labour will soon perceive this important fact, and a great number will flock to the islands of the Pacific as soon as they are assured of sufficient Government protection.

In Fiji, Sir Arthur Gordon will doubtless look after these matters; but ought not the Imperial Government to take up the subject? If the statement is correct that the true wealth of tropical countries rests in the labour, should not the Imperial Government look after the interests of all its tropical possessions by superintending and regulating the supply of foreign labour. The West Indies, the Mauritius, Natal, Ceylon, Northern Australia, Queensland, Fiji, etc., all demand tropical labourers, which India and China can easily supply. The Registrar-General of Bombay informs us that the population of India is increasing by 2,000,000 annually. It is quite impossible for India to support its present population, together with such a yearly increase; should not, therefore, a proper system of emigration be determined upon? Our tropical possessions in the Pacific can easily absorb a vast number of labourers, and India would be greatly relieved. If, however, caste, prejudice, or custom cannot be overcome, there is a plentiful supply of labour to be obtained from China. Many Chinese are already in the islands, but many more are required. The Chinese make good settlers, and infuse some of their own untiring energy into the people around them. It is to be hoped that the Imperial Government will remove the restrictions which were lately imposed upon Chinese emigrants from Hong Kong.

There is very little doubt but that the Imperial Government can easily arrange a liberal labour supply from Asia if it favourably considers the proposal; but we have something else to consider besides the mere importation of labourers—*we must endeavour to retain them after their term of service has expired.* Increase of population in Polynesia implies increase of wealth. Fiji can well support a million inhabitants, and when the little colony contains that population, it will also possess a very fair supply of voluntary labour. Necessity will then compel the natives to work more strenuously than they do at present; the struggle for existence will be greater, and a greater amount of labour must result. It will therefore be seen that the present inhabitants of Fiji are not alone to be considered; a large increase must be provided for, and it is consequently necessary for the Government to gravely consider the land question. As much land as possible should be retained in order to provide for future increase, and foster future settlement.

Sir Hercules Robinson might not have fully considered this subject when he proposed that tribal lands should vest in the chiefs.

An unavoidable mistake has been made in the West Indies, which should, if possible, be avoided in Polynesia. The supply of female coolies, in anything like proportionate numbers, has been much too small, and the result has been found to be thoroughly demoralizing; marriage laws have been completely thrown aside. Too many male labourers ought not to be introduced without a proportionate number of females.

Health of the Islanders.

As yet the natives have not considered any sanitary regulations—their houses, although comfortable and suited to the tropics, are badly drained and ill-ventilated, the greater number of them being extremely unclean habitations. Mat upon mat is often piled upon the naked earth until the bottom layer is a mass of decomposition; the consequence is that vermin abound, and the natives have to resort to the use of lime in order to keep themselves personally free from the pest. Contagious diseases of every kind spread amongst them like wildfire—an epidemic kills them off by thousands. Should we not endeavour to prevent this? The natives should be induced to build their houses upon higher ground, not upon the sea-shore; also to keep them in open spaces. In many inland villages I have seen the rank vegetation clustering around the very walls of the huts, which sometimes it is even difficult to discover. A traveller all at once stumbles on a native village buried in the luxuriant growth of the tropics. More wood and stone should be used in the construction of the private dwellings; coral will make a good floor when wood is not to be obtained.

The natives are also very improvident in their domestic habits, sometimes gorging to excess, at other times almost starving; they have no regular hours for taking food, but the principal meal is towards evening. Their chief article of diet is vegetable, which renders them incapable of sustaining any very prolonged labour. It is doubtful whether the free use of cocoa-nut is beneficial to health; in my opinion, maize would be found far more nutritious. The dense coast population of Ceylon is chiefly supported by the cocoa-nut, and we often hear of great epidemics raging in that island; some 10,000 natives were carried off by cholera in 1867.

Hardly sufficient attention is paid to the purity of the water supply, upon which health in the tropics so greatly depends. Where running water is used, the streams are generally fouled by the natives, and standing water ought to be avoided;—the great amount of vegetable decomposition constantly taking place soon charges standing water with a pestilential deposit. Some of the islands are, however, in themselves very unhealthy. These are principally to be found in Western Polynesia; why they should be so is a difficult matter to determine. In many instances the islands surrounding any particular spot are healthy, whilst the spot itself is the abode of fever and ague; indeed it is oftentimes found that three sides of an island are healthy, while the fourth is totally the reverse.

The prevailing winds have much to do with the subject, and likewise the neighbourhood of the Australian continent. Large deposits of vegetable matter in a state of decomposition will also be found to greatly influence the healthy condition of the atmosphere. For these reasons the windward side of any island is more healthy than the leeward, in consequence of receiving the steady current of the south-east trade winds.

In the report of the Commissioners—Commodore Goodenough and Mr. Layard—concerning the cession of Fiji, there is a paper containing some observations by Dr. Messer upon the health of the islands. That gentleman states that the Fijian Archipelago is singularly free "not only from tropical diseases, but also from most of those diseases which in England and other countries yearly cause a large amount of sickness." This is saying a great deal for future white residence in that group. It would be of the utmost advantage if our medical officers, generally, in the Pacific would report upon the health of the islands, as the most healthy are the most valuable for European residence. The climate of an unhealthy island will greatly retard the work of colonization. Our information on the subject is at present very vague, but I think I am fully entitled to say that the Pacific Islands are more healthy, and more suitable for European residence than the West Indies or British Guiana.

Language and Education.

The education of the islanders has been principally confined to religious teaching. Nothing else could have been expected, nor anything better imparted. Whilst, however, perfectly agreeing with what has already been done, I think that it will be found absolutely necessary to pay more attention to secular and industrial education, especially in those islands which have been christianized. The Melanesian Mission in Norfolk Island, and the Wesleyan training schools in Tonga and Fiji, combine the three;—an extension of this plan is alone required. I am quite certain that the missionaries will cordially assist in any matter connected with the welfare of the natives. Both secular education and industrial habits must be inculcated, and the more compulsory the system the better it will be for the natives. There should not be any hesitation in the course to be pursued. The lazy habits of past generations have to be rooted out, and compulsory means are the most suitable for the work. Boys and girls should be compelled to attend the schools, and the Fijian Government should consider the advisability of establishing such schools in every village. Public nurseries and public schools might well be combined. One great difficulty exists with regard to secular education. Each group of islands has not only its peculiar language, but in many instances distinct district dialects—the missionaries say, distinct languages. The Rev. H. Codrington, in one of his early lectures, remarks, " It is not that each island has its own language, but that there are many languages, mutually unintelligible, on one island. I have a little chart of a part of the New Hebrides—the Shepherd Islands, including Tisiko and Fate; there are twelve islands and thirteen tongues, mutually unintelligible."

Western Polynesia, however, possesses a greater diversity of language than Eastern or Central Polynesia, in consequence of having been populated not only by colonies of Asiatics and Papuan negroes, but also by many wanderers from Polynesia itself, driven westward by the trade winds. New Hebrides and the Solomon Islands contain many settlements of pure Polynesians. In Eastern and Central Polynesia the different dialects of the parent Malayan tongue are not so numerous. They must, however, rank as distinct languages in consequence of the missionary clergy having been compelled to erect them into that position. The Sandwich, Society, Cook's, Samoan, Tongan, and Fijian Islands have each their published Bibles, grammars, dictionaries, and vocabularies. Portions of the Scriptures have also been translated into some of the languages spoken in the following islands:—Marquesas, Caroline, Marshall, Gilbert, New Hebrides, Banks, Loyalty, New Caledonia groups. The Press has indeed aided Christianity in the Pacific.

Whether it is advisable to continue this bountiful supply of language is very doubtful. A population of little over a million does not require 25 or 30 different languages. It would be much better for the natives to learn one useful language, which could be used as a medium for imparting secular education, than the present numerous dialects of one or two parent tongues. One language is amply sufficient for Eastern, Central, and Northern Polynesia, another for Western Polynesia. In my opinion two languages are alone required—one founded upon a Malayan, the other upon a Papuan basis. The subject is very important, as the future work of Government in the Pacific will be much aided by such a simplification, for the cost of ruling the islands will be increased in proportion to the number of languages. It is also doubtful whether the English language is suitable to the tropics; the natives under our rule will pick it up, but it is much too harsh to become the popular language in Polynesia—French and Spanish are both more suitable. It would, however, be better for the English language to be taught than the numerous native languages which are at present being in a manner built up. Australia will contribute a large number of English-speaking people to the population of the Pacific, and South-eastern Asia many Indian and Chinese. The necessity for having one language common to all, and easy of acquisition, is hence evident.

Position of the Australasian Colonies.

The position of the Australasian Colonies with regard to these islands is very important, as the trade of the Pacific is almost certain to be conducted from their ports for many years to come. There are few safe harbours in Polynesia, and the rise and fall of tide is very slight, consequently the Australasian ports must be largely relied on for many purposes.

The carrying trade of the Pacific will have to be principally conducted by means of small vessels of 80 to 150 tons burthen, either steam or sail, or a combination of both. Auxiliary screw wooden schooners or steamers will be found most suitable. Australasia can supply these vessels better and cheaper than any other country. One or two ports of the western coast of America may share in the trade, but the Australasian ports are likely to be the most relied upon.

Colonial shipping will also supply a cheap freight for island produce to European markets. At present, outward English shipping to Australia cannot always depend upon a homeward freight. Vessels have constantly to go from Melbourne, Sydney, and New Zealand to India and China in order to obtain a return cargo. The trade of the Pacific will supply that shipping with a return freight, and both countries will mutually profit. Of course, eventually, the islands will require their own lines of vessels, and accommodation will be required in the English docks for the Pacific trade, just as it is required for the West Indian.

The islands will draw from the colonies their supply of coals, building materials, flour, and other standing articles of consumption, also a vast quantity of material. Towns are yet to be built, roads and bridges to be constructed; small dry docks, mills, foundries, machinery, water and gas-works, lighthouses, telegraphs connecting group to group and island to island; indeed, all the wants of civilization have yet to be supplied, and the colonies are certain to share largely in the supply. At present the islands possess absolutely nothing—cultivation and production have hardly commenced.

The imports and exports of the British possessions alone in the West Indies amount to £15,000,000 sterling. The Pacific hardly imports more than £700,000 per annum. The West Indies employ a million tons of English shipping—not a vessel leaves an English port for the Pacific.

It is almost certain that the resources of the Pacific will shortly be greatly developed, and the position of Australasian Colonies with regard to that development is a very important consideration. Australasia is as valuable to the Pacific as the Pacific is to Australasia ; indeed, if the islands would consult their best interests, and also look to their geographical position, instead of seeking protection from America, France, and Germany, they would petition the Australian Colonies for assistance. It is for the interest of these colonies to render such assistance, whereas the powers above named have no particular interest in the matter.

Which of the colonies will take the lead in the island trade is uncertain. but in my opinion New Zealand, from its position, is likely to do so. Auckland is 1,200 miles nearer the greater number of the groups than Sydney or any Australian port. For nine months in the year the south-east wind prevails, and New Zealand lies to the windward of Australia. Auckland is likely to become the seat of a large ship-building trade, possessing, as it does, a good harbour, and plenty of iron, coal, and timber. Sydney will supply a great amount of merchandise ; Queensland, meat ; and South Australia, flour, etc.

New Zealand likewise possesses another great advantage over Australia —its beautiful climate ; a fit sanitarium for tropical invalids. Many planters even now resort to this Colony in order to recruit their health. Ladies and children will find it of the utmost advantage to annually leave the islands for a couple of months, in order to escape the summer heat.

The bond of union between the colonies and the islands must become a very strong one. Population is gradually overflowing ; colonial merchants are establishing agencies in the Pacific ; and there will hardly be a planter who will not possess many friends in one or other of the Australian Colonies.

Final Remarks.

I must now bring the paper to an end. The subject upon which it treats is so extensive that the great difficulty under which I have laboured is, not to find what to say, but what to leave unsaid. In a paper such as this it is almost impossible to do justice to so great a subject. Many important matters have been omitted. But slight reference has been made to New Guinea ; the civilization and colonization of that island must be a task of time. In my opinion, the various groups of islands referred to require far more immediate attention than New Guinea. Their colonization is forcing itself upon our attention, although it has taken nearly a hundred years for the question to ripen into its present importance.

New Guinea, as I have before remarked, is a *terra incognita;* there is not much danger of any Great Power attempting to colonize it for some time to come. All that we require at present is the protection of our trade through Torres Straits, and the Royal Colonial Institute has duly brought that important point before the notice of the Imperial Government. That the civilization of New Guinea will be found a more easy task than that of the Malay islands is true, but there is no necessity for us immediately to perform the task. Our missionaries will first lead the way. I notice that in May last the Wesleyan missionary barque, "*John Wesley*," left Fiji with a deputation of white missionaries, and about fifteen native teachers, for the purpose of taking the first steps to implant Christianity on the north-west of the island, and at the same time on the islands of New Britain and New Ireland. The London Missionary Society have selected the south coast. There is very little doubt but that these noble efforts will succeed, yet the task is a difficult one. The natives are somewhat fierce and treacherous, and the climate, so far as we are acquainted, very unhealthy. It would be of much advantage if the Home Government directed our war schooners to visit the new stations occasionally. Nothing has been found more hurtful to missionary enterprise than the isolated condition of the clergy. For many months they are left to themselves to struggle with their numerous difficulties. The one or two mission vessels cannot perform the necessary work of visiting all the stations. I trust the societies at home will seek a little co-operation in this matter from the Imperial Government.

In the body of the paper it will be observed that reference has often been made to the West India Islands. In my opinion, the past history of those islands will be found a very valuable precedent for future action in Polynesia. The opening of the Isthmus of Panama by a canal has a most important bearing upon the future of the Pacific. The successful accomplishment of that great work will vastly increase the value of the islands. Through them will pass a great trade to Australasia and Eastern Asia, and back again to the Western Hemisphere. Great circle tracks are almost certain to be followed, and one or two of these tracks cut the islands. Such a traffic must greatly benefit the Pacific. The opening of the canal will also permit the island trade going direct to English markets, as the distance will then not be much greater than to any other.

That the canal will be constructed is almost a certainty; a late American commission upon the subject does not consider the difficulties insurmountable. The cause of civilization would be greatly advanced if America, France, and England warmly took up the subject;—our own Government, I believe, is fully alive to its importance. In conclusion, I may be allowed to express an earnest wish that the Imperial Government will consider the advisability of pursuing some definite policy. Action in Polynesia should not be made to depend upon the mere question of the suppression of slavery. It is not too much to consider that the islands will eventually form a great confederation; but much depends upon the manner in which they are acquired by the great powers. The tendency of late years in the West Indies has been towards such a confederation. Under a federal system the cost of government will not be so great, taxes will be more uniform, and the labour supply can be better regulated—three very important considerations in tropical countries. I trust that Great Britain will act in such a manner as to enable the islands eventually to form a powerful confederation. I cannot close this paper without adding one tribute of respect to the memory of the latest martyr to the cause of civilization in the Pacific—James Graham Goodenough, commodore of the Australian station. Admired and respected by all who knew him, loved and esteemed by all his officers, his loss will be deeply felt. He fell a martyr in the attempt to restore confidence in the minds of the savage natives of Santa Cruz, after having successfully brought about the annexation of Fiji to the British Crown. Few events, since the death of Captain Cook, have created so powerful an impression upon the public mind. Bishop Patteson and Commodore Goodenough have both fallen victims to the treachery of these particular islands. When are these losses to cease? Almost a century since, La Perouse and his unfortunate comrades were cast away upon these very islands, and not one returned to tell the tale. Is it not time for us to regard these natives as dangerous to humanity? The lives of our sailors and traders in the Pacific are at their mercy. The late commodore would not allow them to be punished; but have we not a duty to perform? Should we not at once take steps to prevent the future loss of valuable lives? England cannot afford to lose such sons as John Coleridge Patteson and James Graham Goodenough.

APPENDIX A.—*Statistical Chart of the Islands of the Pacific.*

NORTH PACIFIC.

Name of Group.	No. of Islands	Formation.	By whom Discovered.	Area Square Miles.	Name of Mission	Native Population.
Bonin Islands ...	50	Volcanic	Spaniards	...	Roman Catholic	...
Ladrone or Marian Islands...	20	Do.	Magellan, 1521	1,254	Do. 1668 ...	55,000
Pelew Islands ...	20	...	Villalolos, 1543	...	Do. 1710 ...	10,000
Caroline Islands	300	Volcanic and Coral	Portuguese, 1526; Drake, 1579; Mendana, 1595.	...	American Board of Foreign Missions, Hawaian Mission	*150,000
Marshall, or Mulgrave Islands	30	Coral	Marshall and Gilbert, 1788	...	Hawaian Miss'n. A. B. F. M. Samoan Mission	12,000
Gilbert or Kingsmill Islds.	16	Do.	Do.	...	Hawaian Miss'n. A. B. F. M.	10,000
Sandwich Islds. (1871)	13	Volcanic	Cook, 1778	6,090	A. B. F. M. 1820 Hawaian Mission Soc. Prop. Gosp'l. Am. Miss. Asso.	58,765
EASTERN POLYNESIA.						
Marquesas	5	Do.	Mendana, 1595	777	Hawaian Mis. A. B. F. M. R. C. M.	10,000
Paumota, or Low Archipelago	78	Coral	De Quiros, 1606	4,125	R. C. & L. M. S. Soc. Prop. Gosp'l.	8,000
Tahiti, or (1871) Society Islands...	3	Volcanic	Do.	734	L. M. S. 1797 R. C. M.	13,847
Georgian Islands	6	Do.	Do.	...	L. M. S.	10,000
Austral, or Tubai Islands ...	5	...	Vancouver, 1791	...	Do.	4,000
Cook's, or Hervey Islands...	7	Volcanic and Coral	Cook, 1778	...	Do.	16,000

APPENDIX A.—*(Continued.)*

NORTH PACIFIC.

Name of Group.	Foreign Residents.	Government.	Imports £	Exports £	General Remarks.
Bonin Islands ..	30	Spanish	...	...	No native population. A few Japanese. Lloyd's Harbour, a very good one.
Ladrone or Marian Islands..	...	Do.	...	...	The fleet of Prince Maurice, of Nassau, refreshed at Guam, 1625.
Pelew Islands ..	...	Native King & Spanish.	...	...	*Antelope* wrecked, 1783; Prince Lee Boo accompanied survivors to England.
Caroline Islands	120	Native Chiefs	...	...	Many excellent Harbours. Great resort of Whalers. Severe Hurricanes. Natives faithless and treacherous. Enormous ruins.
Marshall or Mulgrave Islands	6	Do.	...	...	Radick and Rallick Chains.
Gilbert or Kingsmill Islds.	...	Native King	...	...	On the Equator. Severe hurricanes. Degraded and savage type of Natives.
Sandwich Islds. (1871)	5,500	Monarchy and Constitution since 1840	325,176	378,418	Cook killed at Hawaii, 1778. Independence recognised, 1843. Sugar principal export.

EASTERN POLYNESIA.

Name of Group.	Foreign Residents.	Government.	Imports £	Exports £	General Remarks.
Marquesas..........	...	French, 1842	...	...	Bad Harbours. Fine race of Natives.
Paumota, or Low Archipelago	...	French Protectorate, 1846	...	...	Eighteen uninhabited. Great pearl shell fishery.
Taihiti, or (1871) Society Islands...	...	Do.	120,000	90,000	Cotton principally exported.
Georgian Islands	...	Native Government.	...	...	Independence from Tahiti recognized. Fair code of laws. Two of the Islands under French protection.
Anstral, or Tebai Islands ...	...	Native Chiefs	...	...	Good Harbour in Rapa. Beautiful climate.
Cook's, or Hervey Islands..	30	Native Queen and Chiefs	...	...	No harbours. Beautiful climate. Hurricanes occasionally.

APPENDIX A.—*(Continued.)*

CENTRAL POLYNESIA.

Name of Group.	No. of Island.	Formation.	By whom Discovered.	Area Square Miles.	Name of Mission	Native Population.
Phœnix	8	Coral	Cook, 1773.	...	...	...
Ellice	...	...	...	...	L. M. S.	2,000
Tokelau, or Union	...	Do.	...	...	..	500
Navigator, or Samoa (1871)	10	Volcanic	Roggewein, 1722; Bougainville, 1768	1,650	L. M. S. Wesleyan M. S.	35,000
Friendly Islands, or Tonga	100	Volcanic and Coral	Tasman, 1643	...	L. M. S. 1797 Wes. M. S. 1831	30,000
Fiji (1873)............	200	Volcanic	Do.	7,404	Wes. M. S. 1835	140,500
WESTERN POLYNESIA.						
New Hebrides ...	...	Do.	De Quiros, 1606 Bougainville, 1768; Cook, 1774	...	Melanesian Miss. and Presby. Miss. S.	*80,000
Banks Island ...	...	Do.	..	...	Melanesian Miss.	...
Santa Cruz Islds.	12	Do.	Mendana, 1570	...	Melanesian Miss	...
Loyalty Islands	4	Coral	...	1,354	L. M. S. 1841 Mel. M. & R.C.M.	*15,000
New Caledonia...	2	...	Cook, 1774	10,875	R. C. M.	29,000
Solomon Islands	140	Volcanic	Mendana, 1567	...	Melanesian Miss.	*200,000
New Ireland	...	Do.	...	...	...	...
New Britain	...	Do.	...	24,000	...	...
Admiralty Islds.	40	...	...	...	...	...
Louisade Islands	...	...	Torres, 1606	...	...	...
New Guinea	...	...	Portuguese, 1511; Torres, 1606	260,000	L. M. S. and Wesleyan M. S.	...

APPENDIX A.—*(Continued.)*

CENTRAL POLYNESIA.

Name of Group.	Foreign Residents.	Government.	Imports £	Exports £	General Remarks.
Phœnix	...	Native Chiefs	...	...	Few inhabitants.
Ellice	...	Do.	...	...	Islanders once ignorant of warfare. Peruvian slavers in 1863 almost depopulated the group.
Tokehau, or Union	...	Do.	...	...	No soil upon some islands. Natives once unaccustomed to the use of fire.
Navigator, or Samoa (1871)	500	Native Chiefs & Constitution	25,000	45,000	Possesses the finest Harbours in the Pacific. Rarely visited by hurricanes. Good climate.
Friendly Islands, or Tonga	60	Native Monarchy	...	...	Low islands. Severe hurricanes. Earthquakes common.
Fiji (1873)	1,786	English, 1874	87,653	84,802	Hurricanes frequent and severe. Superficial area equal to Wales.

WESTERN POLYNESIA.

Name of Group.	Foreign Residents.	Government.	Imports £	Exports £	General Remarks.
New Hebrides	30	Native Chiefs	...	...	Hurricanes frequent and severe Unhealthy islands. Havannah harbour good. Williams murdered at Erromanga, 1839. Sandal wood discovered, 1828.
Banks Island	...	Do.	...	...	Mota Island, head quarters of Melanesian Mission.
Santa Cruz Islds.	...	Do.	...	...	La Perouse lost, 1788. Bishop Patteson murdered, 1871. Commodore Goodenough, 1875. Numerous & savage population.
Loyalty Islands	...	Do.	...	...	France claims control over the group.
New Caledonia	*10,000	French, 1853	...	...	Natives resemble Tasmanian Aborigines (now extinct). Ruins of ancient roads and aqueducts.
Solomon Islands	...	Native Chiefs	...	...	A magnificent group. Superficial area about 14,000 square miles. Great cannibals. Crocodiles seen upon Ysabel.
New Ireland	...	Do.	...	...	A large and beautiful island. Numerous and contented population.
New Britain	...	Do.	...	...	M. D'Urville (1827) much struck with its value and beauty. Numerous population.
Admiralty Islds.	...	Do.	...	...	Thickly populated. Cocoa-nut abundant.
Louisade Islands	...	Do.	...	...	Very ferocious Natives.
New Guinea	...	Do.	...	...	In 1828 the Dutch took possession of a little south-west territory, but afterwards abandoned it. They still retain the Arron Islands, lying to the south-west, and containing about 60,000 inhabitants.

* Conjectural.

APPENDIX A.—(*Continued.*)

Explanation of Chart.

As the accompanying statistical chart of the Pacific Islands is the first of the kind attempted, I trust that every allowance will be made for inaccuracies. I have found it very difficult to obtain any reliable information; even the missionary accounts vary considerably.

Notice has been taken only of the principal groups, although scattered amongst them are numerous solitary islands of much value. For example—Savage Island, or Nive, population 5,000, discovered by Cook 1773; Wallis Island, population 3,000, the residence of the Roman Catholic Bishop of Oceania; Ocean Island, population 2,000; Pleasant Island, population 1,400, so named from its beauty; Gambier Island, population 1,500, under French protection; Easter Island, Fanning Island, and many others.

The names of the various groups are somewhat confusing; in many instances I have given those by which they are most popularly known. It is difficult to name correctly the two groups, generally called the Society Islands. Captain Wallis, I believe, named them the Georgian Islands, in honour of George III. Cook called them the Society Islands, in honour of the Royal Society. Ellis calls the Eastern Group (Tahiti) the Georgian Islands, and the Western Group, the Society Islands. I think that Tahiti should be called the Society Islands, as it was there that Cook made his observations.

With regard to the number of islands which each group is stated to contain, it is necessary to explain that most of them are mere rocks, or chains of islets upon one great reef, or numerous islands enclosed by one reef. There are very few large volcanic islands in any particular group. Fiji, for example, stated to contain 200, has only three or four large islands and six or seven small ones, whilst the remainder are mere spots, containing from two to a thousand acres each. The Island of Hogolue, commonly so called, in the Caroline Group, is an immense atoll, or coral reef, enclosing a vast lagoon, having a circumference of some 300 miles. Within the lagoon are four great islands, each from 20 to 25 miles in circumference, and more than 20 smaller uninhabited cays, covered with cocoanut and other trees.

The difference between the volcanic and coral islands it is important to distinguish, as the former are more suited for the growth of coffee, cotton, sugar, tobacco, etc., than the latter.

Exclusive of New Guinea, the area of the islands may be about 98,000 square miles, or five times as great as our West Indian possessions, excluding, of course, British Guiana. The gross area of any group is only an approximation, and cannot be relied on. By reducing kilometres into miles I have been enabled to arrive at some idea of the superficial area of the French possessions.

A further survey of the Pacific is sadly needed. Since the "*Herald*" and Commodore Wilkes expedition, but little has been added to the Admiralty charts. I am, however, somewhat uncertain whether the Imperial Government has not lately directed a few necessary surveys to be undertaken.

The population of any group marked with an asterisk is purely conjectural. One writer supposes the New Hebrides, for instance, to contain 200,000 natives, another 60,000. I prefer to under-rate, rather than over-rate, the native population. The total of the numbers given in the chart amounts to 843,612, to which must be added the population of the Phœnix, Santa Cruz, New Ireland, New Britain, Louisade, and Admiralty groups, and also the inhabitants of the numerous solitary islands before referred to.

Exclusive of New Guinea, the population of which it is quite impossible to conjecture, there cannot be less than 1,200,000 natives in Polynesia.

The foreign residents are principally European. I do not consider that there are more than 20,000 whites in the Pacific, of which number probably 10,000 are in New Caledonia.

The total of the imports amounts to £557,829, and exports, £598,215. Add to these sums the imports and exports of the Tongan Archipelago, the only remaining group of any present commercial importance, also the goods sold by the trading schooners in exchange for island produce, and the grand total of imports and exports will not exceed £1,450,000 per annum. The supply of the French convict station at New Caledonia can hardly be included under a commercial heading. *

The following table supplies a few statistics concerning other tropical countries ;—

	Area in Square Miles.	Population.	Imports.	Exports.
			£	£
British possessions in the West Indies, 1871	19,988	1,089,818	5,186,086	5,804,093
British Guiana, 1871	76,000	193,491	1,897,183	2,748,720
Mauritius, 1871	708	316,042	1,807,382	3,053,054
Ceylon, 1872	24,454	2,405,287	5,169,524	3,163,153
Java, 1871	51,336	17,298,200	4,213,428	7,459,735
Phillipine Islands †	65,100	4,319,269	..	..

In comparison with these figures, the result of my calculations and approximations may be given as follows :—

	Area in Square Miles.	Population.	Imports.	Exports.
			£	£
Pacific Islands	98,000	1,200,000	700,000	750,000
New Guinea	260,000	..	..	..

It will therefore be seen that the Pacific Islands, possessing a superficial area of five times the extent of our possessions in the West Indies, and a greater population, do not at present consume one-eighth of the amount annually imported by those islands. ‡

* In 1874 New Caledonia imported £503,263 and exported £35,598.

† In 1871 the Phillipine Islands exported to Great Britain alone £1,391,254, and imported £463,359.

‡ It is important to note that, in speaking of the West Indies, I only refer to the British possessions.

Art. VIII.—*Colonial Standard Survey.* By J. T. Thomson, F.R.G.S.

(Read before the Wellington Philosophical Society, Sept 30, 1876).

This is not intended to be a treatise on the methods employed in Standard Survey. Full information may be had on these by the study of technical works. All that can be attempted here is to indicate such professional measures as experience has shown to be the best for the particular circumstances of this colony.

Mr. J. A. Connell has ably discussed the subject of actual survey. So in this paper I shall confine myself as much as possible to matters not touched on by him.

To the Home country and other European nations we look for examples of the highest skill applied to the standard work—that is in the professional operations which govern detail measurements,—and ask ourselves, can the same processes be applied here, or do the wants of colonial settlement prevent this? This question, I hope, may be made clear before we come to the end of this paper.

The first step made in the great triangulation of Great Britain and Ireland, and which has since developed itself into a general and actual survey of territory and property, was the measurement of a base on Hounslow Heath in 1784, intended solely for the purpose of connecting by triangulation the observatories of Paris and Greenwich. Being thus instituted for a purely scientific object, it was continued so, and the next step was to measure an arc of the meridian, for the purpose of ascertaining the true form of our globe. After this a further extension of its operations was given to it by the commencement and combination of topographical and actual surveys in combination with the superior processes. But it must be here stated that these latter measures did not mark out and delineate new properties about to be taken possession of, but old properties already possessed and marked or fenced in. Thus the Home survey has not been one of settlement as ours in New Zealand is.

Another great point in British survey must here be mentioned, viz., that of India, embracing as it does over 1,300,000 square miles of territory, while the British Islands cover 122,000 square miles only. This was commenced by great trigonometrical operations over the Madras presidency in 1799, the primary object of which was, with other surveys of the same nature in different parts of the world, to ascertain the true figure of the earth, the subsidiary object being to provide geographical data for military topographical surveyors; and it is curious to remark that the initiatory support that great triangulation obtained both from the British and the Indian Governments was from the same motive—a motive apart from the purely scientific objects of the projectors, viz., that these operations would give opportunity for military reconnaissances, and so (especially in India) be useful in the time of war.

* "Trans. N.Z. Inst." Vol. VIII., Appendix.

The system of great triangulation cast over India is not that of "net work" as cast over the British Islands, but what is technically termed "gridiron" or "chain series." In this respect it imitates the systems of Russia and France. Thus though all the immense extent of territory has been embraced, yet not more than one-fifth of the whole can be said to be triangulated. The Madras portion is an exception to the above rule only, which is "net work." The "chain series" pursue meridians at intervals of 1 to 2 degrees of longitude, and follow parallels at intervals of 1 to 5 degrees of latitude. But there are several great areas unaffected even by these; such as the region east of Scinde, extending 420 miles east and west, and about 345 miles north and south, the region of Orissa, of equal extent—other regions in various parts uncovered being smaller than these.

In the series of the largest triangles theodolites 36 inches in diameter are used in India, each requiring 27 men for their transport.

At the commencement of Lambton's operations in India it is interesting to note that objections to great triangulation were raised by the eminent geographer Rennell, he proposing an astronomical instead of a geodetic basis; but Lambton, amongst other arguments in his reply, showed that in the breadth of the Indian Peninsula an astronomical error of 40 miles had occurred—in the position of the city of Arcot 10 miles and Hydrabad 32 miles, all in longitude; hence in those days longitude was the difficulty. Had the wonderful properties of the electric telegraph as applied to this very subject then been known, it is possible that the controversy would have ended in the support of Rennell, not in overturning great triangulation in its elucidating the problems of meridian arc survey, but in curtailing its extension beyond that process.

I have not been able to obtain any authentic return of the cost of great triangulation in Britain, and as there have been ample records of the same system in India, I refer to the following:—

	Sq. miles	£	£ s. d.
Everest's great arc series	56,997	cost 87,833	1 11 7 per square mile
Bombay longitudinal..	15,198	,, 13,742	0 18 3 ,,
Budoan do	12,468	,, 17,259	1 5 0 ,,
Rangheer do	16,087	,, 11,837	0 14 9 ,,
Amua do	5,565	,, 10,495	1 18 2 ,,
Karara meridional longitude.. ..	5,819	,, 13,490	2 6 2 ,,
Guriwani do	6,298	,, 5,301	0 17 0 ,,
Gora do	4,416	,, 7,694	1 14 6 ,,
Chundwar do	3,565	,, 6,450	1 16 6 ,,
Parimath north meridional longitude	4,765	,, 5,287	1 2 7 ,,
Calcutta meridionial longitude ..	4,136	,, 11,030	2 13 8 ,,

Highest £2 13s. 8d. per mile, lowest 17s. The mean cost of great or primary triangulation may thus be taken at £1 11s. 9d, per square mile.

Having the area of the country, therefore, to be submitted to this process, the total cost may be nearly calculated.

But the most important feature of this system of triangulation affecting colonial survey requirements is in its requiring to advance or spread out from one or two points only, from very accurately measured base lines. Thus in the British Islands, all parts of the country, have only been reached by a lapse, from the commencement, of 90 years, and what has been done for India has taken 75 years. There may be no inconvenience from this in these immemorially possessed countries, but where an unmarked wilderness is to be divided amongst an inflowing people the case is of an opposite nature. Here the wants of the people demand ubiquitous and immediate attention over the whole area of the country under the process of colonization. But to this subject I will afterwards refer, and next notice the degree of accuracy attained by great or primary triangulation.

All first efforts are necessarily imperfect, however great the skill and assiduity of the projectors, and in this most refined system of geodesy we find no exception. The original labours of Roy and Mudge, in England, and Lambton, in India, have been revised in order to bring their work up to the perfection attained by modern instruments and inventions. Thus, in the first meridian arc triangulations, between Dunose and Misterton Carr (200 miles apart), the distance between Arbury Hill and Corly (a side of one of the "chain" of triangles near the middle of the arc), it was found that from the Dunose base the length was 117,463 feet, and from the Misterton Carr base, 117,457·1 feet, a difference of 5·9 feet, or 70 inches in somewhat more than 22 miles—*i.e.*, 3·2 inches per mile. In recent times bases in Ireland have been measured by Colby's compensation bars, by which each 100 feet can be measured with an accuracy equal to half the breadth of a sharp steel point, on a plate of metal observed by a microscope. * In India the Dehhra Doon base, 7·42 miles in length, was measured in reverse order, with an error of only 2·396 inches, or about $\frac{3}{10}$ of an inch per mile, and the Bider base, about $7\frac{8}{10}$ miles in length, compared with the Sironj base by triangulation and computation, though 400 miles apart, was found to have a difference of 4·296 inches, or about $\frac{5}{10}$ of an inch per mile.

Steel chains had been used in the measurement of bases but to be abandoned, and on this subject Colonel Walker says that, "taking all circumstances into consideration, the conclusion is inevitable and irresistible that the chain base lines are worthless for the purpose of controlling the principal triangulation of this survey (of India), and more particularly that portion

* Markham, "Great Trigonometrical Survey of India," page 90. The Loch Foyle base measured, in this manner, nearly eight miles, or exactly 41,640·8873 feet, with an error of less than a quarter of an inch per mile.

of it which has been completed since the year 1834 with the best modern instruments. They have served the purpose for which they were immediately required, but they have been superseded by the base lines which were subsequently measured with the Colby apparatus of compensation bars and microscopes."

To the stock farmer or the agricultural settler the opinions of Colonel Walker will appear hypercritical; indeed, how earnest is he not—yet that very earnestness proves a state of views and interests irreconcilable. Where shall we draw the line of mutual concession, or shall the settler wait the pleasure of the great triangulator?

It is interesting here to remark how the modern invention of the electric telegraph has invaded the domain of the great triangulator, with whom, notwithstanding his subtle splitting of needle points, it is a rival in unravelling profound physical phenomena. Thus, in the measurement of longitude between Madras and Mangalore.* The distance by great triangulation is 20′ 36″·78: by telegraph, 21′ 35″·85; difference, 0″·93, or 13″·95 of arc. These figures are by Everest's "Elements of Globe Ellipticity," but by Clarke's the difference is reduced by 3″·5, or to 10″·45. The editor of the report remarks on this, that the fact is consistent with the result of Captain Basevi's pendulum operations, which show that the density of the strata of the earth's crust is greater under the depressed beds of the ocean than it is under the land elevated above the sea level. Thus the direction of the plumb line at Madras, on the east coast, is most probably deflected to the east of the normal to the mean figure, while at Mangalore the direction of the plumb line is deflected to the west of the corresponding normal. The length of the arc between the apparent zenith points is consequently diminished, and must therefore be less than the length deduced from trigonometrical observations.

And so also under the Himalayas we find the same law appertaining, viz., that the crust of the earth has greater density under the plains than under the huge excrescences of nature towering over them, and the laws which govern such physical conditions have been mathematically elucidated in the theory of terrestial gravity.†

I allude to these subjects in India, as it is the region of great contrasts, so it affords most apt illustrations. It is a region wherein we see enormous wealth in the few; most sordid poverty in the many. To a colony like this, it presents an aspect in which there is almost no analogy, and as principles permeate from centre to extremes, so we find that, as affecting the particular theme of this paper, there is no exception. The most profound and refined

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* Report Indian Survey, 1872-3, page 15.

† Treatise by Archdeacon Pratt. "Phil. Trans.," London, 1871, p 338.

system of operations of survey in India go on concurrently, side by side, with the most rude and inaccurate. The former system, we need not say, is in the great triangulation; the latter, which may be known to few here, is the Khusrah survey, *i.e.*, in the "property" or "field measurements" of the native officials. And so general is this latter system, that if considered as applied to the wants of the population of India, it is the rule, not the exception. Nor can it be avoided. So much so is this the case that in government hand-books Khusrah survey has been admitted to authoritative description, together with modes of distributing its errors for fitting into the minor circuits of village areas. The error of Khusrah survey extends from three to seven per cent. of the area measured,* and no wonder. As I observed it 30 years ago, in the territory of Malacca, the native surveyor was seen to be armed with only a twisted rattan of one-quarter orlong (60 feet) in length, which expanded in drought and contracted in wet one to four feet. He had no compass. With this he measured the length and breadth of the rice grounds, and estimated and plotted the divisions without regard to irregularities of boundary; but in orchards and fruit plantations, in which this country excells, the operation was even more inaccurate, for here the Khusrah surveyor, or *penukur* as he was called, simply measured round the area, calculating and plotting the contents from the periphery, whether the shape was round, square, oblong, or polygonal. Hence the fertile crops of lawsuits and internecine wars between neighbours, for by measurement under this rude process it is evident when once obliterated there could be no authoritative re-establishment of boundaries by actual survey.

And while I mention this professionally humiliating state of things, I must guard myself against any assumption that this is the fault of the responsible heads of the survey department there. In so vast a population as the empire of India contains, the influence of the Europeans on the internal economy of native habits and associations is as a drop in a bucket. The native is jealous and tenacious of his own immemorial ways, hence amelioration can only be by slow degrees; and that simple yet effective improvements have been brought about in a primitive mode of survey, handed down from ages, since I left the country, I am also aware, though to what extent I am unable to say.

This leads me to the remarks that we often hear from the lips of Europeans, viz., how fond the natives are of litigation. Indeed, they add, so fond are they of this that they fight till the last inch of land has been parted with, nay more till they have pawned their jewels, wives, and children, stripping themselves of their household gods, till little remains. Now India while it is the land of contrast of condition, so also is it the land

* Report on Indian Surveys, 1872-3.

of *unsympathy*. The European only scans the surface, and he little knows the forces that act underneath. That there is powerful action though unseen has been often and too conspicuously proved. But were we to place Europeans under the same circumstances in relation to that we most prize, viz., our heritable lands, how would it be with us, with the rivers spreading over our fertile fields, the exuberant vegetation obscuring our pastures and hill plantations, so that the marks are obliterated, and with no mode of practical and legal settlement, would not litigation be rife, and bloody feuds also ? Then may not our unfavourable estimate of the Hindoo be harsh ?

But this paper is not intended as a discussion of social or political theories, so we must confine it to the narrow professional limits, and return to its subject. Here then in India we have a proof of (as it would be esteemed in New Zealand) an utterly worthless actual section survey authoritatively in operation alongside of geodetic operations of the highest class and refinement. And when we say so we may be asked how it affects the point under consideration ? The answer is in this wise, that it brings us to a conclusion contrary to popular notions, viz., that great triangulation does not guarantee correct actual survey, and it will be shown hereafter that it may even deteriorate it.

So much by way of preface. The rest of this paper will be devoted to an exposition of our views in relation to what should be the professional nature of standard colonial survey, in which the settlement of the people is the paramount object. *

At the outset of a Colonial survey it is of importance that the principles of the standard branch, should be at once determined on, and in this determination it must be considered how far professional bias must give way to the immediate wants of the settlers. If a mode of operations can be devised that administers to these wants without involving actual—*i.e.*, recognisable practical error, it is my opinion that it would be well to accept this.

The basis of all trustworthy settlement or section survey is triangulation, of which there are three distinct systems, namely—primary, secondary, and tertiary. When I first took service in New Zealand I had the honour to advise the Government of Otago on this point, and I then suggested that primary triangulation, were it commenced in the Colony, must be executed by the General Government. † But I indicated no time when this should commence, my responsibilities being limited at that time to the Southern Province.

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* See my letter dated June 9th, 1856, to the Superintendent of Otago.

† Where contrary to the state of India above depicted our position is one of close sympathy with the people, who come here to seek new homes and settle themselves.

Since then another officer has suggested primary triangulation.* There can be no question of its high value when properly executed, as by it alone geodetic or globe-form problems can be independently solved; but this value must be taken in a purely scientific sense. And the two inferior systems, though not claiming to do work in this category, may yet be of value otherwise not to be exceeded, being trustworthy within the requirements of Colonial survey operations.

The cost of primary triangulation is £1 11s. 9d. per square mile, †; that of secondary, £1 7s. 9d.‡ Now, as the area of New Zealand is 102,000 square miles, the cost of each for the whole Colony respectively will be £161,925 and £141,525, or complete, as designed, £303,450. I mention the two together, because if primary triangulation be decided on, secondary is also absolutely necessary. Taking the experience of the British Islands, the time required to complete the same would be 75 years. § Thus, were the cost alone not sufficient to deter their introduction as a standard, their tardiness would. Settlers and land purchasers with their families could not wait four or five, not to mention 37½, years till placed in possession of their homes and title deeds.

It has certainly been suggested that actual section survey might go on in advance of triangulation by setting out the work in "approximate meridians," and substituting "rough diagrams" for properly finished plans before standard observations are made and *reduced*. || But as the time suggested by the proposer of eight or ten years, under which the observations of the primary, secondary, and tertiary triangulations might be *reduced*, appears to me to be much under estimated, I turn to the highest authority on these subjects, and under whose charge are the largest trigonometrical operations of modern times. Colonel Walker, Superintendent of the Great Trigonometrical Survey of India, under date 1st December, 1870, remarks as follows¶:—"It is obvious that every operation of a survey must necessarily be fallible, and therefore that all newly obtained facts of observation that are susceptible of being combined with those that have been previously acquired are liable to disturb the results which were previously arrived at. Every additional base line, and every new chain of triangles, must necessarily exercise some influence on operations generally, and more particularly

* Palmer.—N.Z. Parl. papers, 1875, H.I. p. 22.

† Average of eleven districts in British India. Markham, l. c. page 292.

‡ Major Triangulation of Otago Block, 1857.

§ Triangulation of British Islands commenced in 1784, and finished in 1874; area 122,000 square miles.

|| Palmer.—l. c. page 25.

¶ "Great Trigonometrical Survey of India," Vol. I., Preface.

on those in their immediate neighbourhood. Thus, therefore, before triangulation could be *finally reduced*, and all its parts harmonised, it is necessary either that the whole of the angular and of the linear measurements shall be completed, or that they shall have so nearly approached completion, that what remains to be done may hereafter be fitted with what has already been done without any serious violation of principle. It is only of late years that the operations of the survey have been sufficiently advanced towards completion to justify the commencement of the final *reductions*. These reductions, however, are now being proceeded with, and the time has arrived when publication may be commenced."

I may add that when the above remarks were made, the primary and secondary triangulations of India had not been eight or ten years in operation, but 71 * ; and lately, during many years, employing 80 officers, with their staffs, at an annual cost of £70,000. † To those having local experience it will be evident that till these *reductions* have been made no titles or Crown grants, based on "rough diagrams" and "approximate meridians," could safely issue. This delay, we know, would not be borne by the people and their representatives for one year, much less eight, ten, or 71 years. But to the local surveyor it will also be apparent that such an accumulation of "rough diagrams" and "approximate" bearings in the records of so large an establishment as the General Survey Department of New Zealand would amount to a vast perpetuation of the evils which it is now the object of the Government to prevent.

It is necessary here to remark that primary triangulation as applied to colonial settlement survey can scarcely be considered even as an experiment. It was attempted in Australia, but had to be discontinued, owing to its cost and tardiness. ‡ In no other part of the British dominions, nor in the United States of America, has it been applied as a concurrent and ruling process with or over settlement survey, and in regard to actual survey all that can be said of it is this, that in old, long-settled and wealthy countries, by "breaking down" the triangles it has been available in controlling the chain measurements of properties and estates, whose boundaries having been long built or fenced needed no haste for their delineation. Here the contrary is the case, for no sooner does an immigrant settler pay for his land than he expects possession and titles.

The only question of importance then that remains is this—do primary and secondary triangulation secure superior correctness in section survey? This question must be answered in the negative, as we know from actual

* Markham, l. c. page 292.

† Report on Indian Surveys, 1871-2.

‡ Report General Survey of Victoria, 1859-60.

experience. Thus the section survey in the southern portion of this colony has been proved by mathematical reduction to a general accuracy of within two to three links per mile, * while the average error of the surveys of British India, where ruled by primary triangulation, is twelve links per mile, † and the information that I have obtained directly from officers connected with the Ordnance Survey of England shows the error there to vary from three to fourteen links per mile. Nor is the cause of this far to seek. It lies in the fact that inordinate care and estimation of the refinements of observation re-act disadvantageously in the practical work. It reduces the status and respectability of the section surveyor, whose office, however despised and unimportant in England or India, is all important here. Hence the higher accuracy of our actual survey is due to the better class of officers employed.

But while I say so much at present, it is not to be understood that I oppose primary triangulation for all time to come; as the wealth of the colony increases, as learned classes arise, as knowledge becomes a pursuit for its own sake, as learning advances in our universities, and as our scientific societies grow in strength, the subtle and profound problems that primary triangulation elucidates will then be usefully and intelligently studied. Further, in support of this the legislature may be fairly asked to vote the cost of a staff of specially trained officers and assistants. ‡

To make myself fully understood on this subject, I may state that the main object of the promoters of primary triangulation in Europe and elsewhere is to ascertain the figure, dimensions, and specific gravity of the earth, as stated before. With these investigations, in course of time other physical problems and modes of observation have become associated, so that in these modern days the system would be held to be incomplete were they omitted. Thus originally, with the primary triangulation on a meridian, the zenith sector almost alone was had recourse to for astronomical comparison of differences of latitude. Now the electric telegraph is had recourse to for comparisons in differences in longitude. By this means abnormal conditions of the density of the earth, as indicated by pendulum operations, have been explained, and certain curious anomalies of the constitution of the solid crust of the earth have been submitted to mathemati-

* Exposition of Otago Surveys, p. 16. J. T. Thomson, C.E., F.R.G.S., Dunedin, 1875.

† Report on Surveys of British India, 1871-72, p. 35.

‡ The State of Massachusetts, the best settled in the United States, having been occupied since the year 1620, now moves for a primary triangulation, but only on purely scientific grounds. This is due to the influence of the wealth and intellectual pre-eminence of society in that state. See "*North American Review*," July, 1875. The Federal Government of the United States has allowed a coast primary triangulation to drag its slow course for 25 years under great difficulties.—J. T. T.

cal test in the theory of terrestial gravity.* Abnormal states of surface curvature have also been detected, and a consequent aberration from the true zenith. With these investigations extremely delicate levelling operations are carried on by which minute rise and falls in the elevation of land are made apparent—the laws of delta depositions, are also effectively elucidated. Again, tidal observations have careful and continuous attention, whereby not only the general laws that govern these undulations on the surface of the ocean are explained but all local phenomena that are connected therewith. Then also magnetic declination shares a large degree of attention in its hourly, diurnal, and annual motions. With declination is also observed the dip of the needle and magnetic intensity in different localities and latitudes. Meteorological observations are made at different elevations, etc. These minute subtle analyses of physical questions (of which the above is the merest abstract) are modern adjuncts to pure geodetic or globeform surveys, of which the basis is primary triangulation.

To propose to undertake the above system of survey, with its great prolongation of time, in this distant part of the world as a basis of settlement operations, no doubt carries a certain degree of *éclât*, but when practical considerations are fairly stated as I have endeavored to do, unsurmountable difficulties will be seen to stand in the way. I take it for granted then that it will be admitted that such slow and elaborate operations had better be deferred till society has grown apace, when great or primary triangulation may be undertaken, not in a perfunctory manner, which would be its necessary character at this present time, but completely and with credit to the promoters.

Hence I would advise that in the New Zealand General Survey staff only two or three officers devote themselves to purely scientific observations, such as are absolutely necessary for ruling that standard work which connects the actual with the geographical. Thus the whole force of the department, with the above exception, can be given to the immediate settlement of the inflowing people, securing, by the practical system we adopt, their boundaries and titles.

For the above reasons, and at this present period, I do not recommend the commencement of primary or great triangulation. What, then, is to be done? I reiterate that triangulation is necessary for checking section or settlement survey. For this purpose minor or tertiary triangulation cannot be dispensed with, as it alone affords points at sufficiently close distances. Hence the next question arises: Does it suffice of itself as a connecting link between the geographical and actual operations? The answer is, No.

* "Philosophical Transactions," London, 1871, and Report Indian Surveys, 1871-72, p. 20.

What, then, is to rule it? There are two systems which may effect this purpose, viz.—major triangulation or meridional circuit survey; and here again comes a stage of operations in which judgment must be exercised. It is a stage in which many circumstances must be considered, but the principal consist—1st, in the natural and very proper professional bias of the surveyor to aim at the refinements of observation;—this involves time and cost; and, 2nd, in the necessities of the settler to get possession of his land purchase, so that he may quickly build a house for his family. These two tendencies are evidently not in harmony, but quite the contrary; so, to meet the wants of the settler a line of concession must here again be devised by the surveyor which does not involve practical error.

As there can be no question as to the necessity of placing the immigrant in his home as quickly as possible, the only considerations, then, that we may here discuss are the relative accuracy, cost, and despatch of the two systems of standard surveys above named. On the subject of accuracy there is considerable room for differences of opinion, which I will notice as shortly as possible. Instances of the error attached to major triangulation, executed with 8 and 10-inch theodolites in New Zealand, are given at 12 inches, * 6½ to 14½ inches, * while errors attached to minor triangulation, executed with 5-inch theodolites, have been found to vary from half a link to six links per mile; but the average error, by crucial test, has been proved to be not exceeding two links per mile. † Again we have a notable example in Mr. Connell's minor triangulation of the Lake District, in Middle Island, carried over a large expanse of mountainous country, of work closing within an error of 4⅓ inches per mile. ‡ Thus, under somewhat incongruous testimony, we may fairly conclude that major triangulation may be admitted to have an error of one link to the mile attached to it, while minor triangulation has two links. Now, the object of stating this opinion is to enable us to compare the relative accuracy of major triangulation and meridional circuit, as the latter for its distances is dependent on minor triangulation, though its bearings are taken by the 8 and 10-inch theodolites used in major triangulation. Thus the comparison brings out this main fact, that, in bearings, the accuracy of the two systems is equal; but, in distances, one has the advantage in accuracy of less than one link per mile. Does this invalidate the meridional circuit system in the purposes of Colonial survey. I say, No. It is amply accurate for checking actual or section survey; so where the interest and comfort of the immigrant settlers require despatch it may be freely had recourse to by the surveyor in perfect confidence that it

* Palmer—l. c. p. 5 and 9.

† Thomson.—l. c. p. 15.

‡ "Trans. N.Z. Inst.," Vol. VIII.—Appendix, p. 31.

will work out the problem of settlement survey correctly to the end. Thus a surveyor may professionally concede to the wants of the settler so far. I may also here, in addition, state this circumstance: that in standard survey true bearing is of more importance than distance, errors in the former not being eliminated till the boundaries of circuits are reached, while errors in distance are eliminated at boundaries of survey districts, which are limited to twelve miles square.

We next come to the relative cost. That of major triangulation, being affected by the nature of the country, has been variously stated, but we quote the following;—In Otago, 540 square miles cost £759, or £1 7s. 9d. per square mile, or about ½d. per acre.* In Auckland and Wellington, 1,019,600 acres cost £2,400, or $\frac{56}{100}$ of a penny per acre. † Other work of a similar nature has been estimated at a rate more or less, but we may accept these as the average in accessible country.

The cost of meridional circuit survey is obtained from the operations executed by Mr. McKerrow, now chief surveyor of Otago, which covered 12,000,000 acres of territory, at a cost of £3,500; that is 3s. 6½d. per square mile, or $\frac{1}{15}$ of a penny per acre. Thus the relative cost of major triangulation and meridional circuit is ·53d. to ·066d. or as 8 to 1 nearly. ‡ Now as cost means money and money means time, it is evident that the despatch or rapidity of meridional circuit standard survey is eight times greater than those of major triangulation. Hence its advantage in meeting the responsibilities of Government in their relations to the wants of outlying and dispersed settlers, now spreading themselves over all parts of the colony. With the immense amount of onus now on the Government to have recourse to it is not a political only but an absolute necessity. §

With these facts before us, then, we arrive at this opinion, that having abandoned primary triangulation, and secondary or major triangulation having a slight advantage (but in a professional point of view only) over meridional circuit, *it should be had recourse to in carrying out the standard survey when circumstances will permit this.* Hence in the revisal of all untrustworthy sectional work, of which there are 11,095,287 acres in the colony,|| major triangulation on carefully measured bases should be had recourse to,

* Major Triangulation, Otago Block, 1857.

† Report of Inspector of Surveys, 28th May, 1875.

‡ The cost for the whole colony will be as £141,525 to £18,062 also respectively.

§ This is the practical question in all parts of the colony. Can an immigrant settler wait eight years to get possession when he can be placed in one year by the Otago standard system of survey?

|| Palmer.—l. c. p. 28. Section surveys, 6,405,500; Native do, 4,689,787. Total, 11,095,287.

for here the areas being for the most part already settled and divided by fences, little inconvenience owing to delay can be felt by the population. Otherwise also where haste is not imperative the same system should be adopted.

It now remains for me to briefly express my views in relation to the process that may take the place of primary triangulation. These are in no way altered since I stated them fifteen years ago. * In the geographical branch the only vital argument in favour of primary triangulation was the difficulty of obtaining differences of longitude. With the introduction of the electric telegraph into the colony this has entirely disappeared. So completely is this the case that excepting for close distances the latter has an immense superiority in accuracy. Thus in the Trans-Atlantic longitude determined by the United States Coast Survey the longitude of Harvard Observatory (America) from Greenwich Observatory was found by three separate routes and sub-marine cables to this degree of exactness—

	h. m. s.	
1867	4 43 31·00	Greatest error 0″·06, or 0″·9 of arc equal to 64·8 feet.
1870	4 44 31·05	
1872	4 44 30·96	
† Mean	4 44 31·01	

As the colony through the extension of the electric telegraph is now in a position to ascertain differences of longitude, in the same manner and with exactness relative to the size of instruments within our reach, and we may rely with perfect confidence on this system for establishing what has hitherto been the most difficult problem of geography. Hence the transit instrument and telegraph will establish our longitudes; the zenith sector our latitudes, on which at certain points the standard survey will close. This geographically binds all the processes together and completes the system.

Art. IX.—*The Building Materials of Otago.* By William N. Blair, C.E.

[Read before the Otago Institute 5th September, 1876.]

Limes, Cements, and Aggregates.

Properties of Cementing Materials.

Before proceeding to treat in detail the native productions, it is necessary to consider the properties of limes and cements generally. In doing so, I should begin by stating that the terms "Lime" and "Cement," although always used to denote different and distinct articles, are appli-

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* Outline of Colonial Survey, 1861, p. 5.

† "Electric Telegraph Journal," London, Oct. 15, 1873.

cable to either of them. The cementing ingredients are the same in both cases, the only difference being in the proportions in which they occur. Pure lime is practically worthless for building purposes; it never acquires the necessary cohesive strength in any situation, and never hardens at all in a damp place. In order to make good mortar the limestone must contain a mixture of clay—the proportion varies from 8 per cent. in ordinary building lime to 35 per cent. in strong hydraulic cement. If it were necessary to have a clear dividing line between limes and cements, the best place to strike it would be at the neutral point where the adhesive and cohesive forces are equal. The particles of rich and moderately hydraulic limes adhere more readily to a foreign substance than to each other, but the conditions are reversed with strong hydraulic limes and cements. This gives the only tangible difference I can imagine between the two articles, but as it does not admit of a practical application, the distinction would only be valuable from a scientific point of view.

Limes and cements are usually divided into four classes, according to their properties and strength—

1st. *The Common or Rich Limes* that contain less than 10 per cent. of clay or other impurities.

2nd. *Poor Limes*, in which the impurities consist of from 10 to 25 per cent. of sand or other insoluble ingredients that will not enter into chemical combination with the lime.

3rd. *Hydraulic Limes,* such as contain from 10 to 30 per cent. of alumina and soluble silica.

4th. *Hydraulic Cements,* containing from 30 to 40 per cent. of alumina, soluble silica, and other impurities.

In addition to the ingredients named, each of the above classes frequently contains small quantities of iron, manganese, magnesia, potash or soda, with sulphuric and other acids, which do not seem to have an injurious effect on the cementitious properties of the article; on the contrary, some of them, such as iron and soda and some of the acids, are always present in the best cements;—the quantity, however, of all foreign substances, except silica and alumina, seldom exceeds 5 per cent. We may therefore assume, shortly, that our mortars are simply lime and clay in varying proportions.

As already stated, the common or rich limes are comparatively useless where strength is required, and absolutely worthless in a damp situation. They are easily burned and slaked, swell to a great extent in slaking, shrink in drying, and are soluble in water when set. Their adhesive properties are stronger than their cohesive ones, consequently they cannot be used without a large admixture of sand. It is common to hear the expression that mortar is injured by too much sand, but the chances are that its bad qualities are the result of the opposite condition, and, above all that, the sand and lime are not properly mixed. If greater care was exercised in this behoof, so that an approach could be made to the theoretical maximum of an atom of sand between each atom of lime, the result would be an immediate doubling of the strength of rich lime mortar.

Poor Limes possess all the bad qualities of the rich ones, and have an additional drawback in irregularity of consistency through not slaking so readily, which necessitates grinding.

Hydraulic Limes are frequently sub-divided into three or four sections, ranging from *slightly* to *eminently* hydraulic, the former being practically a rich lime, and the latter a cement. These limes do not slake readily, nor do they expand much in the process. The higher kinds slake so slowly and so imperfectly that they are always pulverized by grinding. Hydraulic limes set under water in from three to fourteen days, according to the strength of the sample.

Hydraulic Cements cannot be slaked by water in the usual way; they are, properly speaking, not calcined, but vitrified. The produce of the kilns resembles slag from a blast furnace, and it requires the aid of stone-breakers, iron rollers, and French burr mill-stones to convert it into the cement of commerce. In common with the higher kinds of hydraulic lime, cement does not require any admixture of sand to make it into mortar; the maximum strength is obtained by using it in a pure state. Some hydraulic cements set under water in a few minutes, but the best kinds take a few hours. In seven days the latter attain a tensile strength of 250 pounds to the square inch.

The quality of limestones cannot be determined by a knowledge of the geological formation in which they occur, nor by their general appearance. Hydraulic limes are perhaps more plentiful in what may be called the mediæval rocks—cretaceous to carboniferous—than in any others; but, as they are frequently met with in the formations above and below those named, we may give them an almost universal range of locality. The character of the stone seems to be determined chiefly by its immediate surroundings—the outer beds are argillaceous or silicious, according as the adjoining stratum is clay or sand, and the whole rock is influenced by the manner in which it was deposited, and the subsequent changes to which it was subjected. If the lime had been deposited in still, clean water on a rocky bottom, and had attained a considerable degree of hardness before being disturbed by convulsions from below, or pressure from above, we might expect it to be comparatively pure; but if deposited in an estuary where the water is muddy and the bottom soft, and where floods leave occasional beds of silt and sand, the stone cannot fail to contain impurities. Even after the deposit has taken place the stone may be altered by mechanical and chemical agencies, there being a peculiar relationship between the lime and clay in hydraulic limestone that seems to be easily affected by external causes. A good illustration of the influence of its surroundings on the character of the stone is found at Mr. Macdonald's quarries, Otago Peninsula. The rock is much shattered, and divided into large blocks by "backs" running through it in all directions. The blocks in one of the beds produce two distinct varieties of stone, the analyses of which are given in. Nos. 13 and 15, Table III. The light-coloured stone occupes from two to three feet of the outside of the block, and gradually merges into the dark one which composes the heart;—they vary little in consistency, but, as will be seen from the table, there is a great difference in their composition. Assuming the block was originally homogeneous, of which there can be little doubt, we find that the crust has lost 4 per cent. of carbonate of lime and 2¼ per cent. of carbonate of magnesia, while, on the other hand, it has gained 2 per cent. of iron in addition to the increased percentage of silica and alumina due to the abstraction of the lime and magnesia.

Hydraulic limestones are generally compact in texture and dark in colour, grey, blue, drab, or brown being the prevailing colours; white indicates pure lime. It does not, however, follow that all the dark-coloured limestones are hydraulic, for they may contain sand and other insoluble matters that neutralize the effect of the clay; and the darkest of all limestones—black marble—is almost pure carbonate of lime. Still, a rule may be established in a negative manner by saying that no white limestones produce hydraulic lime.

Notwithstanding the advance made in all the practical sciences within the last few years, there is still a doubt as to the causes that produce the setting and hardening of lime and cement mortar. The old theory was that all mortars hardened by the absorption of carbonic acid from the atmosphere, and it was supposed that in time the quantity absorbed would equal that expelled in burning, so that the mortar would revert to its original carbonate, and become again a limestone. It is true that rich limes will not set without carbonic acid. The mortar in the inside of a bastion at Strasbourg was found, after 160 years, to be quite soft, and the same thing was observed in a masonry pillar, nine feet in diameter, at St. Peter's, Berlin, its age being 80 years. It has also been found by experiment that a mortar of rich lime will not set in the exhausted receiver of an air pump. But carbonic acid alone will not perfect the hardening process, consequently it is supposed to be assisted by the crystallization of the carbonate of lime between and around the particles of the aggregates.

Without such extraneous aid it is difficult to account for the hardening of mortar in thick walls. The operation proceeds from the outside, consequently every advance made is a barrier to the next in so much that it excludes the air from the softer mortar inside. There is every reason to believe that hydrate of lime, when exposed to the atmosphere, will revert to its original carbonate; but the process is such a slow one that it may be almost classed with the geological epochs. The oldest mortar in the world, that from a Phœnecian temple in Cyprus, is still far short of the ingredients it possessed when a limestone.

The induration of hydraulic mortars is attributable in a small degree to the same causes as affect the rich ones, but principally to the formation and crystallization of complex silicates of lime and alumina, the precise nature of which is imperfectly understood. It is quite evident that the absorption of carbonic acid has very little to do with the setting of hydraulic mortar, for against its slow action already noticed we have the fact that large blocks of cement concrete harden uniformly to the consistency of stone in a few months under water, which proves that the setting property is inherent, and not the result of external influences.

The treatment they receive in burning has a considerable effect on the quality of limes and cements of all kinds, but more particularly on those that are only moderately hydraulic. Under burning has been known to impart a spurious hydraulicity to rich limes, and over burning occasionally destroys that property in cement, but as a rule there is little trouble in obtaining maximum results with these extreme classes. The burning of hydraulic limes is a much more delicate operation, the niceties of which can only be acquired by long experience in the art generally, and considerable practice with the actual materials that are to be operated on.

As already indicated, the ordinary aggregates are essential to the induration of rich limes, but in the higher hydraulic varieties and in cement they are simply diluents. As rich limes do not possess the faculty of expelling any excess of moisture with which they are in contact, it is advisable to employ a porous aggregate, such as the sands produced by aluminous and calcareous rock, but when the aggregate is only employed to weaken the mortar by making it go further, there is little danger in using hard silicious sand, provided it is free from earthy impurities; indeed, this is an indispensible condition in all aggregates. It has been ascertained by experiment that the best proportion of sand for rich limes is 2½ to 1, and for ordinary hydraulic limes 1¾ to 1. This explains the partiality of builders to rich limes. It will, in their own phraseology, "carry more sand," which means that strength and comfort are sacrificed for an insignificant saving in cost.

In order to institute a comparison between the various articles under discussion, I give the following table of tensile strength per square inch in pounds on limes, cement, and mortar one year old.

Cement and Limes neat.

Portland cement	500 pounds
Roman "	185 "
Good hydraulic lime	170 "
Ordinary " "	120 "
Rich lime	40 "

Mortars.

Portland cement with 1 of sand	310 pounds
" " " 2 "	205 "
" " " 3 "	140 "
" " " 4 "	100 "
" " " 5 "	50 "
Good hydraulic mortar	140 "
Ordinary " "	85 "
Good mortar of rich limes	50 "
Bad " " "	20 "

Geographical Distribution.

It was shown in a former paper that limestone as a geological formation occupies an immense area of Otago, but it does not follow that the supply of lime for industrial purposes is equally extensive, many of the calcareous rocks being incapable of producing lime of good quality. There is, however, no scarcity of lime suitable for building and agricultural purposes throughout the province. It is known to exist in considerable quantities in the following districts:—Oamaru, Otepopo, Waihemo, Maniototo Plains, Waikouaiti, Lower Harbour, Peninsula, Waihola, Waimea, Winton, Aparima, Waiau, and Wakatipu. These localities are so widely dispersed that we may safely calculate on a supply being available for any demand that can arise.

The only natural cement hitherto discovered in Otago is the well-known Septaria or cement boulders of the Moeraki district, which resemble in every respect the English stones from which Roman cement was originally manufactured. According to Dr. Haast, the boulders follow the coast from Shag Point to the Terapupu Creek, then run in a straight line to the Little Kiwi Creek, which is struck at a point about half a mile from the sea. In the first four miles the deposit is a mere line of boulders lying on the beach or imbedded in the cliffs, but on leaving the coast it expands into a belt from 20 to 30 chains wide and 5½ miles long.

Many of the volcanic clays that exist in such profusion along the sea board from Saddle Hill to Oamaru possess cementitious properties similar to the Pozzuolanas of Italy and the Tyrass of the Rhine, but as they are only used in combination with lime, they will be considered along with the other aggregates, or as a component part of artificial cements.

The aggregates proper consist of shingle, gravel, and sand, which have an almost universal distribution throughout the province.

Tables of Analyses.

The subjoined tables Nos. I. to IV. give the analyses of the principal lime and cement stones hitherto discovered in Otago, together with English and foreign types. They are arranged into the four classes already referred to, viz., 1st, Rich Limes; 2nd, Poor Limes; 3rd, Hydraulic Limes; and 4th, Cements. A large number of the analyses of Otago stones are from the Jurors' Report of the New Zealand Exhibition and the publications of the Colonial Museum, but all the recent ones are by Professor Black, to whom I am very much indebted for assistance in investigating this subject. Under his direction fifteen analyses of limestones and clays were made specially for the purpose of this paper by Mr. P. S. Hay, B.A. These analyses were done with great care and accuracy, and in the most exhaustive manner, consequently they form a valuable contribution to our information on one of the most important colonial resources.

Rich Limes.

The English and foreign types given in Table I. comprise eight examples that range in purity from statuary marble, a pure carbonate of lime, to the carboniferous limestone of Whiteford in Wales, that has ten per cent. of impurities. It will be observed that ordinary white chalk approaches next to marble in purity, it only contains ½ per cent. of foreign ingredients.

Analyses are given of fifteen Otago limestones that furnish rich limes, which shall now be considered seriatim.

No. 9 is a white, compact, crystalline stone from Southland, locality unknown, probably Winton. Its constituents are 98·80 per cent. of carbonate of lime, and 1·20 per cent. of soluble silica. It is thus entirely worthless as a cementing material.

No. 10. A compact crystalline stone of faint yellow colour from Winton, evidently closely allied in all its essential properties to the preceding one, and equally deficient in cementitious qualities. I believe that these two specimens are fair samples of the stone in the vicinity of Lime Hills, Winton, of which there are about 1000 acres.

No. 11. Fossiliferous, compact, and very hard stone of a dirty yellow colour, from Kakanui. This specimen was analyzed by Professor Black for Mr. Cairns. It contains 98 per cent. ot carbonate of lime and magnesia, and 1½ per cent of sand, consequently must be placed in the same category as the Southland limes. The stone is burned extensively for building purposes, so I am sure the houses in which it is used cannot be very dry.

No. 12. Yellow fossiliferous stone from the Oamaru district, the precise locality unknown. It is referred to by Dr. Hector as a stone largely employed by Mr. Hutcheson for burning into lime. From the analysis and description given it must be closely allied to the preceding specimen.

No. 13. Soft fossiliferous stone from the eastern side of Waihola Gorge, white in colour, granular in texture, and very absorbent. This is not so abundant nor so much used as the hard variety No. 16.

No. 14. Yellow lithographic stone from the Oamaru district. It has all the external appearances of a lithographic stone, but does not exist in large quantities; it is found associated in the same rocks with No. 12.

No. 15. Grey and yellow travertine limestone of a porous texture from the Dunstan Gorge. This stone, which is sometimes called calcareous spar, is formed by the deposition of lime held in solution in the water of streams and springs. The water acquires the lime in flowing over or through rocks containing this mineral, and it is deposited in concretionary masses on the banks. Travertine is found in the small creeks that flow into the Clutha and Kawarau rivers between Clyde and the Shotover. This stone was first burned for lime in 1864, when it was used in the masonry of the Gentle Annie Bridge.

No. 16. White, compact, and very hard stone from Waihola. This is the stone from which the well-known Waihola lime is produced. It exists in large quantities in available positions on both sides of the gorge through which the railway runs. The rock is very much shattered and dislocated, few of the horizontal joints being more than six inches apart. This facilitates quarrying and breaking, and to some extent balances the excessive hardness, which otherwise would be a great barrier to cheap working. I regret that the Waihola limestone cannot be pronounced good, as, from its favourable situation, it would be an immense boon to Dunedin and the surrounding districts. The limestone contains 94½ per cent. of carbonate of lime, which is decidedly too rich for building in a damp situation, or where strength is required. This, and analysis No. 13, by Dr. Hector, are copied from an old advertisement of Dr. Croft's; they refer to specimens taken from the eastern side of the gorge, but I believe the stone now used, on the western side, is equally pure with No. 16. Indeed, it was lately stated in the papers that it contained 98 per cent. of carbonate of lime, which, if correct, makes the matter still worse.

No. 17. Grey granular stone from Oamaru, found in the same locality as Nos. 12 and 14. It contains 2½ per cent. less carbonate of lime than the former, and is therefore so much better in quality.

No. 18. Bluish-grey compact stone from Dowling Bay. This is a sample from the top seam. Although a rich lime it contains small quantities of all the ingredients that give hydraulicity with little sand, consequently it will make fair mortar for ordinary work in a dry situation. It forms one of five beds of limestone that occur at Dowling Bay, Lower Harbour, the particulars of which will be given further on.

No. 19. Fawn colored, incoherent, and absorbent stone from Aparima, in Southland. It contains 92 per cent. of carbonate of lime, and 5½ per cent. of insoluble matter, the precise nature of which is not stated. As the chances are that this is not all sand, we may pronounce the sample a good lime of its class.

No. 20. Compact grey stone from Fews Creek, Lake Wakatipu. According to the analysis, this sample contains 4½ per cent. of insoluble matter not detailed out, but Dr. Hector says that this consists of black sand, iron pyrites, and bituminous matter, in which case the quantity of sand must be inappreciable. The stone will yield lime suitable for ordinary building purposes in the dry atmosphere of the Lake district in which it occurs. Another specimen of stone from this locality was analyzed by Professor Black, with the results given in item No. 16, Table II. It contains 12½ per cent. of sand, so I had no hesitation in putting it in the class of poor limes. There is nothing strange in the discrepancy between the two analyses. They may both be correct, although the samples had been collected within a few feet of each other. Impure limestone deposits all over the world have the same character of irregularity in composition between the various strata. The difference may therefore be accepted as a favourable indication of the quality of the Wakatipu limestone. In all probability the intermediate beds will produce strong hydraulic limes. In his "Geology of Otago," Captain Hutton estimates the thickness of the calcareous deposits in the vicinity of Fews Creek at 600 feet, and reports the existence of similar rock at Afton Burn, on the west side of the lake, and at Stoney Creek, on the Upper Shotover.

No. 21. Bluish compact stone from the Horse Range. This stone belongs to the higher class of crystalline limestones, such as partake of the character of marbles; indeed, it merges into true marble in many places. The deposit occupies a large area of the western side of the range, near Palmerston, in accessible situations for working. With proper treatment this stone would yield a lime suitable for the ordinary purposes of the house builder. The analysis shows a deficiency of alumina, which indicates slow setting, but its ultimate induration is not thereby affected.

No. 22. Grey shelly limestone from Southland, locality unknown. Although the analysis is not complete, it shows this to be a very good lime of its class, probably the best hitherto discovered in Southland.

No. 23. White granular stone from the Oamaru district. This is the well-known building stone. So far as can be judged from the analysis, it would furnish a much better lime for building purposes than the stone usually burned in the locality.

Poor Limes.

Table II., which gives the analyses of two foreign and nineteen Otago stones that furnish poor limes, is introduced more for the purpose of showing those that are to be avoided than as a basis for the consideration of their properties. It will be observed that with the exception of No. 16 from Wakatipu, all the stones contain upwards of 20 per cent. of silica in the form of sand, consequently their character as poor limes is fully established. The great majority of the samples are from what may be termed the Caversham stones, varieties of which occur at Waihemo, Waikouaiti, Upper Harbour, and Kaikorai. No. 12 is a portion of a Moeraki boulder analyzed by Professor Black, and found to contain 21·00 per cent. of sand. No. 18 is the grey building stone that overlies the white limestone on the eastern side of Waihola Gorge. Although objectionable in a cementing material, the excess of sand is an advantage when the stone is used for building purposes. It is worthy of note that instead of being black as might be expected from the appearance of the stone, the sand it contains is found to be pure white. No. 16 above mentioned is a compact dark stone from the same locality as No. 20 in the class of rich limes. It has been referred to at some length in considering the properties of the latter, but I might add that possibly the presence of 12½ per cent. of sand is not sufficient to neutralize the other good qualities. If it were entirely absent the composition of the stone would resemble that of the English ones, which yield quick setting Roman cement.

Hydraulic Limes.

I now come to the consideration of the most important branch of my subject, that of hydraulic limes, and in doing so you should be reminded that its importance does not arise from the simple fact that the lime has the faculty of hardening under water. That is mainly useful in being the test by which the character of the material is established. In displaying this property we know that it is an hydraulic lime, and as such possesses a certain degree of strength and certain powers of resisting moisture, which render it infinitely superior to the richer sorts. Even now, when the manufacture of Portland cement has reached a high stage of perfection, we find the blue Lias limes of England used in the Liverpool docks, and on the other hand no building of any pretentions to stability or comfort is erected with common or rich mortars. Hydraulic lime is therefore more capable of universal adaptation than any other cementing material we possess.

Table III. gives the analyses of three English and seven foreign limestones that yield hydraulic limes of varying strength. The former are from the blue Lias limestones, an extensive geological formation that extends diagonally across England from Dorset to York. They are undoubtedly the best in the Old Country, and have been extensively used in all the principal engineering works there. The Eddystone and Bell Rock lighthouses were built with a mortar of Aberthaw lime (No. 2) and Pozzuolana. The blue Lias lime of Lyme Regis (No. 5) was used in the London docks, and that from Holywell (No. 10) is still preferred to cement at the Mersey docks, Liverpool, where it is made into mortar with two of sand and one-third of smithy ashes. Recent experiments show that this mixture is only a tenth weaker than Portland cement mortar made with three parts of sand, which is the usual proportion for similar work. Although not shown directly by the analysis, Professor Black calculates that the Holywell stone contains about nine per cent. of silica in the form of sand.

The best known of the foreign hydraulic limes in the table is the Theil stone from Ardíche, in France (No. 4). Perhaps there is no other hydraulic lime in the world that has been so much used in exposed marine works as this one. The harbour works at Algiers, Marseilles, and Port Said all bear testimony to its high character. It has been 20 years in the sea at Algiers without showing symptoms of deterioration; and Mons. Vicat, the great French authority, said that Thiel limestone was the only one he knew that would unquestionably yield a mortar indestructible in salt water. The cementitious properties of this lime have been subjected to a severe test at Port Said breakwater. It is used with fine sand in making large concrete blocks like those at Oamaru. Sand of this kind by itself is not a particularly good aggregate, and the blocks have to stand very rough treatment, as they are thrown into the sea, instead of being lowered gently by machinery. My apology for referring to these foreign materials at such a length is that we have hydraulic limes in Otago that are, so far as chemistry can determine, identical with them in all their essential properties. In fact there is no difference in the composition of the two articles, the discrepancy in the analysis being in all cases within the limit of error claimed by the best analytical chemists.

No. 11. Yellowish white conglomerate stone of a hard compact texture, found 3½ miles south of Oamaru. Dr. Hector's analysis is not quite exhaustive, as the soluble silica is not estimated. It is evident, however, there must be a certain quantity of that base in combination with the alumina, in which case we may assume the lime to be feebly or moderately hydraulic. I have no information as to the exact locality of this deposit, nor as to whether it is used for mortar, but I have no hesitation in pronouncing it the best lime for building purposes hitherto discovered in North Otago. It is very much superior to the lime in common use from the Kakanui kilns.

All the other Otago limestones in Table III. are from the Peninsula and Lower Harbour Districts; they seem to be members of one large deposit that extends from Seal Point, on the southern side of the Peninsula, to Dowling Bay, on the northern shore of the Lower Harbour. It is near the surface from the ridge south of Mr. Macdonald's kilns to the gully at Harbour Cone; appears again at the head of Hooper's Inlet, and for the last time on Mr. Dodson's property in Dowling Bay, right across the harbour. The breadth of this reef or dyke is unknown; probably it is not more than half a mile, and the aggregate thickness of the seams now visible is at least 70 feet. There are five or six distinct beds of varying quality and depth; as a rule they are well defined, particularly near the upper and lower sides, but occasionally more than one kind of stone is found in the same stratum. Mr. Macdonald, of the Peninsula kilns (the highest on the reef), only counts four beds, while Mr. Robertson, of the Glenmore kilns (which are situated on a much lower level), shows six tolerably distinct specimens from as many different layers. Two of them are, however, so thin that they can scarcely be called beds, and it is also quite possible that they exist in a less marked degree in the upper quarry. There are five well defined seams at Dowling Bay, four of which have been analyzed, viz. —one, two, three, and five, counting from the top. The fourth, which is 20 feet thick, was partially analyzed, but, being found to contain 28·13 per cent. of sand, it was useless to proceed further. Whether regarded as to structure, consistency, general appearance, or chemical composition, these Otago rocks exhibit all the peculiarities of hydraulic limestones of no mean order. Still, as the best authorities recommend a practical test also, I applied it, and the result is equally satisfactory. Mr. Macdonald, at my request, kindly burned samples of what I considered hydraulic stone. As was expected, the lime would not slake in the usual way, and it was pulverized by grinding in a chaff-cutter and sifting through a cloth. In consequence of other engagements I could not complete the experiments at that time, so the lime lay for eight months in a state of powder, which is not calculated to improve its setting properties. There happens to be a parcel of English blue Lias lime at present in Dunedin, so I tested it and the ordinary rich kind from Waihola along with the hydraulic sample from the Peninsula. All the three kinds were submitted to the same treatment and tested together. They were made into mortar neat, and with a mixture of two parts of sand; one set was left to dry in the air, and the other placed at once in water. So far as could be determined by mere inspection, the action of the indurating process was parallel in the English and Peninsula limes; perhaps it was a little more energetic in the former, but the difference, if it did exist at all, was scarcely perceptible. The wet samples of unmixed limes had expelled the surplus water they contained—which is what is technically known as having "set"—in three days, and in fourteen days they had acquired the consistency of soft bricks. The pure samples in air hardened without cracking, and were comparatively insoluble in water on the fourteenth day. On the other hand, the Waihola limes in water never set at all; they were softer on the fourteenth day than when immersed, the pure sample in the air cracked and crumbled in setting, and all the air samples were quite soluble. The above results, taken in connection with the chemical test, place this sample of the Peninsula limes in the class of eminently hydraulic, as fixed by the best authorities.

Nos. 12 and 13. Dark fawn, compact stone, analyzed respectively by Drs. Hector and Black, are evidently the same article; it occurs associated with No. 15 in the second highest bed at Macdonald's quarries. As will be seen from the table, this stone resembles closely the blue Lias of Aberthaw, in Wales, their essential constituents being as follows:—

	Aberthaw Stone.	Peninsula Stone.
Carbonate of lime	86·20	86·05
Clay	11·20	11·67

The Otago specimen has 2¼ per cent. magnesia in addition, but this is not a fault. Mr. Armstrong informs me that the dark Peninsula stone resembles in appearance the hydraulic limestone of Burdie House, in Midlothian.

No. 14. Drab granular stone from the lowest seam at Dowling Bay. This corresponds in quality with the second highest bed at the Glenmore quarries on the Peninsula, of which Professor Black made a partial analysis. It should yield a very good hydraulic lime, for although it may be somewhat deficient in the ingredients that ensure hydraulicity, it is absolutely free from those that are supposed to have a contrary effect.

No. 15. Fawn-coloured compact stone from the second highest stratum at the Peninsula kilns. The resemblance between this and the famous Theil limestone of France is very remarkable, as will be seen from the following abstract of their principal ingredients:—

	Theil.	Peninsula.
Carbonate of lime and magnesia	82·36	82·03
Clay	14·90	14·29
Oxide of iron	1·70	2·80

No. 16. Yellowish compact stone from Portobello, analyzed by Dr. Hector. The exact locality is not stated, but in all probability it is from the Peninsula or Glenmore quarries. A partial analysis by Professor Black of the lower seam at the latter place gives precisely the same quantity of carbonate of lime. The proprietor says that 22 feet of this bed has been laid bare without coming near the bottom. Although not shown in the table, there is little chance of much deleterious matter being in this stone. So it may be set down as capable of furnishing very good hydraulic lime.

Nos. 17 and 18. Specimens of compact stone from the top seam at Macdonalds and the third at Dowling Bay. Although somewhat different in colour, these stones are almost identical in composition, and, as will be seen from the following statement, they resemble closely the hydraulic limestones of Lyme Regis of the Dorsetshire Lias :—

	Lyme Regis Stone.	Peninsula Stone.	Dowling Bay Stone.
Carbonate of lime and magnesia	79·20	79·95	79·67
Clay	17·30	16·54	18·89

Nos. 19 and 20. Fawn-coloured stone from the third seam at Dowling Bay, and the lowest at the Peninsula quarries. These again are practically the same, and they find an English prototype in the blue Lias of Holywell. Judging from the analyses, the products of this bed might fairly be called cement stones. They are in the highest class of hydraulic limestones, and seem to have all the attributes of a natural Portland cement. Their points of resemblance to the English materials are shown in the following table :—

	Raw Material of Portland Cement	Holywell Stone.	Dowling Bay Stone.	Peninsula Stone.
Carbonate of lime and magnesia ..	69·87	72·90	71·20	71·72
Silica	20·54	20·10	19·18	18·85
Alumina	3·49	3·52	4·54	5·26
Iron	4·44	2·21	1·99	3·29
Insoluble in hot acids	—	25·27	23·70	22·80

But if we carry the comparison further, it will be seen that there is a still greater affinity between the English and colonial articles. There is less than ¼ per cent. difference between the quantities of magnesia in the Dowling Bay and Holywell stones, and only a tenth per cent. difference in oxide of iron between the latter and the Peninsula one. The seam of this stone at Dowling Bay is 20 feet thick, and there are also immense quantities on the Peninsula. The rock appears to be perfectly homogeneous, so there is little danger of irregularity in burning when once the proper temperature has been ascertained. If the qualities of this stone come up to my expectations, of which I have little fear, the value of the discovery to the community at large can scarcely be over-rated, and from the researches that have been made, I am confident any failure that may take place will result from improper manipulation, and not from a defect in the raw material.

Hydraulic Cements.

Hydraulic cements, the fourth and highest class of material in the scale, is poorly represented in Otago. The only specimen hitherto discovered is the Septaria of Moeraki, and this is very much inferior to the two hydraulic limestones last described. In fact, they should exchange places; properly speaking, the cement boulder is a limestone, and the limestone a cement rock. The present arrangement is adhered to simply because it corresponds with a time-honoured English custom. Although there are so few colonial articles to be described under this head, it does not follow that such will always be the case, I therefore give twelve analyses of English and foreign cements in the raw and manufactured states; they may be useful for reference in case further supplies of native cements are discovered. Septarian nodules or boulders have been used since the beginning of this century in the manufacture of Roman cement; they are found along the south and eastern coasts of England, from Weymouth to Lowestoft, and at several localities inland. There are also solid masses of similar stone at Harwick, in Suffolk, and Calderwood, in Lanarkshire. The Septarian boulders are well dispersed over the Continent of Europe, and cement rock occurs in France and the United States of America. That of Boulogne, in France, approaches next in quality to the artificial Portland cement; it is found in a thick stratum 160 feet below the Septarian beds, and is sufficiently soft to be excavated with pick and shovel.

There is comparatively little risk in manufacturing cement from a solid homogeneous stratum of the raw material, but it is almost impossible to get uniform results from Septaria; a glance at one of our Moeraki boulders is sufficient to demonstrate this. It will be seen that the core is almost pure lime, and the exterior of the ball nothing but clay, while in many cases the quantity of lime is equal in different sized boulders. Dr. Hector analyzed the whole mass of the nodule, including the calcareous veins, and found it to contain $72\frac{1}{2}$ per cent. of carbonate of lime, but freed from the veins the yield of lime was only 59 per cent. The stone in No. 13, Table IV., should furnish an eminently hydraulic lime, but the produce of No. 12, Table II., which Professor Black says is a fair representative of the Moeraki boulders, would be a poor lime of very inferior quality.

Practical experiments made with cement from Moeraki boulders are equally irregular and unsatisfactory. Mr. J. T. Thomson manufactured a considerable quantity in 1868, and tested it against Portland cement in the following manner :—Two bricks were laid together with mortars of the two cements, and kept a month in water and a fortnight dry. The highest results obtained were, with Moeraki mortar, three to one, and Portland, one to one. It took 400 pounds in both cases to tear asunder the bricks. Assuming they were placed crosswise, this would give a tensile strength of 22 pounds per square inch. About the same time Mr. G. M. Barr got an unmixed sample that stood 150 pounds in 24 days, against 110 for Portland cement under the same conditions. These comparisons are not, however, fair to the imported article, as the samples tested must have been of a very inferior quality. Instead of 25 pounds in the first experiment, ordinary Portland cement should have stood 140, and instead of 110 in the second, the resistance should have been 270 pounds. Mr. John Macgregor also tested the Moeraki cement, but the result was less satisfactory than either of the above. Two samples of mortar were made with pure cement and salt water—one was kept dry for 10 days, and the other in salt water for 87 days. Neither of them stood any measurable strain. Mr. Macgregor also noted that the samples contracted very much in setting, which indicates too much carbonate of lime. The irregularity in composition of the Moeraki boulders is so great that it would be practically impossible to manufacture cement from them of a uniform quality; one kiln might be equal to the best Portland, and the next quite worthless. We may therefore conclude that the expense of selection on the one hand, and the risk of failure on the other, are insurmountable obstacles in the way of its general utilization.

Artificial Cements.

When I began to investigate the subject of native cements and limes, I was under the impression that we had no stone capable of furnishing hydraulic limes, consequently some little time was devoted to the consideration of providing an artificial substitute; but the existence of natural cementing ingredients of a high character having been fully established, the necessity for adopting the latter expedient is removed, the subject will therefore be dismissed in a few words.

As you are probably aware, English Portland cement is made from two of the most common and abundant raw materials in the country—chalk and clay—and the manufacture is equally simple. The materials are mixed in the proportion of seven of the former to three of the latter, then burned in a kiln and pulverized as already described. In Germany, where there is no chalk, a substitute is found in hard limestone. This entails extra labour in pulverizing the raw material as well as the cement, but the result is practically the same.

Ordinary yellow clay does not make good cement; that in common use is a dark blue unctuous variety found in tidal estuaries and swamps. Blue clays, supposed to be suitable for the purpose, are abundant throughout the province. A sample from the railway cutting at Caversham was analyzed by Professor Black with the following results, which are shown alongside an English type :—

	Otago Clay.	English Clay.
Silica	65·28	68·45
Alumina	23·18	11·64
Iron	3·20	14·80
Lime and magnesia	2·58	0·75
Alkalies	1·04	4.00
Water	5·19	—
	100·47	99·64

These figures are not near enough to prove that this clay is good for making cement, but they are sufficient to show that there is every chance of getting the proper kind if required.

Portland cement is a low-priced article, the value of which is more than doubled by the charges of importation, and it can be manufactured without much skilled labour, consequently it is an industry that might well be started in New Zealand if there were no hydraulic limes to compete with it. The best places in Otago for a factory are the Waihemo and Aparima districts, both of which furnish soft limestones and fuel, the main requisites. The soft marl found at Waikouaiti and Greytown, being supposed to contain the ingredients of raw cement, was analyzed and gave the following result :—

Clay	27·84	per cent.
Iron	11·24	,,
Lime	24·78	,,
Sand	35·16	,,
	99.02	

The last item neutralizes the good qualities of the others, so we pass it into the category of unsuitable materials.

The idea of utilising the rich limes induced me three years ago to make an examination of volcanic clays to ascertain if they contained any of the properties of the Pozzuolanas of the old world that have been used from time immemorial to mix with lime in hydraulic works. About 40 specimens of all shades of colour imaginable were collected and tested by being made into mortar with an equal proportion of lime, then kept in water for two months. Four or five samples of drab and neutral tints gave indications of being feebly hydraulic, so possibly a more complete investigation would lead to the discovery of a material of considerable utility. The great objection to Pozzuolanas is that, like the Moeraki boulders, uniformity of composition cannot be ensured.

Aggregates.

Except in the case of the higher hydraulic limes and cements, where the maximum strength is obtained by using them in a pure state, as much depends on the aggregate as on the cementing material, notwithstanding which there is no article used in construction that commands so little attention. The main essentials of a good aggregate are sharpness and freedom from earth or other impurities of a similar nature. The proper size and hardness vary with the quality of the cementing material;—rich lime takes a coarse soft sand, and cement a fine hard one.

As no attempt had been made to determine the relative merits of the Otago sands, I collected a number in the vicinity of Dunedin and experimented on them in the following manner, and with the results given in Table V. Each kind of sand was made into mortar with Waihola lime in the proportion of one of lime to two of sand. The lime had been air-slaked, and was sifted through a gold-dust sieve before being used. The ingredients were measured in the most exact manner, and carefully mixed with the smallest quantity of water that would give plasticity. The mortar was then used to cement ordinary bricks placed crosswise, which gave a bearing surface of about 18 square inches. After being kept in the open air for 160 days the bricks were pulled asunder with weights increased gradually to the breaking point. It will be seen from the table that the highest results were obtained from Anderson Bay sand, which broke with a strain of 226 pounds. About 1½ square inches of the mortar in the inside was not quite hard. Assuming that this only supported half as much as the other portion, we make the cohesive strength 13 pounds on the square inch. Two samples of each kind of sand were tested. Taking only the highest in each pair, we find that, out of a total of 27, four broke with strains ranging from 226 to 150 pounds, nine from 150 to 100, six from 100 to 75, and six from 75 to 47, while two did not stand any measurable strain. I regret to add that many of the last three classes are constantly used in Dunedin.

General.

In conclusion, I shall briefly recapitulate the leading points of my subject, and consider its practical bearing.

Leaving out the materials in Tables II. and IV., which are comparatively valueless, the following will show the various purposes for which the Otago limes are suited, each class being capable of performing the functions of those under it as well as its own :—

Rich Limes.—

Nos. 9 to 14. { Whitewashing and agricultural and caustic purposes only.

,, 15 to 18. Brickwork in partitions and plastering.
,, 19 to 23. Low thin brick walls in a dry situation.

Hydraulic Limes.—

Nos. 11 to 13. Ordinary walling above ground.
,, 14 to 16. Foundations of ordinary buildings, concrete, and engineering structures above ground.
,, 17 to 20. Nearly all the higher class masonry for which cement is usually employed.

The rich limes are well dispersed throughout the province, but the hydraulic ones are confined to the vicinity of Dunedin, except we include the Lake Wakatipu deposits, the hydraulicity of which has not been proved. Although lime has been burnt on the Peninsula for many years, none of the good seams have been utilised. The proprietors inform me that there is no market for this quality. Builders will not use it in preference to the rich lime, as the latter carries more sand, and in the absence of any information on the subject, professional men and the public generally have no choice. In order to institute a comparison between the various articles under discussion, I have prepared the following statement, showing the strength and cost of mortars now used in Dunedin, together with an estimate of other kinds prepared from the hydraulic limestones.

Mortar.

	Tensile strength per square inch in pounds.	Cost of mortar for a cubic yard of brickwork.
Now in use—		s. d.
Portland cement with 2 of sand	205	14 6
,, ,, ,, 3 ,, ...	140	11 0
,, ,, ,, 4 ,, ...	100	9 0
,, ,, ,, 5 ,, ...	50	8 0
Rich Lime ,, 2½ ,, ...	15	3 9
Estimates for new mortars—		
Weak hydraulic lime slaked	50	4 0
Ordinary ,, ,, ground in mixing ..	100	4 6
Strong ,, ,, shell lime ground ..	140	7 0

In contrast to the above it should be stated that ordinary hydraulic mortar in England costs from 1s. 10d. to 2s. per cubic yard.

Judging by the quality of the ingredients, and the manner in which they are manufactured, I should not estimate the tensile strength of our ordinary lime mortars at more than ten pounds per square inch, which is less than half the strength of European mortars that are designated "bad." Their defects are quite apparent to any one who takes the trouble to examine the southern side of a building. It will be found that, after a lapse of years, the mortar even on the surface is often quite soft and friable. A good example which I noticed lately exists in the masonry of the Waitaki Bridge, erected in 1869; although apparently well proportioned and prepared, the mortar in some places is still no harder than stiff clay. There is no greater anomaly in the constructive arts than what is displayed in the use of weak mortar with strong bricks. We might as well connect plate iron with lead rivets. In designing a bridge or a roof every part is strained alike, so there is nothing wasted; but in the case before us, three-fourths of the work is thirty times stronger than the remainder. As shown above, the cost of increasing the strength of our mortars five times is 3d., and ten times 9d. per cubic yard of brickwork. These figures would only represent £10 and £30 on the new telegraph office, so the question of expense cannot stand in the way of the substitution of hydraulic limes for those in common use.

At present the annual consumption of Portland cement in New Zealand is about 40,000 casks, representing an expenditure to the consumer of £40,000. Of this quantity I am confident that nine-tenths is used in works for which our native products are equally well adapted; indeed, with the exception of some wet tunnel lining and foundations, where quick setting was a desideratum, there have been few works executed in New Zealand that required cement. We are, therefore, spending £36,000 on a foreign article, while a native one that would serve our purpose can be obtained at half the cost. This state of affairs has resulted entirely from ignorance of our resources, and of the quality of the materials within our reach.

The principal hydraulic limestones of the Peninsula are rather inaccessibly situated; at present their only outlet is by road to Dunedin, a distance of ten miles, but a moderate expenditure on a tramway two miles long would connect them with the proposed Portobello Railway and the waters of the harbour. The deposit at Dowling Bay occupies a very favourable position on the beach, four miles below Port Chalmers. The new road to the Heads passes through it, and there is deep water within a few yards of the limestone rock.

In order to utilise these stores of hydraulic limes to the best advantage, I would suggest the adoption of a plan that seems to have been followed in America: The quality of the stone, not only in each quarry, but in each bed of that quarry, is so clearly determined that its name conveys a distinct meaning to professional men who stipulate for certain kinds in certain work. Gradually the names acquire a commercial value, like the brands in ordinary manufactures, and thus the public generally acquire the knowledge necessary to ensure each article being used in its proper place.

TABLE I.

ANALYSES OF OTAGO LIMESTONES THAT FURNISH RICH LIMES, WITH ENGLISH AND FOREIGN TYPES.

Number.	Description.	Locality.	Lime and Carbonate of Lime.	Carbonate of Magnesia.	Silica Soluble.	Silica Insoluble.	Alumina Soluble.	Alumina Insoluble.	Sand Insoluble.	Clay partly Soluble.	Sesqui-oxide of Iron Insoluble.	Oxide of Iron Soluble.	Carbonate of Iron Soluble.	Iron Alumina.	Insoluble Matter not Determined.	Alkalies Water and Loss.	Analyst or Authority.	Remarks.
	English & Foreign Types																	
1	Statuary marble ...	Italy	100·00	...	...	...	...	...	...	...	...	...	...	...	...	...	M. Vicat	
2	Ordinary chalk	England	99·50	...	...	...	...	...	...	...	...	...	...	...	...	0·50	Various	
3	Strasbourg stone ...	France	98·00	...	...	...	...	...	...	...	...	...	...	...	...	2·00	M. Berthier	
4	Yellow vesicular ...	,,	97·00	2·00	...	0·60 ...	0·40	...	...	...	...	...	...	...	...	...	M. Vicat	
5	Portland Oolite	Dorset, Eng.	95·16	1·20	...	1·20 ...	...	...	...	...	...	...	...	0·50	...	1·94	Profs. Daniel	In common use as building stones
6	Ordinary limestone ...	Barnack, ,,	93·40	3·80	...	...	...	...	...	...	...	...	...	1·30	...	1.50	and	
7	Ketton Oolite	Rutland ,,	92·17	4·10	...	...	...	...	...	...	...	...	...	0·90	...	2·83	Wheatstone	
8	Carboniferous	Whiteford ,,	89·75	...	...	0·60 ...	8·88		...	...	...	...	...	...	...	0·85	Dr. Clarke	
	Otago Limestones																	
9	White crystalline ...	Southland	98·80	Trace	Trace	...	1·20	...	...	...	...	...	...	...	1·20	...	Dr. Hector	Jurors' Reports, N.Z. Exhibition
10	Faint yellow do	Winton	97·90	,,	,,	...	0·60	...	...	...	...	Trace	...	...	...	...	,, ,,	,, ,, ,, ,,
11	Yellow fossiliferous ...	Kakanui	97·00	1·00	...	...	...	...	1·50	...	...	...	...	...	...	0·50	Dr. Black	Laboratory Report, 1875-6
12	Do do	Oamaru	95·95	2·17	0·60	...	0·45	...	...	...	...	Trace	...	...	0·74	...	Dr. Hector	Jurors' Reports, N.Z. Exhibition
13	White granular	Waihola	95·76	Trace		3·32	...	...	...	...	...	...	...	0·92	...	...	,, ,,	
14	Yellow lithographic ...	Oamaru	95·18	1·29	not estimated	...	1·20	...	...	...	...	0·47	...	...	2·33	...	,, ,,	Trace of sulphate, Jurors' Reports, N.Z. Exhibition.
15	Grey and yellow travertine	Dunstan	95·04	2·56	Trace	...	0·60	...	...	...	...	...	...	...	1·80	...	,, ,,	Jurors' Reports, N.Z. Exhibition
16	White compact	Waihola	94·66	Trace		4·05	...	...	...	...	...	...	...	1·29	...	...	,, ,,	,, ,, ,, ,,
17	Grey granular	Oamaru	93·43	2·58	0.50	...	1·01	...	...	...	...	Trace	...	...	2·45	...	,, ,,	,, ,, ,, ,,
18	Bluish grey, top seam...	Dowling Bay	92·91	1·96	0·31	2·82	1·09	1·41	...	...	oxide 0·34	0·43	...	...	...	1·27	Dr. Black	,, ,, ,, ,,
19	Fawn granular	Aparima	92·20	Tr ce	not estimated	...	Trace	...	...	...	...	2·20	...	...	5·60	...	Dr. Hector	,, ,, ,, ,,
20	Grey compact	Wakatipu	91·60	2·94	0·20	...	,,	...	...	...	...	0·84	...	...	4·42	...	,, ,,	,, ,, ,, ,,
21	Bluish do	Horse Range	90·99	2·16	3·10	...	,,	...	...	...	...	0·62	...	...	2·90	0·23	,, ,,	,, ,, ,, ,,
22	Grey shelly	Southland	90·80	Trace	not estimated	...	2·29	...	...	...	...	not estimated	...	...	6·89	...	,, ,,	,, ,, ,, ,,
23	White granular	Oamaru	90·14	...	0·46	...	1·54	...	...	...	...	0·54	...	...	7·14	0·18	,, ,,	,, ,, ,, ,,

TABLE II.

Analyses of Otago Limestones that furnish Poor Limes, with English and Foreign Types.

Number.	Description.	Locality.	Lime and Carbonate of Lime.	Carbonate of Magnesia.	Silica Soluble.	Silica Insoluble.	Alumina Soluble.	Alumina Insoluble.	Sand Insoluble.	Clay partly Soluble.	Sesqui-oxide of Iron Insoluble.	Oxide of Iron Soluble.	Carbonate of Iron Soluble.	Iron Alumina.	Insoluble Matter not Determined.	Alkalies Water and Loss.	Analyst or Authority.	Remarks.
	English & Foreign Types																	
1	Sandy stone of Calraic	France	70·00	...	2·00		1·25		24·75	...	...	...	...	...	...	...	M. Vicat	
2	Coarse stone of Dessin	,,	61·89	7·44	3·10		1·57		26·00	...	...	...	...	...	...	...	,, ,,	
	Otago Limestones.																	
3	Grey	Caversham	68·51	Trace	0·72	...	1·79	...	...	...	...	0·79	...	...	27·65	0·54	Dr. Hector	Jurors' Reports, N.Z. Exhibition
4	Greyish yellow	Kaikorai	68·50		...	...	...	...	27·60	2·40	...	0·80	...	...	...	0·42	,, ,,	,, ,, ,, ,,
5	Dark grey	Waikouaiti	65·77	Trace	...	...	...	...	...	...	...	...	...	2·83	31·40	...	,, ,,	,, ,, ,, ,,
6	,, ,, ...	Upper Harbour West	64·60	1·16	1·00	...	3·00	...	...	...	...	Trace	...	...	30·01	0·22	,, ,,	,, ,, ,, ,,
7	Grey	Pleasant River	64·10		...	...	...	...	29·50	1·20	...	0·80	...	...	...	...	,, ,,	,, ,, ,, ,,
8	Bluish grey	,, ,,	63·08	1·10	0·63	...	0·60	...	...	...	...	0·83	...	...	29·53	4·22	,, ,,	,, ,, ,, ,,
9	Greyish yellow	Kaikorai	62·80		...	...	...	...	28·00	5·50	...	1·80	...	...	...	0·60	,, ,,	,, ,, ,, ,,
10	Light yellow	Waihemo	61·60	0·28	...	...	1·80	...	...	...	...	1·20	...	...	34·80	0·32	,, ,,	,, ,, ,, ,,
11	Dark Grey...	Kaikorai	60·86	1·99	1·57	...	2·90	...	...	...	...	1·78	...	...	30·19	0·71	,, ,,	,, ,, ,, ,,
12	Moeraki boulder... ...	Moeraki	60·50	2·50	...	...	...	...	21·00	14·00	...	...	...	...	...	2·30	Dr. Black	Laboratory Report 1875-6
13	Bluish grey	Caversham	53·00		...	...	...	...	24·40	19·10	...	1·40	...	...	...	2·20	Dr. Hector	Jurors' Reports, N. Z. Exhibition
14	Greenish grey	,,	51·22	1·56	...	...	...	...	...	...	...	...	...	2·92	43·64	2·66	,, ,,	,, ,, ,, ,,
15	Bluish grey	Hawksbury	51·17		...	...	...	...	25·00	21·50	...	0·80	...	...	...	1·90	,, ,,	,, ,, ,, ,,
16	Compact dark blue ...	Wakatipu	50·79	2·80	0·23	23·58	8.84	7·49	...	...	1·56	2·80	...	...	...	1·91	Dr. Black	12·46 per cent of silica in form of sand
17	Dark grey	Hawksbury	50·05	1·70	0·70	...	2·94	...	...	...	...	0·90	...	...	42·94	0·77	Dr. Hector	Juror's Reports N.Z. Exhibition
18	Fine grey, soft	Waihola	43·30	Trace	...	27·60	...	...	...	19·00	2·40	...	...	...	...	0·70	Dr. Black	21·98 per cent. of silica in form of sand
19	Buff yellow	Kaikorai	42·10		...	...	...	...	21·00	29·30	...	1·70	...	...	...	5·90	Dr. Hector	Jurors' Reports N. Z. Exhibition
20	Dark grey	Tokomairiro	41·20	Trace	...	...	...	...	...	...	...	...	...	5·20	52·20	1·40	,, ,,	,, ,, ,, ,,
21	Pale yellow	Kaikorai	40·45	1·70	3·40	...	1·75	...	...	...	...	Trace	...	...	46·80	5·90	,, ,,	,, ,, ,, ,,

TABLE III.

Analyses of Otago Limestones that Furnish Hydraulic Limes with English and Foreign Types.

Number.	Description.	Locality.	Lime and Carbonate of Lime.	Carbonate of Magnesia.	Silica Soluble.	Silica Insoluble.	Alumina Soluble.	Alumina Insoluble.	Sand Insoluble.	Clay Partly Soluble.	Sesqui-oxide of Iron Insoluble.	Oxide of Iron Soluble.	Carbonate of Iron Soluble.	Iron Alumina.	Insoluble Matter not Determined.	Alkalies, Water, and Loss.	Analyst or Authority.	Remarks.
	English & Foreign Types																	
1	Shelly stone of Nièvre ...	France	88·00	...		6·85		4·00	...	...	...	1·15	...	...	...	...	M. Vicat	Feebly hydraulic; sets under water in 15 days.
2	Aberthaw	England ...	86·20	...	...	...	...	...	...	11·20	...	...	...	...	...	2·60	Hy. Reid	
3	Bituminous bluish grey	France	82 25	...		10·50		5·50	...	...	...	1·71	...	...	...	...	M. Vicat	Sets under water in five days.
4	Theil Limestone... ...	,, ...	81·36	1.00	...	...	...	...	...	14·90	...	1·70	...	...	...	1·10	Gen. Gilmore	Used in Port Said breakwater
5	Blue Lias of Lyme Regis	England ...	79·20	...	...	...	...	...	...	17·30	...	...	...	...	...	3·50	Hy. Reid	Used at London Docks
6	High Falls stone... ...	America ...	79·04			11·10		2·52	...	...	peroxide 1·42	...	...	...	...	4·54	Prof. Boynton	
7	Yellow	France	77·40	...		13·25		8·35	...	...	...	1·00	...	...	...	...	M. Vicat	Eminently hydraulic; sets under water in three days.
8	Metz limestone	,, ...	77·30	3·00	...	...	...	...	...	15·20	...	manganese 1·50	3·00	...	...	...	C. Tomlinson	Eminently hydraulic.
9	Lezoux	,, ...	72·50	4·50	...	...	...	...	...	23·00	...	...	...	...	...	...	,,	
10	Blue Lias of Holywell ...	England ...	71·55	1.35		20·10		3·52	...	...	...	2·21	...	...	...	0·84	Dr. Muspratt	{74·73 soluble, 25·27 insoluble} in acids. Used in the Liverpool Docks.
	Otago Limestones—																	
11	White conglomerate ...	Oamaru ...	87·08	Trace.	not estimated.	...	2·85	...	...	...	...	0·79	...	...	8·58	0·78	Dr. Hector	Jurors' Reports, N.Z. Exhibition.
12	Dark compact	Portobello ...	86·80	,,	,,	...	0·80	...	...	...	...	Trace.	...	...	12·40	...	,,	,, ,,
13	Dark fawn compact	Peninsula ...	86·05	2·22	0·20	7·00	0·90	3·57	...	...	0·55	0·97	...	...	...	1·46	Dr. Black	3·17 p. ct. silica in form of sand.
14	Drab granular, 5th low'st seam	Dowling Bay ...	84·03	0·33	...	10·93	1·23	2.76	...	...	1·00	0·98	...	...	...	1·26	,,	Trace of sand and mica.
15	Fawn compact	Peninsula ...	82·03	Trace.	0·36	9·10	2·30	2.53	...	...	0·55	2·80	...	...	...	0·33	,,	2·67 p. ct. silica in form of sand.
16	Yellowish do.	Portobello ...	81·10	1·70	not estimated.	...	Trace.	...	...	...	...	0·60	...	...	16·60	...	Dr. Hector	
17	Fawn, top seam	Peninsula ...	77·97	1·98	0·22	10·51	1·61	4·21	...	...	0·85	1·53	...	...	...	1·12	Dr. Black	3·60 p. ct. silica in form of sand.
18	Drab granular, 2nd highest seam... ...	Dowling Bay ...	78·87	0·80	0·62	12·70	1·52	4·05	...	...	oxide 0·70	0·35	...	...	...	0·39	,,	3·80 p. ct. ,, ,,
19	Dark fawn, 3rd do. ...	,, ,, ...	69·70	1·50	0·31	18·87	0·80	3·74	...	...	0·69	1·30	...	...	...	2·09	,,	7·60 p. ct. ,, ,,
20	Do. do., lowest seam...	Peninsula ...	69·46	2·26	0·16	18·69	2.10	3·16	...	...	0·95	2·34	...	...	...	0·97	,,	7·03 p. ct. of sand, but mixed with some clay.

TABLE IV.

Analyses of Otago Cement Stones with English and Foreign Types.

Number.	Description.	Locality.	Lime and Carbonate of Lime.	Carbonate of Magnesia.	Silica Soluble.	Silica Insoluble.	Alumina Soluble.	Alumina Insoluble.	Sand Insoluble.	Clay Partly Soluble.	Sesqui-oxide of Iron Insoluble.	Oxide of Iron Soluble.	Carbonate of Iron Soluble.	Iron Alumina.	Insoluble Matter not Determined.	Alkalies, Water, and Loss.	Analyst or Authority.	Remarks.
	English & Foreign Types																	
1	Raw materials Portland cement	England ...	69·87	...	20.54		3·49		...	...	...	4·44	...	...	...	1·66	Various	
2	Portland cement, artificial	,, ...	68·11	...	20·67		10·43		...	...	...	0·87	...	...	...	...	...	Manufactured by White Bros.
3	,, ,, ...	,, ...	62·00	...	23·00		8·00		...	...	...	4·00	...	...	...	...	Hy. Reid	Average quality.
4	,, ,, ...	Germany ...	60·40		23·86		9·20		...	...	peroxide 5·12	...	...	...	...	1·92	Herr Feichtenge	
5	Boulogne cement stone	France	63·60	...	...	...	...	...	...	23·80	...	...	6·00	...	...	6·60	C. Tomlinson	
6	Portl'nd cement, natural	Boulogne ...	65·13	0·58	20·42		18·88		...	...	...	...	...	...	...	...	Various	Quick setting.
7	Calderw'd cement stone	Scotland ...	71·30		8·80		3·40		...	...	protoxide 10·20	...	...	...	...	6·30	Prof. Penny	
8	Vassy ,, ,,	France	63·80	1·50	14·00		5·70		...	...	...	...	11·60	...	...	8·40	C. Tomlinson	Quick setting.
9	Rosendale ,, ,,	America ...	63·76		27·70		2·34		...	...	peroxide 1·26	...	...	...	...	4·94	Gen. Gilmore	,, ,,
10	Yorkshire ,, ,,	England ...	62·54		24·00		...	...	...	...	...	1·81	...	...	...	...	Various	
11	Sheppy ,, ,,	,, ...	61·40		18·00		...	...	...	...	...	5·25	manganese 6·75	...	...	...	,,	
12	Harwich ,, ,,	,, ...	52·00	...	9·37		...	...	...	...	...	17·75	...	...	...	11·37	,,	7·50 per ct. sulphate of soda, etc.
	Otago Cement Stones—																	
13	Septarian boulder ...	Moeraki ...	72·40	0·30	0·80	...	...	...	17·80		...	...	...	8·70	...	0·60	Dr. Hector	Colonial Museum Report, 1870-1.

TABLE V.

Tensile Strength of Waihola Lime Mortars with Different Sands.

No.	Description.	Locality.	Weight in lbs. Required to Tear Asunder Bricks.	Remarks.
1	Grey, with faint yellow tinge; fine, but sharp.	Mr. Knox's pit, Anderson Bay.	226 218	1⅓ sq. inches in middle not quite hard. 2 " " " "
2	Grey; fine, and sharp; small quantity of clay.	Railway cutting at English Church, Caversham.	212 nil.	Good bed, uniformly hard. Broke in fixing; flaw in bed.
3	White; very soft, clean, and fine.	Railw'y cutting at Abbott's Creek.	150 136	Uniformly hard throughout. " " "
4	Round quartz gravel.	Mr. Cutten's pit, Anderson Bay.	158 109	Uniformly hard throughout. " " but not all adhering.
5	Dark grey; irregular and soft.	Mr. Casey's pit, Anderson Bay.	143 122	2½ sq. inches in middle not quite hard. Thickish bed; soft in centre.
6	Yellowish grey; fine, very sharp.	Mr. Knox's pit, Anderson Bay.	143 67	2½ sq. inches in middle not quite hard. 2½ " " " "
7	Quartz gravel.	Railw'y cutting at Abbott's Creek.	140 82	Uniformly hard. Not adhering properly.
8	Reddish yellow, irregular; clay and quartz.	Railw'y cutting at Abbott's Creek.	138 88	Very thin good bed; uniformly hard. Bed not good.
9	Deep red; coarse; irregular.	Railw'y cutting at Abbott's Creek.	138 nil.	Uniformly hard. Broken on shelf.
10	Deep reddish yellow; fine and sharp.	Mr. Cutten's pit, Anderson Bay.	122 122	Piece in middle like a small oyster not quite hard.
11	Orange; very soft and fine.	Railw'y cutting at Abbott's Creek.	106 97	Not well set. " " "
12	Whitish grey; soft.	Mr. Casey's pit, Anderson Bay.	102 nil.	2¼ sq. inches in middle not quite hard. Broken on shelf.
13	Yellowish grey; soft.	Mr Casey's pit, Anderson Bay.	102 nil.	Not well bedded. Did not carry 28lbs.; seems to have been broken.
14	Greyish white; fine: very sharp.	Mr. Knox's pit, Anderson Bay.	96 nil.	Uniformly hard. Broke in handling; not adhering properly to bricks.

TABLE V. *(Continued.)*

No.	Description.	Locality.	Weight in lbs. Required to Tear Asunder Bricks.	Remarks.
15	Reddish yellow; fine and sharp.	Mr. Casey's pit, Anderson Bay.	88 nil.	2½ sq. inches in middle not quite hard. Did not lift 21 lbs.; not quite hard; not adhering well.
16	Grey; fine.	Railway cutting at Cargill Hill.	82 68	Good bed; uniformly soft. " " " "
17	Grey and yellow; fine.	Railway cutting at Cargill Hill.	82 nil.	Good bed; uniformly soft. Did not carry 28 lbs.
18	Greyish yellow; very sharp.	Mr. Harris's pit, Anderson Bay.	81 70	Good bed; 3 sq. inches not hard. " " 5 " "
19	Yellowish grey.	Railway cutting at English Church, Caversham.	75 nil.	Uniform consistency throughout. Broke in handling; not bedded.
20	Yellow; fine and sharp	Mr. Harris's pit, Anderson Bay.	67 nil.	2 sq. inches not quite hard. Would not stand handling.
21	Deep reddish yellow; fine and sharp.	Mr. Cutten's pit, Anderson Bay.	65 nil.	Bad bed; soft in heart. Did not lift 28 lbs.; piece like a small oyster not quite hard.
22	Deep orange; very sharp	Mr. Cutten's pit, Anderson Bay.	61 nil.	Very good bed; 4 sq. inches; not quite hard. Broke in handling.
23	Light orange; very sharp.	Mr. Cutten's pit, Anderson Bay.	61 nil.	Good bed. Did not carry 28 lbs.
24	Yellow; sharp and fine.	Railway cutting at Cargill Hill.	54 nil.	Good bed; soft throughout. Did not carry 14 lbs.; bad bed.
25	Yellow; sharp and fine.	Railway cutting at Cargill Hill.	47 nil.	Pretty well set. Broke with about 10 lbs.
26	Yellow; mixed with pebbles as large as peas.	Railw'y cutting at Abbott's Creek.	nil. nil.	Broke in handling. Did not carry its own weight soft throughout.
27	Yellow; fine and sharp	Railw'y cutting at Abbott's Creek.	nil. nil.	Broke with its own weight. Do do; had not set.

Art. X.—*The Building Materials of Otago.* By William N. Blair, C.E.

[*Read before the Otago Institute, 31st October,* 1876.]

Timbers.

Properties of Timbers.

Although the properties of timbers generally are better known than those of the other building materials that have already been discussed, it is necessary for the proper investigation of our subject to consider the leading characteristics that bear on their economic value, and in doing so I shall trace the timber through the various stages of its existence.

Structure.—As you are probably aware, the structure of ordinary timber is, to all intents and purposes, identical with that of a brick wall: it is composed of vertical and horizontal layers, breaking joints, and cemented together in much the same way. Tbe vertical joints, consisting of the annual rings and medullary rays, are quite clear and distinct; but the horizontal ones, made from the interlacing of bundles of woody fibre of irregular lengths, are only visible to the microscopist. It is this difference in the length of the scarf, or joint, that makes splitting timber so much easier than cutting it across the grain. The concentric rings represent the growth in a year or season; they are generally very distinct in timber grown in a cold climate, where there is a decided period of repose in the the vegetation; but in many tropical trees the rings are scarcely discernable, and some botanists allege that occasionally so many as four rings are formed in one year. The medullary rays are thin plates of woody matter that radiate from the pith to the bark, and form the weft which interlaces with the warp of the annual rings. Although believed to exist in all timbers, these rays cannot be traced in the firs and pines of the old country, but are very conspicuous in oak, beech, and other hard woods; this rule does not hold good in Otago, for there are few timbers hard or soft in which they do not appear. These medullary rays are what give the peculiar watered figure called silver grain, which is so much prized by cabinet-makers and other manufacturers of fancy wood-work.

Growth.—The principal agent in the formation and development of woody fibre and tissue is the sap, which performs the same functions in plants that blood does in animals. After being extracted by the roots from the soil, it rises through the trunk to the leaves, and is there subjected to certain chemical changes that fit it for the formation of timber. In saplings, the fluid permeates and rises through the whole trunk; but in old trees with solid heart-wood, it is confined to the sap-wood and the bark. At this stage the heart-wood contributes nothing to the other parts of the tree except in supporting them. The leaves are the lungs of the plant, but, instead of making the original fluid thinner, and purifying it by the extraction of carbonic acid and the addition of oxygen as in animals, they make the sap thicker, and *add* carbonic acid, which is the food of plants. The precise nature of the chemical process carried on in the leaves, and the exact constituents of its product, are imperfectly understood. After the sap has acquired the necessary ingredients, it returns through the outer layer of the wood and the inner layer of the bark, leaving in its course a deposit of ligneous matter on each, and permeating to a greater or less extent all the rings of sap-wood. The deposits made on the bark and wood harden into rings of timber and bark, the former to increase the size of the tree, and the latter to replace the scales that are continually falling off the outer surface. The conversion of sap into heart-wood is attributed to the combined action of the juices and the compressive force exercised by the shrinkage of the outer rings and bark; but against this idea we have the fact of the change being generally sudden: one ring may be perfect heart, and the next sapwood of a very inferior quality. Whatever be the cause of this ripening of the timber, the process is not simultaneous with its growth, for the rings of sapwood always decrease in number as the tree approaches maturity, and there are frequently fewer rings on one side than the other.

Climate, situation, and soil, exercise a great influence on the character of timber. Among different trees the best timber is obtained from tropical countries, but in the same species the product of cold climates is found to be the strongest and most durable. Most authorities, ancient and modern, pronounce in favor of slow growth in timber trees as essential to perfection; but I observe that Mr. Laslett, Inspector of Timber to the Admiralty, entertains an opposite opinion formed from observations on oak and fir trees. I can easily understand the possibility of rapid growth being conducive to strength and durability, as it proves that the plant is well fed and in vigorous health. Although the wood may be soft and porous in the young tree, it does not follow that the old one will inherit these qualities; the energy that puts forth strong shoots is in all probability sufficient to provide them with a proportionate supply of woody fibre and the other essentials of strength.

Timber grown in open ground is stronger and more durable than that from the dark forest, but, on the other hand, it is more subject to twists, shakes, and irregularity of composition, and the trees are often stunted and crooked. The effect of the weather is well shown on the southern side of the Otago Peninsula, where the trees are blown into shapes as grotesque as could be seen in a Dutch garden.

The influence of situation and soil on the growth of trees is very remarkable, as the following table, compiled from the "Forester," will show. It gives the diameter in inches at eight feet from the ground, of various kinds grown in favorable and unfavorable situations :—

	Favourable Situations.	Unfavourable Situations.
Oak, 80 years old	31½ inches	11½ inches
Scots Pine, 50 " "	17 "	7¼ "
Larch, 35 " "	17 "	8 "
Spruce Fir, 35 " "	15 "	6 "

Felling.—One of the most important considerations in the cultivation of timber for building purposes, is the time at which it should be cut—first, the age of the tree, and, next, the season of the year. The desideratum in the first instance is the zenith of growth—when maturity has been reached, and the decline not begun; and, in the second, when the tree contains the minimum of sap. Unripe timber is soft, sappy, and liable to decay; and, when too ripe, it is brittle, and the decay has already commenced at the heart. There is comparatively little difficulty in judging as to the ripeness of timber: when the top shoots cease to grow vigorously, and the branches become stunted and thick, it is ready for the axe. The following are given in various works as the ascertained ages of the common English trees :—

Yew	1,214 to 2,820 years.
Lime	1,147 "
Oak	810 to 1,500 "
Larch	576 "
Elm	335 "

As a further indication of their ages, Mr. Laslett gives a very complete list of the known timber trees throughout the world, with the number of concentric layers in an inch of an ordinary-sized specimen. I subjoin a few of the more common varieties :—

English Oak, fast grown ..	1·50	Iron Bark, Australia	4·00
" Elm " ..	1·50	Pine, Oregon	4·32
Cedar, Honduras..	1·95	Greenheart, Demerara	4·60
Elm, English	2·80	White American Oak	4·70
Beech, "	2·83	Fir, Dantzic	4·82
Oak, "	2·84	Pine, Yellow, Canadian	5·22
Ash, "	2·90	Ash, American	6·36
Mahogany, Honduras	3·20	Kauri, New Zealand	6.70
Blue Gum, Australia	3·30	Spruce Fir	11·40
Teak, Moulmein	4·00	Elm, Canadian	14·00

There is a considerable difference of opinion as to the proper season for felling timber; while all authorities are agreed in considering it the time when there is least sap in the tree, the time itself is not decided. One party argues that as vegetation is suspended during winter, there must be little sap in the timber. But the other maintains that midsummer is the best season for felling, as all the juices that rise in spring are then expended in forming leaves. With deciduous trees, and in a cold climate, the chances are greatly in favour of winter felling, but, with evergreens and in a warm climate, there seems little choice between summer and winter. Of course there is a very marked difference in the quality of timber felled in winter and spring, and in summer and autumn. Experiments made in Germany to settle this point gave the following results. Timber cut in December was impervious to water end-wise; in January, a few drops percolated through in 48 hours; in February, two quarts went through in that time; and the March cut timber allowed two quarts to run through in two and a half hours. It is to be regretted that these experiments were not carried over the whole year, as the result would go a long way towards deciding the relative merits of winter and summer felling. Notwithstanding the fact that spring is admitted on all sides to be the worst season of the year for felling timber, it is the one in which the "indestructable" English oak is cut; this is in consequence of the bark, which is used for tanning, being more valuable when the sap is rising. Summer is considered the best time for cutting alder and beech in England; it is also the season in which oak is felled in Italy and pines in Germany.

The ancients believed that the moon had a ripening influence on timber, consequently it was felled during her last quarter. The same belief was embodied in the Code Napoleon, and prevails to this day in the forests of Germany and Central America. It has a commercial significance in the latter place, for mahogany that is guaranteed to have been cut during the proper phase of the moon commands a higher price than any other. This lunar influence is probably quite imaginary, but when we consider the effect of the planets' attraction on the ocean, it is not unreasonable to suppose that vegetable juices may be attracted in a similar manner, at the same time we would expect a manifestation twice a month, as in the tides, instead of once only.

Qualities of Timber.—The chief attributes of good timber are—a minimum amount of sapwood, compactness of texture, and depth of colour where colour exists. The proportion of sap-wood varies in trees of different ages and kinds—chestnut, fifteen and half inches in diameter, has three-eighths of an inch of sap all round; oak, seventeen inches diameter, has one and quarter inch of sap; and Scotch fir, twenty-four inches diameter, two and half inches of sap. The ordinary defects in growing timber are the shakes, or cracks and hollows that appear in the heart of full grown and over ripe trees. A small straight crack in the centre of a log does little harm, but when it is of a star shape, and has a twist in the length of the timber, its strength as a beam is seriously impaired, and it cannot be cut into planks. Another defect, known as the cup shake, consists in want of cohesion between the annual rings; it is less common but more serious than the one just described. The heart cavity is caused entirely by over ripeness in the trees, and its extent is in direct proportion to the time they have been allowed to stand after maturity. The cup shake is rare in Otago, but the other two defects occur in several kinds— a straight heart crack filled with gum or resin is very common in rimu, and the hollow heart is always met with in aged totara and cedar.

Seasoning.—There is no operation connected with the utilizing of timber on which so much depends as seasoning, at the same time there is no subject that receives so little attention from practical men, particularly in new countries. When it is considered that proper seasoning doubles the strength of timber, and increases its durability to an indefinite extent, the folly of using it in a green state is too apparent to need comment. Barking the trees a few months before felling, which is a very old custom, assists materially in draining the sap, and if to this is added the cutting through of the sap-wood all round, it makes the process very complete. Barking as a means of seasoning, is practised to some extent in the North Island, but I never heard of its being resorted to for this purpose in Otago. After felling, timber is seasoned naturally by the weather, or artificially by steeping in water, smoking, boiling, steaming or drying in a warm atmosphere. The object in all cases is to abstract such portions of the sap as are calculated to cause decay, but in doing so there is a danger of going too far: the juices that give elasticity, toughness, and durability may be abstracted along with those of a pernicious kind. It is found that natural seasoning is the best, and next it that by steeping the timber in running water, but both are very much slower than any of the other methods named. According to Laslett the time required for seasoning timber in open sheds is as follows:—

Pieces	12 to 16 inches,	Oak	14 months,	Fir	7 months.
,,	8 ,, 12 ,,	do	10 ,,	do	5 ,,
,,	4 ,, 8 ,,	do	6 ,,	do	3 ,,
,,	2 ,, 4 ,,	do	4 ,,	do	2 ,,

The same sizes of timber would be equally well seasoned by steeping for ten days in running water, and afterwards drying under cover for a month. The other methods of seasoning complete the work in a few hours and upwards, but what is gained in time is frequently lost in strength and durability; the only real benefit they bestow is the saving of shrinkage.

The amount of moisture contained in the ordinary English timbers is shewn by the following table :

	In pounds weight per cubic foot. Green.	In pounds weight per cubic foot, when seasoned.
Oak	77	52
Ash	65	50
Beech	65	50
Elm	70	48
Fir	54 to 74	31 to 41

The ultimate transverse shrinkage in the seasoning of boards twelve inches square and half an inch thick, is found to be for oak, $\frac{1}{12}$ the breadth ; Riga fir, $\frac{1}{32}$; Virginia pine, $\frac{1}{27}$; larch, $\frac{1}{27}$; elm, $\frac{1}{24}$; kauri, $\frac{1}{64}$.

Decay and Preservation.—The causes of decay in timber are of three kinds :—1st. Chemical decay—a natural decomposition by the action of the air and moisture ; 2nd. Vegetable decay or dry rot, a decomposition that takes place through the growth of fungi ; and 3rd. Animal decay, waste by the destruction caused by worms and insects. The first of these is to all intents and purposes a slow combustion effected by the acids of the atmosphere, and greatly accelerated by changes from wet to dry. Most timbers will last a long time if kept constantly wet or constantly dry in an equable temperature, but the best only will stand exposure to severe alternations from wet to dry ; the most trying situation for timber in this respect is in posts in the ground, decay always attacks it first at the surface, between wet and dry. I am not aware of any cure for this natural decay ; charring, painting or tarring will retard its progress, but the only safe course is the use of a durable timber well seasoned. In connection with this I may notice a practice that exists among our settlers of inverting posts when putting them in the ground to increase their durability ; like the lunar influence already noticed this was long thought to be only an imaginary benefit, but lately the matter has become an established fact. Experiments made in England on oak posts from the same tree showed those put in the ground with the top upwards as they grew, to be rotten in twelve years, while their neighbours that were inverted showed no symptoms of decay in sixteen years. This is explained by assuming that the capillary tubes are provided with valves which open upwards, on inverting the post these valves oppose the rising of moisture.

The relative durability of the timbers in common use in England has been ascertained by inserting pieces 2⅝ inches square into the ground; they decayed in the following order :—

Lime, American Birch, Alder, and Aspen ... ... 3 years.
Willow, Horse Chestnut, and Plane ... ... 4 „

Birch	5 years.
Elm, Ash, Hornbeam, and Lombardy Poplars ...	7 ,,

Oak, Scotch Fir, Weymouth Pine, and Silver Fir, were only affected to a depth of half an inch in seven years, and Larch, Juniper, and Arbor Vitæ were not touched at all in that time.

Vegetable decay or dry rot, is a regular disease induced in unseasoned timber by defective ventilation. In most parts of the world this is the worst enemy that timber has; we hear of ships being destroyed, and houses being made uninhabitable in an incredibly short time through its ravages and even cargoes of timber are seriously affected on the voyage from America to England. Hitherto this disease has been little known in Otago, not because any precautions are taken against it, but simply on account of the defects in our wooden buildings which give ample ventilation. I have seen several instances of dry rot in brick and stone buildings in Dunedin, but few in wooden ones; it is however very common in the timber work of mines.

The third cause of decay in timber, that by animals, is also of minor importance in Otago: the marine animals have caused some little trouble, but the land ones are scarcely known as destroyers in material that has been used. The latter class consist of a small beetle supposed to be much the same as the English one, and the large white worm that used to be eaten by the Maoris. These beetles are very destructive, particularly in carvings, but they are easily destroyed by fumigations; the large worm is very common in old trees lying in the forest, and I have seen it in piles that had not been barked, but never in wrought timber.

The marine animals most destructive to timber are the *Teredo navalis* or marine worm, and *Limnoria terebrans*, a small boring crab of the leech family, both of which are common in New Zealand waters. Captain Hutton finds that our *Teredo* is somewhat different from the European one, consequently it is called the *Teredo antarctica*. The *Teredo* is a worm-like animal from three to twenty-four inches in length, and from a quarter to an inch in diameter, according to the nature of the wood in which it has taken up its abode. It is furnished with a wonderful boring apparatus, like a pair of shell augurs, by which it perforates the hardest timber with astonishing rapidity. The smaller animal, which Mr. Kirk says is allied to *Limnoria lignorum*, although scarcely larger than a grain of rice, is as destructive as the *Teredo*. Large numbers attack the timber and speedily destroy it by fairly eating it away; indeed some animals of this species are able to penetrate stone.

The effectual preservation of timber in all conditions is a problem not yet solved. Oleaginous and bituminous substances retard the progress of decomposition, but without thorough seasoning and ventilation they are of little value. On the contrary, anything that closes the pores of the timber while it contains sap promotes decay. One of the best preservatives of timber is the creosoting process, invented 40 years ago by Mr. Bethell, which consists in extracting the natural juices by pumping and refilling the pores with creosote. Timber prepared in this manner resists decay of all kinds for a long time, but on account of the inflammable nature of the preparation and its obnoxious smell, timber that has undergone the process cannot be utilized in ordinary architectural work.

Nomenclature.

There is no subject connected with New Zealand timbers that is in such an unsatisfactory state as the nomenclature. The utmost confusion exists in the names of many kinds, and there are very few that bear the same name throughout all parts of the colony. In consequence of our ignorance on this point many of the best timbers have been rejected, and inferior ones accepted in their place, a proceeding which has led to disappointment and loss both in private buildings and public works. With the view to remedy this evil I have prepared a table (No. I.) hereto appended, showing the various names of all the principal Otago woods: the popular name is that by which the tree is best known, whether botanical, native, or given by the settlers, and the synonyms consist of the proper botanical name, and any native or vernacular names that have been applied to the plant. Many of the trees were formerly known by other botanical names, but the one given is now universally accepted, consequently the others are not required. The great majority of all these old botanical names can be found in "Hooker's New Zealand Flora" and "Gordon's Pinetum." As the leading Colonial authorities have been consulted in preparing this table, I have considerable confidence in its accuracy and completeness. The identity of two or three of the smaller plants with some of the native and vernacular names is not fully established, but there is little or no doubt with regard to all the others.

Geographical Distribution.

According to a return made to Parliament in 1874, Otago possesses about 2,250,000 acres, or 3,500 square miles of forest lands. With the exception of a block of 600 square miles in the north, which is almost treeless, the forests are well dispersed throughout the province, and the largest supplies are in very accessible situations. Practically there is a belt of forest along nine-tenths of the Otago coast. It is quite unbroken from the north-west boundary at Martin Bay to Riverton, a distance of 200 miles, and the gaps from thence to Waikouaiti, near the north-east boundary, are few and short. The West Coast belt extends with greater or less continuity right across the country to the Waiau valley, and its resources are comparatively unknown. The timber on the seaboard is good, but that in the interior is supposed to be scrubby. There is a considerable quantity of birch in the seaboard forest from Martin Bay to Preservation Inlet, but round the south and east coasts they consist of pines and the other common varieties. Stewart Island is one large pine forest, with a fair sprinkling of rata. Southland is remarkably well supplied with timber. A glance at the map shows an alternation of bush and open country that resembles the conception of a landscape gardener more than a natural arrangement. These isolated patches of forest embrace the whole width of the country, and extend 50 miles inland. One of the largest bushes in the interior of the province extends along the face of the Eyre mountains from the Five rivers to the Te Anau lake, including the Mararoa district. It covers about 400 square miles. This and the lake forests, altogether about 400,000 acres, are all birch. The principal forests now available near the sea, in Southland, are from Riverton to the Waiau, sixteeen miles long by twelve broad; and the seaward bush, from Invercargill to the Mataura, twenty miles long, and from two to three broad. The Ototara, Waikiwi, and Makarewa bushes in the vicinity of Invercargill are also of considerable extent. Following up the coast the next large forest is the Tautuku bush, extending from Waipapa point to the Clutha river, a distance of forty-five miles and inland about twelve. We have then smaller patches at Kaitangata, Akatore, Dunedin, Waikouaiti, and Otepopo. The principal isolated bushes in the interior occur at Waiporai, Tapanui, and Switzers. Except on the west coast, where it descends to sea level, birch does not exist in forests below an altitude of 900 feet.

The principal supply of provincial timber for the Dunedin market comes from Southland and Catlin river, where the forests are accessible to water and railway carriage. Although Stewart Island is particularly well favoured in respect to harbour accommodation, its isolated situation has hitherto been a barrier to the development of the timber trade, and the west coast supplies have never been touched.

Classification.

Timbers are usually arranged into classes, according to their botanical or structural affinities and peculiarities. The most common arrangement at home is to divide them into leafwoods and pinewoods, which keeps the hard and soft kinds separate; but this mode of classification would not have the same result in New Zealand. I shall therefore consider the Otago timbers under two heads, with the conventional names of "Hardwoods" and "Softwoods."

Hardwoods.

Mapaus.

The trees in this family are too small to yield useful building materials; but it is important in furnishing the strongest wood in Otago, I have therefore given it the first place in the tables. The five trees that will be considered under the generic name of Mapau are not all members of the same botanical order. The first three are *pittosporeal*; the fourth, red mapau, is the only Otago representative of a large New Zealand family; and the fifth, white mapau, although belonging to an extensive order, has no immediate relatives in the colony. The mapaus are found in all the low-lying forests, and are particularly plentiful in the neighbourhood of Dunedin.

No. 1. Black mapau—Pittosporum tenuifolium. A small tree seldom exceeding 30 feet in height, and twelve inches in diameter. It has pale green shining leaves and purple flowers. The wood, which is of a dirty white colour, is tough and fibrous. Mr. Balfour's experiments at the New Zealand Exhibition, showed it to be nearly 90 per cent. stronger than English oak. *

No. 2. Black mapau—Pittosporum Colensoi. With the exception of being generally larger, this tree is identical with the former; indeed, some authorities suppose that they are merely varieties of the same species.

No. 3. Turpentine—Pittosporum eugenioides. This is the largest of the mapau family; it sometimes attains a height of 40 feet, with a diameter of 24 inches. The bark is thin, and of a light colour; the leaves are silvery green, and the flowers pale yellow. Altogether, this is one of the handsomest trees in Otago. The bark exudes a thick gum, and the juice of the leaves, which is somewhat similar, was formerly used by the Maoris as a perfume, but I fear it is too resinous for European tastes.

The three trees above described yield a close, compact, heavy wood, hard, tough, and fibrous in the grain, but much given to warping when used green. It is not durable in fencing posts, or similarly exposed situations, but answers well for rails. Hitherto this timber has not been used in constructions of any kind; it is not suitable for many building purposes, but would do for handles and implements where strength is required.

No. 4. Red mapau—Myrsine urvillei. This is a small tree, well known

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* This and all subsequent comparisons of the same kind throughout the paper are made from the results of Balfour's experiments as compared with those of Barlow, the standard authority in Balfour's time. Recent experiments by Laslett give, in some cases very different results, so a better comparison between the strengths of Otago and other timbers can be made by inspecting Table IV., where Barlow's and Laslett's experiments are both given.

to everyone from its conical shape and dark foliage. It seldom exceeds fifteen inches in thickness, but is much prized by settlers on account of its durability and straightness of grain. The timber is strong, heavy, and compact, like English beech, but much darker in colour. Red mapau will not stand long in the ground; but, so far as ordinary decay is concerned, it seems almost indestructible in most other situations. Many of the braces in the old Dunedin Jetty, erected seventeen years ago and recently removed, were of mapau sapling three or four inches in diameter. They were nearly all in good preservation, and free from the ravages of marine worms. Slight symptoms of approaching decay were observed in the braces that had their butt-ends in the water, but all others were quite sound. The timber is, however, very subject to the attacks of a small boring beetle when kept dry. Hitherto red mapau has only been used for firewood and fencing, but it is suitable for making furniture and carpenters' tools.

No. 5. White mapau—Carpodetus serratus. A small tree like the black mapau, No. 1. It has mottled green leaves, and large white flowers; the wood is white and fibrous. Although its absolute strength is not so great as that of the red mapau, it is tougher, and consequently better suited for the handles of tools.

According to observations made by Mr. T. Baber, C.E., Auckland, young trees of the mapau family attain a height of thirteen to seventeen feet in ten years.

Manuka and Rata.

These trees belong to different branches of the Myrtle family, one of the most extensive in the world. They resemble each other in the quality and appearance of the timber and the bark, but are very different in size of trunk and character of foliage; they also affect different localities and soils.

No. 6. Manuka—Leptospermum scoparium. This is the variety known as white manuka, which is much smaller than the red. It grows best on stiff clayey soils that will scarcely produce anything else, but is common on the margin of large bushes in all the low-lying districts of the province, where it acts as a breakwind to less hardy plants. This tree is best known as an ornamental shrub, but occasionally attains to a diameter of from nine to fifteen inches. Its properties as a timber are generally the same as those of the next variety:—they will be considered further together.

No. 7. Manuka—Leptospermum ericoides. Is common in isolated positions on the whole of the eastern seaboard, and occurs in considerable quantities in the vicinity of Dunedin, Purakanui, and Otepopo. The tree occasionally attains a height of sixty feet, with a diameter of from two to three feet at the butt; but these are extreme sizes—logs thirty feet long and ten inches diameter at the smaller end may be considered the practical limit of workable timber. So far as habits and habitat are concerned, this tree is identical with the preceding variety. Like most other hardwoods, manuka does not grow straight, and it is much given to warping and cracking; but I do not know that it inherits these defects to a greater extent than is done by jarrah, ironbark, and other Australian timbers of the same class, and it is freer from heart shakes and knots.

Manuka is noted for its great strength and hardness, combined with a considerable amount of toughness, although, as a class, it did not give the highest average. One specimen stood the greatest transverse strain of any Australasian timber tested at the New Zealand Exhibition. Manuka is one of the best timbers in Otago for firewood, consequently there has been a great demand for it, particularly in the vicinity of Dunedin, and the supply is running short; but it is satisfactory to note that young trees grow up rapidly when the old ones are removed. This timber is well adapted for piles in situations where they are kept constantly wet, for swingletrees, spokes, and handles of tools, also for the teeth of wheels. This last is a purpose that requires wood of a particularly good quality, and although not quite so suitable as rata, manuka has been found to answer admirably. The teeth in the spar-wheels of the "*Express*" and other coasting steamers are made of manuka, and they are wearing remarkably well.

The old settlers had a high opinion of the durability of manuka, and used it extensively in fencing posts, house blocks, and similar situations of the most trying kind, but it has not proved equal to their expectations. Under ordinary circumstances manuka will decay in the ground in from six to ten years, according to the situation. The longest lived fence that I have heard of is at the Beaumont Ferry, where the posts were not decayed quite through in eleven years. This is, however, an exceptional case, as the fence was erected on dry, porous, alluvial soil, that did not retain moisture. Manuka has proved very durable in marine works;—the great majority of the piles in the old Dunedin Jetty, erected seventeen years ago, were of this timber, and remained quite sound till its removal last month. The George Jetty at Port Chalmers, erected a year later, is in the same condition, but here the test has been more complete—all the other timbers are very much affected by the *Limnoria*, and the manuka is untouched. Mr. Kirk, in 1874, reported that he had seen manuka fender piles at Port Chalmers much perforated by the *Teredo*; but the piles he refers to must have been removed since his visit, for there are no signs of the worm in the manuka piles now. The only evidence of its having attacked this timber is in the Bowen Pier, erected four years ago, where one white manuka has been perforated to a small extent.

No. 8. Rata—Metrosideros lucida. This tree grows on high ground at Catlin River and the Longwood Ranges, but descends to sea level at the Bluff, Stewart Island, and the West Coast. It grows best on a light gravelly soil, and attains to a height of thirty or forty feet, and an extreme diameter of about six. Logs can be obtained twenty-four feet long and three feet diameter. The tree sometimes grows with a clear straight stem of this height, but frequently it divides into large branches three or four feet from the ground; this kind furnishes valuable bent timbers for ship-building. Rata has a thin stringy bark like manuka, but larger leaves, and beautiful red flowers. The timber is the heaviest in Otago, being a little heavier than water. It is very dense and solid, with little or no sap-wood, and of a dark red colour like mahogany. Although not nearly so strong, rata is suited for many of the purposes to which manuka is applicable, and has an additional advantage in being larger, straighter grained, and less liable to warp. Its dark colour might render it suitable for furniture, but I fear the absence of figure will be an objection. Hitherto rata has been little utilized. The construction of railway waggons at Invercargill, and the making of teeth and bushes, are almost the only purposes to which it has been applied, but the result is very satisfactory. The bearings of a water-wheel at Waikara are in good order after eighteen years' service, and the railway waggons are pronounced equal to those made from imported timber. Mr. M'Queen prefers rata to any other native wood for teeth and bushes. He says that manuka and kowhai do not wear so well—they wear off in grit or threads, whereas friction only increases the glassy hardness of rata.

Although this timber has not been used in situations that would test its durability, there is every reason to believe that it possesses this property to a considerable extent. I show a sample taken from an old log on a part of the Kaihiku Ranges, where no living rata tree has existed since the settlement of the province. It is still quite sound, and there is a large quantity in the same condition.

No. 9. Kowhai—Sophora tetraptera. This is the sole New Zealand representative of a large genus of the pea tribe, but it is intimately related to the well-known *Clianthus* of our gardens. The tree, which is of solitary habits, is found in shady damp situations and on light soils in all the seaboard forests. It grows to a height of about forty feet, and has a clear straight stem about twenty-five feet long, and from eighteen inches to three feet in diameter. It seldom exceeds two feet in the vicinity of Dunedin, but from that to three feet is quite common in Southland, particularly at Forest Hill. Kowhai when young has a smooth, tough, and stringy bark, which gets coarse and brittle as the tree approaches maturity. It has beautiful drooping foliage of a feathery appearance, and yellow flowers like laburnum. Altogether the plant is one of the handsomest in our forests. It is popularly supposed that kowhai is a very slow grower, and the settlers believe that it takes twenty years to produce an axe handle, but this is an erroneous idea. So far as can be determined from the annular rings, an ordinary sized tree reaches maturity in from 150 to 200 years. It should also be noticed that the tree is easily raised from seed, and easily transplanted.

The timber is remarkably straight grained and free from knots, but is subject to a heart-shake that impairs the strength of beams and induces splitting in piles. It is stronger than rata, but weaker than manuka. It is, however, superior to both in toughness, and warps very little. The sap-wood, which is clearly defined, is very small; in about 200 logs, ranging from six to twenty-two inches in diameter, it never exceeds one and half inches in thickness. The wood is of a yellow colour like laburnum, but resembles oak in grain and figure. It contains a strong resin or gum, the peculiar smell of which never leaves the timber however well seasoned.

Kowhai is used for the same purposes as manuka and rata, together with fencing posts, house blocks, piles and similar work in a damp situation, for which it is better adapted than either. The screw shaft bearings of the "*Betsy Douglas,*" and the pins and bushes of the paddle floats of the "*Coomerang*" are of kowhai, and Mr. Sparrow pronounces it equal to *lignum vitæ* for such work. Messrs. Guthrie and Larnach use this timber extensively for carved work, such as the rims for carriage wheels, the top of circular windows and tilt frames. A good proof of its toughness and straightness of fibre is given in the teeth and bows of hay rakes. The latter are turned to the diameter of a quarter of an inch, and bent into a semicircle of nine inches without sign of giving way.

The durability of kowhai is thoroughly established. It has never been known to fail in any situation in which it has been tried. But it was scarcely necessary to make a trial, for the old trunks that have been lying in the forests from time immemorial are still as sound as when they fell. Indeed this old timber is frequently used for fencing posts and house blocks. Kowhai has been little used in marine works. The only instance that I know of is some bracing in the old Dunedin jetty, which was perfectly sound after being in place for seventeen years. The same remark applies to fencing and house blocks that have been in use for a much longer period.

No. 10. Fuchsia—Fuchsia excorticata. The fuchsia, which is the parent of many of the cultivated varieties, can scarcely be called a timber tree, but as it possesses many good qualities, and has been applied to useful purposes, it is entitled to a passing notice. The tree, which is found along the seaboard, sometimes attains a height of thirty feet, and a diameter of two feet, but it is so twisted and gnarled that it seldom yields a straight fencing post. The timber is hard, tough, and imperishable, but much given to warping and cracking. It has been used in house blocks for 20 years without showing symptoms of decay.

No. 11. Broadleaf—Griselinia littoralis. There are few trees in the bush so conspicuous, or so well known as the Broadleaf, which is the sole Otago representative of its species. It is found in all the low-lying forests, but attains its maximum size on the East Coast. It grows to a height of fifty or sixty feet, and a diameter of from three to six; the bark is coarse and fibrous, and the leaves a beautiful deep green of great brilliancy. Although much larger, this tree, like the fuchsia, furnishes very little serviceable timber; it is bent and twisted, irregular outside, and hollow in the heart. The timber is very hard and brittle, and, although crooked, is easily split; it is red in colour, and sometimes prettily marked, and not liable to crack or warp, consequently it would make furniture. Hitherto it has only been used in fencing, house blocks, and knees for boat-building. The durability of broadleaf in any situation is fully established; it has never been known to fail, and old settlers consider it the most lasting of Otago timbers.

No. 12. Kamai—Weinmannia racemosa. There are two trees of this species in New Zealand, but this is the only one in Otago: it belongs, however, to the same order as white mapau, which it resembles slightly. The properties of this timber, and its identity, have for the last year or two been the cause of considerable misconception and confusion throughout the Province. I shall therefore endeavour to describe it so as to clear up all doubts.

As will be seen by the tables of names, kamai is called black birch in the Catlin River District and Southland, which name is given on account of a supposed resemblance to the "birches," or, more correctly, "beeches," a number of which occur in that locality. I cannot understand how such an idea could have originated, for, except in the case of the bark of one, there is not the slightest resemblance between the birches and kamai. Furthermore, the birch that is like in bark is quite unlike in foliage, and it does not grow in the same forest as kamai. Whatever be the reason, the misapplication of names is complete, for the birches are still commonly called kamai in Southland, and this has brought the latter into disrepute, the birch with which it is most frequently confounded being very subject to decay in damp situations. Kamai is little known on the east coast, north of the Clutha River, but is common from thence right round the south and west coast to Martin Bay, and particularly plentiful at Catlin River and the western districts. Like the pines, it is rare on high altitudes.

Hitherto this timber has been considered of little value by scientific and professional men; it is described as small, and inferior in strength and durability. Mr. Kirk questions all its good qualities, and Dr. Hector says "the use of this timber must be guarded against, as it is perfectly worthless." I hope to give it a much better character. Kamai is generally from fifty to seventy feet high, with a trunk from twenty to twenty-five feet long, and eighteen inches to three feet in diameter, but frequently it attains a height of from 80 to 100 feet, and a diameter of from three to four. I am assured that trees of this size are quite common on the flat land south of Catlin River. Like most hardwoods, this tree does not grow quite straight, but the bends are not so great as to become a serious defect. The bark, which is of a light grey colour, is very thin, and adheres firmly to the trunk even when dry: the leaves are of a brownish colour, about two inches long and one inch broad, with prickly edges and a sharp stiff point. The wood, which is straight grained, dense, and heavy, has a light brown ground colour, with grey and red figures and streaks, and very conspicuous medullary rays. The streaks are very curious—they look like the broad streaks of a carpenter's pencil drawn at random from top to bottom of the timber, and when dry they form a depression in its surface. Kamai has little or no sap-wood at any stage of its growth, so may be utilized, however small. The growing trees are very much subject to heart decay, few of the oldest ones being fit for sawing into large scantling. When sawn up green and exposed to the sun, this timber cracks and twists to a great extent. A number of logs now in Messrs. Guthrie and Larnach's yard are almost useless through this cause. I find, however, that there is no inordinate splitting or warping in timber that has been seasoned gradually with the bark on, and the ultimate shrinkage under any circumstances is not excessive. The strength of kamai has never been tested; it will, in all probability, stand a considerable strain, but may give way without much warning, as it does not seem to be very flexible. The bark of kamai is rich in tannic acid, consequently it is suitable for tanning leather. An analysis by Mr. Skey, of the bark of towai, a variety found in the North Island, gave thirty-one per cent. of tannic acid, which is nine per cent. richer than the bark of young oak, the best tanning material in England.

This timber is suitable for fencing posts, house blocks, railway sleepers, piles, beams and general framing, but not for boardings or joiners' work. Being prettily marked, it might be used for turning and other small cabinet-makers' work.

The durability of kamai under the most trying circumstances is, in my opinion, thoroughly established. Mr. Kirk says that he found old specimens in the forest that were much decayed and worm-eaten, but I have never seen any in which the heart-wood was so affected, and kamai used by the settlers has never been known to fail. I show a section of a tree cut in Seaward

Bush in April, 1862, and which has lain in the forest ever since; it is quite sound and fresh right out to the bark. I also show samples of a tramway sleeper, made from a young tree, that has been in use at the Kew Sawmills, Southland, since 1866; it is still in good preservation. Mr. A. C. Purdie, on a recent visit to Catlin River, kindly collected some valuable information on the subject for me. He found a log that had lain partly buried in the earth for thirteen years quite sound, except about a quarter of an inch of the outside sap, which was beginning to decay. He also was shown saplings that had been used in tramway sleepers for five or six years. Although thus made of immature timber, and tried in the most severe manner, they are still as fresh as when put in. I could multiply similar proofs of the durability of kamai from various districts, and on undoubted authority, so I have no hesitation in giving it a high place for durability. As noticed by Mr. Kirk, it is subject to the ravages of a small boring worm, but the damage done by this animal is too insignificant to be considered a defect in the works for which the timber is best adapted.

Pokakos—Elæocarpus.

The only two trees of this genus in New Zealand occur throughout the whole eastern seaboard of Otago, and are very common in the vicinity of Dunedin. So far as habitat, size of trunk, and general habits are concerned they resemble closely the kowhai, but differ greatly from it in character of leaves and timber.

No. 13. Pokako—Elæocarpus hookerianus. This tree grows to a height of sixty feet, with a clear trunk of from thirty to forty feet long, and two and half feet diameter at the base. The sap-wood is of a dirty white colour, and the heart a blotched or marbled brown. There is, however, very little heart-wood. A tree three feet in diameter will have at least six inches of sap all round. The wood is tough and flexible and difficult to split, but not durable in a damp situation. Pokako is frequently sawn up and sold as white pine, and used for the same purposes as that timber. It has also been made into earth waggons on the Southland railways, and found to answer admirably. The heart-wood is suited for turning or light cabinet work.

No. 14. Pokako—Elæocarpus dentatus. This is recognized as a distinct tree from the last in the North Island, but not so in Otago. The two are found together, and are almost identical in size and appearance, but the wood is different. This one yields a much harder and more lasting timber than the other. It is also freer from sap-wood and easier split. The wood has a pinkish brown colour. Having been little used here in exposed situations we cannot speak as to the durability of pokako, but it is much prized for this property in the North, where it is known by the name of Hinau. Mr. Kirk found mine props and tramway sleepers quite sound after being in use for nine years. This timber is used in Otago for much the same purpose as the preceding variety.

Ribbon Woods.

Table I. gives the name of three different trees (Nos. 15, 16, and 17) that are popularly known by the name of Ribbon Wood. They are, botanically, quite distinct, but possess some properties in common, and are of little economic value, consequently I shall treat them collectively. The trees are seldom more than eighteen inches diameter. The wood is white or light brown, with strongly marked medullary rays, tough and easily split, but quite worthless in point of durability. One variety is so straight grained that long rails can be split quite parallel though only an inch thick. For this reason the timber was formerly in great demand for fencing and shingles, but experience of its liability to decay has brought it into disrepute. Ribbon wood is not durable in any situation that is in the least exposed to the action of the weather.

No. 18. Grass Tree—Panax crassifolium, is common everywhere throughout the province, and well known from its unique appearance. It grows to a height of twenty-five feet, but the trunk seldom exceeds twelve inches in diameter. When young the leaves are from twelve to eighteen inches in length, and droop against the stem, but as the tree grows old they gradually decrease to three or four inches, and become quite erect and rigid. The timber is hard, strong, and durable. The young wood being particularly tough and elastic is suitable for axe handles and similar purposes. The piles in the first jetty erected by the settlers at Port Chalmers in 1850 were of grass tree. A portion of it, still in existence, shows the timber to be in good preservation, and perfectly free from the ravages of marine animals. A piece of the piles between high and low-water mark is discoloured and soft, but the fibre of the wood is still intact, and the remainder of the piles are as sound as when erected. It is worthy of remark that these piles emit a strong offensive smell like that from a cow byre, and that cattle will not eat the leaves of any of the grass trees, which is quite in keeping with the general character of the ivy tribe to which they belong. They have all a strong smell more pungent than agreeable. Probably this may account for the fact that the piles at Port Chalmers were not molested by marine animals.

Soft Woods.

Coniferæ.

So far as the constructive arts are concerned this is the most important of the botanical orders. According to Dr. Hooker, it is represented in New Zealand by five genera and thirteen species, as follows:—

1. Dammara, consisting of 1 species
2. Libocedrus ,, ,, 2 ,,
3. Podocarpus ,, ,, 5 ,,

4. Dacrydium ,, ,, 3 species.
5. Phyllocladus ,, ,, 2 ,,

Total number of species 13

Of the above one in each of the three last genera is a mere shrub or small Alpine tree frequenting the mountain ranges of the interior, generally from an altitude of 3,000 feet upwards. They are therefore of no economic value. The first in the list is the famous kauri, monarch of New Zealand timbers. Unfortunately it is absent from Otago, therefore does not come within the scope of our inquiry. This reduces the number of the *Coniferæ* timber trees in the province to nine. I shall now consider them seriatim in the order established by Hooker, as above, which is also followed in Table I. hereto appended.

No. 1. Cedar—Libocedrus bidwillii. This tree belongs to a small subdivision of the coniferæ family that has only three representatives out of New Zealand, all of which, like our native plants, frequent mountain ranges. These three are all found on the western side of the American continent, from British Columbia to the Straits of Magellan. The members of this genus were formerly classed as *Thuja* or *Arbor vitæ*; but the present name, which means incense cedar, is now universally adopted. I do not know why they should be so named. The New Zealand varieties do not emit incense, and under any circumstance the name seems inapplicable, for the genus was not discovered until long after the practice of burning wood for incense had ceased.

"The Handbook of New Zealand Flora" gives two species of cedar—*Libocedrus doniana* and *Libocedrus bidwillii*; the former of which is stated as furnishing good and the latter worthless timber. In naming *L. bidwillii* Dr. Hooker says :—"I advance this species with much hesitation. It is difficult to suppose that a timber tree described as having excellent wood, and growing at the Bay of Islands at the level of the sea (I gathered *L. doniana* on the banks of the Kawa-kawa river) should be the same as one inhabiting the mountains of the Middle Island, and described by Buchanan as having soft worthless wood, but I can find very little difference between the specimens." He further points out that they are botanically alike, and seems to depend to a great extent on the difference of the timber in making them distinct species. I hope to prove that instead of being worthless this is one of the most valuable and durable timbers in Otago. It is therefore possible that the trees in the North and South Islands are identical. Mr. Buchanan refers to the Otago cedar as *L. doniana*, and mentions no other, but Mr. Kirk seems to recognise two distinct species, and calls the Otago one *L. bidwillii.* I shall therefore adhere to the latter name, but assume that the tree that I describe is the same as Buchanan's *L. doniana.*

Cedar is plentiful on the mountain ranges of the east coast, from the Mataura River to Waikouaiti, but scarce in all the other forests of the province; it is generally found from an altitude of 1,000 to 2,000 feet. The greater portion of the timber trees on Mount Cargill, and the northern slopes of Flagstaff and Mihiwaka, are of cedar. This tree is easily recognized: the trunk is usually quite free of branches, and the head is of a handsome conical shape. The lowest branches, which are also the widest, grow in a horizontal direction, consequently the base of the cone is well-defined. The bark is rough and fibrous like totara, but the foliage, which is erect and stiff, has a greater resemblance to old rimu. The tree grows to a height of from sixty to eighty feet, with a clear trunk of from twenty to forty feet long, and two to three feet in diameter, but the larger of these sizes is rare. At Mihiwaku the trunks are generally from eighteen inches to two feet in diameter, and twenty feet long, but they are somewhat longer near the head of the Waitaki. The tree from which one of the boards shown was cut grew on Pine Hill, the trunk of which measured thirty-five feet in length. The cedars of the Kaihiku Ranges are the same size as at Blueskin, but some trees at Catlin River are much larger. One trunk recently measured was forty feet long, three feet six inches in diameter at the butt, and three feet at the top; the log had a slight twist in the grain, but was straight and sound throughout. Buchanan mentions a cedar, cut in the vicinity of Dunedin, that was four feet in diameter.

The wood is of a dark red colour, straight grained and solid, but rather weak. It resembles very much the famous redwood of California (*Sequoia sempervirens*), which is the timber most used in America for railway sleepers, and here for Venetian blinds. Buchanan says that the heart-wood of *L. bidwillii* is so soft that soap-bubbles may be blown through a foot length of it; but this is no criterion of its value, for the same thing may be done with most straight grained timbers. Blowing bubbles through new planes, which are made of solid beech wood, is a favourite amusement among young carpenters in the Old Country, and I have seen bubbles blown quite easily through an oak stave three feet long that had been taken from an old beer cask. As a matter of curiosity, the experiment was tried with cedar; samples of old and young timber, seasoned and unseasoned, were tried, but in no case could bubbles be blown through three inches of heart-wood. We must therefore conclude that Mr. Buchanan's specimen was more porous than usual.

Cedar grows faster than most European timber trees; judging from the annual rings, it reaches maturity in from 170 to 400 years. There is very little sap-wood generally—not more than from an inch to an inch and a half in ordinary trees. The large one cut at Catlin River had two inches at the butt and three at the top.

This tree is very much subject to heart decay; probably a third of the aged trees in the Blueskin and Kaihiku districts are more or less affected in this way, but those on lower ground on Catlin River are nearly all sound. The decay is usually a core three or four inches in diameter, but occasionally reaching seven inches, and having similar patches throughout other parts of the trunk. This is a serious objection so far as economical cutting up is concerned, but it does not affect the durability of the timber, as the decay ceases as soon as the tree is felled. Although a roughness of bark does not always indicate a hollow heart, it has been observed that a smooth one is a sure indication of sound timber. Cedar has been objected to as subject to excessive and irregular shrinkage and warping, but my experience of it does not warrant such a conclusion. I believe that the sound timber is as little subject to these defects as any other of the pines.

Hitherto this timber has been little used, except for fencing posts, house blocks, piles, and railway sleepers; but it is suited for ordinary house framing, and other purposes of a similar character, where great strength is not requred; the straighter grained portions would make shingles, mouldings, and small cabinet-work. I am assured that good samples work as freely as clear pine.

I have already referred to the low opinion entertained of this timber by leading authorities. It is further described as not durable by Dr. Hector, Mr. Buchanan, and the Jurors of the New Zealand Exhibition. I cannot understand how it could have got into such bad repute, for I can find no evidence against it; on the contrary, there is abundant proof that cedar is one of the most durable timbers in Otago—even the sap-wood lasts for years in situations where the heart of many other pines would fail. Much of the timber found on the ranges, where no tree has lived for centuries, and which is still in good preservation, is cedar. I show several samples found on the bare ranges at Kaihiku. There is a fence of this timber at Tokomairiro twenty-two years old. Mr. James Elder Brown sent me a post in 1872, the heart-wood of which was quite fresh, and he said that the whole fence, about thirty-five chains long, was in the same condition. I show a portion of a cedar post taken a fortnight since from a stockyard on the old Waikouaiti Road, near Flagstaff, erected twenty-three years ago. The heart-wood is as sound as when the tree was felled, and the sap is only decayed for a short distance at the ground level. All the posts in the enclosure are in the same condition; they average from ten to twelve inches in diameter, with about one and a half inches of sap-wood. Mr. Peter Thompson, Queen-street, has a sapling cedar four and a half inches diameter for a flagstaff; it has been eight years in the ground and is still perfectly fresh. Any other pine sapling, under the same circumstances, would be quite rotten in twelve months.

Podocarpus.

This section of the Coniferæ comprises about 60 species that are scattered over all parts of the world except Europe and North America. Of this number Otago possesses five, four of which are timber trees, and one an Alpine shrub.

No. 2. Miro—Podocarpus ferruginea. Miro is common in all the forests of Otago that lie under an altitude of 1,000 feet, and occasionally in those above that level. It is generally found associated in the same bush with red pine. The tree grows to a height of from fifty to ninety feet, with a clear straight trunk twenty to fifty feet long, and eighteen inches to three feet in diameter, but the tallest trees are not always the thickest, particularly in dense forests. This timber, which is far inferior to black pine in point of durability, is so like it in many respects that they are frequently confounded. I shall therefore describe their leading points of resemblance and difference. Generally black pine is a heavier timber than miro, but this is scarcely a distinction, for a full grown tree on the one hand may be compared with a young one on the other. The scales on black pine bark are thicker, and the furrows deeper than those of miro. The foliage of black pine is flat like the English yew, and of a light green colour, shiny on the lower side. That of miro is roundish and erect, and of a deep dull green, which turns to rusty red on drying. Black pine has a cluster of from four to seven small dark berries, scarcely noticeable among the foliage; while miro has a conspicuous single berry like the dog rose or sweet briar, almost identical therewith in size and shape, but of a redder colour. This berry has a strong odour of turpentine. Although black pine is sometimes marked in a decided manner, it has always a ground colour of clear yellowish-brown, but miro is blotched throughout, and the ground colour, which is light dirty red, varies every few inches. A horizontal section of the latter shows that the heart contains a considerable portion of dark-colored wood, which runs in star-like points towards the circumference, hence the blotched appearance of the timber. The figure can be varied at pleasure by simply changing the direction in which boards are cut. The annual rings and other markings in black pine are generally concentric. Consequently a great variety of figures cannot be obtained. Generally the wood of black pine is lighter and brighter in colour and easier worked than miro. The timber can also be distinguished when green by the taste and smell. These are strong and pungent in both cases, but there is a peculiarity in each easily recognised when once known. These particulars may seem too much detailed, but when we consider the disappointment and loss that have frequently resulted from the substitution of one timber for the other, their points of difference can scarcely be too well known. Miro is a fast growing tree, and the annual rings are tolerably distinct. A stump twenty-two inches diameter on Pine Hill gave the age at 160 years. There is frequently more sap than heart in the timber, and the distinction between the two qualities is not well marked, consequently it is not suitable for exposed work, even if durable. A log from a young miro on Pine Hill, twenty feet long eighteen inches diameter at the base, and twelve inches at the top, had an average of seven and a half inches of heart. At Catlin River the smaller trees are almost three-fourths sap, but the full grown ones have only from two to four inches.

Aged miro has usually a crack in the heart, but it is small and straight, so cannot be considered a serious defect. The timber is the strongest of the New Zealand pines, consequently is well adapted for beams in a dry well ventilated situation. As it does not shrink or warp to any inordinate extent, it is suited for ordinary house building, but being more difficult to work than red pine, the latter is preferred by carpenters. Miro is not durable in any exposed situation, except under water. It will perish in a few years if in contact with damp, and is very subject to the ravages of the large grub, which perforates the timber to the heart. I have seen bridge piles at Wallacetown a perfect mass of rottenness through the latter cause, but the portion below water level was sound to the bark. Mr. Kirk reports the same state of things at the railway protective works in Bluff Harbour. The outside piles exposed to the influence of sea water were perfectly sound, but those in the embankment a few feet further in were quite rotten. He attributes the preservation of the former to the action of salt water, but the example at Wallacetown would indicate the same result in any wet situation. Twelve-inch miro piles in the George-street jetty, Port Chalmers, erected in 1860, are eaten away to about four inches by the *Limnoria*, but are otherwise in good preservation.

No. 3. Totara—Podocarpus totara. Totara, which is the best known and most easily recognized of our timber trees, is common in all the forests of the province up to an altitude of 1,000 feet. It is generally found mixed with black pine, but occasionally, as on Inch Clutha, forms an entire bush of itself. The supply of totara in the vicinity of Dunedin and Invercargill is getting scarce, but there is still a considerable quantity about the Clutha mouth, and the west coast supplies are still untouched.

The timber seems to grow well on any ordinary soil, but prefers rich alluvial flats. Ordinary sized trees attain to a height of from sixty to eighty feet, with a clear straight trunk from twenty to fifty feet long and three to five feet in diameter; occasional trees are found up to seven and eight feet, but these dimensions, though common in the North Island, are rare in Otago. Forty stumps recently examined on Inch Clutha range from three to four feet, with a few up to five; the thick trees are generally much shorter than those of medium diameter. The bark is of a light grey colour, thick, furrowed, and stringy; it was formerly used by the natives and old settlers in covering the walls and roofs of whares and huts.

Totara is a comparatively slow grower—a tree three feet six inches in diameter is estimated to be 550 years of age. Mr. Hay, of Auckland, found young trees to grow about twelve feet six inches in ten years; when fully established, they grow two feet in a season. Totara is one of the easiest reared of our native trees. The tree has very little sap-wood, but is subject to decay in the heart, like cedar; it commences on Inch Clutha when three feet six inches in diameter, and increases with the growth beyond that. The timber is of a reddish colour, like pencil cedar, but varies considerably, according to its age and the soil in which it is grown; it is straight in the grain, easily wrought, and not given to warping, but brittle, and apt to shrink if not well seasoned. Totara is suited for fencing, railway sleepers, and piles, together with architectural and engineering purposes generally, except beams, for which, on account of weakness, it is not so well adapted as many of the other timbers.

The durability of totara under the most trying circumstances is well established and well known. I show a piece of a log found at an elevation of about 1,300 feet, on the Mount Pisa Ranges, where no tree has stood for centuries; it is as sound as when the Moa found shelter beneath its branches. I also show a survey peg from the division between Sections 1 and 2, Block X., Waihola survey district, put in by Mr. Kettle in 1848, and taken out in 1874, which is still quite fresh. All the oldest house blocks and fencing posts throughout the province that were of heart of totara are in the same condition, so further proof of its durability is unnecessary. I should, however, remark that piles or posts made of saplings with little heart-wood will not last long in the ground. Mr. Kirk, of Wellington, observed this in bridge piles, and I noticed it myself in fencing posts; the original telegraph poles on the Dunstan line also show the same thing. In black pine and old totara, where the heart-wood is solid, decay stops whenever the heart is reached; but such is not the case with totara saplings—the disease is communicated by the sap to the heart, and both perish together. Totara in the North Island stands the marine worm better than any other native timber, but it has not shown any great resisting powers here. The piles in the Bluff wharf were perforated to the heart, and very much riddled in a few years.

The totara of the west coast, which is generally smaller than that of the east, is considered by Dr. Hector and Mr. Buchanan as a different tree, and Mr.

A. C. Purdie informs me that there is a variety found at Catlin River not described by any of the botanists; it is of a large size, with a smooth bark, and yields very soft ornamental wood suitable for inside work.

No. 4. Black Pine—Podocarpus spicata. Like its two congeners already described, this tree frequents all the low-lying forests of Otago, but it is more plentiful on the east than the west coast; the best supplies now available are at Catlin River and Southland.

The tree grows to a height of from fifty to ninety feet, with a trunk twenty to thirty-five feet long and three to five feet in diameter; the latter, however, is an extreme size—four feet may be taken as the limit in ordinary cases. At Catlin River the sound trunks seldom exceed twenty-four feet in length and three feet in diameter. The appearance and properties of black pine have already been discussed in comparing it with miro, so it is only necessary to refer to the peculiarities of the former. The timber reaches maturity in about 400 years, and has about two inches of sap-wood when ripe. The tree is subject to a small heart-crack, which developes into decay when allowed to proceed, but the evil is not so great as in totara or cedar. Next to miro, this is the strongest and heaviest of the New Zealand pinewoods, and it is, without exception, the least given to warping and shrinking, and in all probability the most durable. It is suitable for all the purposes for which totara is adapted, as well as others where greater strength and solidity are required.

Miro, having been frequently substituted for black pine in exposed situations throughout the province, has brought the latter into disrepute, and the resemblance is so great that professional men were afraid to run the risk of making a mistake. The consequence is that its good qualities are to this day little known and little appreciated. I show a portion of a fencing post cut and erected by Mr. Horman, at Makarewa, in June 1861, and taken up this month; the part most subjected to decay, that at the ground line, is perfectly sound. I have seen a black pine log, that had lain in the Waikiwi forest from time immemorial, as fresh as when it fell; it had been there so long that a fuchsia nine inches in diameter was growing across it. I show a few inches off the end of a log that lay for twelve years in a paddock at Seaward Bush; the sap is all worm-eaten, but the heart, even to the end, is quite solid. Mr. M'Arthur sent me, in 1872, a piece of a post that had been ten years in the ground at Waikiwi; the edges at the surface of the ground were almost as sharp as when split, and there were many more in that locality in the same condition. I have already referred to the sapling telegraph posts. Those of birch and totara were rotten through in twelve months, but the heart of the black pine ones, although very small, stood for five or six years; indeed, it was not decayed when the posts were removed to be replaced by iron ones. Black pine, however, does not stand the ravages of the marine worm as well as totara. The retaining wall at Rattray-street, erected in 1867 and recently removed, had been attacked, though so far from the open ocean.

Black pine and totara contain a resinous matter that resists the adhesion of paint when the timber is green. This property, which builders consider a serious objection, is, in reality, a great recommendation, for it promotes seasoning.

I have in this paper adhered to the popular name of black pine for this timber, but the native name matai, which is always used in the North, is becoming common in Otago also. I trust it will soon completely supersede the former.

No. 5. White Pine—Podocarpus dacrydioides. Although more gregarious than the other pines, this tree is found associated with its congeners in all the sub-alpine forests of Otago. It grows freest in low swampy ground, but the best timber is produced on moderately dry soil.

White pine grows to a height of from 120 to 150 feet, with a trunk up to seventy feet long and five feet in diameter at the base. One log lately examined on the Orepuki railway measured fifty-five feet in length, five feet in diameter at the butt, with three feet of solid heart-wood, and three feet in diameter at the top, with one foot of heart. At Catlin river the average dimensions of trunk is forty feet long, and from two feet six inches to four feet in diameter, the largest trees having about two feet of heart. As a rule there is seldom more than two or three inches of heart-wood in trees under three feet in diameter, and the difference between heart and sap-wood is in all cases very indistinct. The shape of the tree, colour of bark, and appearance generally are somewhat like black pine. Still there is little difficulty in distinguishing them when growing, and the difference in the wood is greater than between any other two of the pines. In consequence of the evenness of the colour, and the closeness of the annual rings, it is difficult to estimate the age of white pine. Ordinary-sized trees probably reach maturity in from 370 to 600 years. Young trees are easily transplanted and cultivated. They shoot about eighteen inches per annum. Old trees have a slight heart crack, but it is too small to be considered a defect.

The sap-wood of white pine is of a dull white colour, and the heart-wood of a pale yellow or straw colour. It is the weakest and lightest of the native building timbers tested at the New Zealand Exhibition. Still its strength is about ten per cent. greater than that of European red deal and English elm, and its weight is much the same as the former. The wood is straight grained, soft, flexible, and not given to warping or excessive shrinkage, consequently it is well adapted for flooring, weather-boards, and the other ordinary joiners' work for which white deal is usually employed. Tradesmen will not allow a comparison to be made between the native and imported articles. They say the latter is infinitely superior, and that white pine is too soft and spongy for anything like good work. I do not think there are sufficient grounds for such a conclusion, which is in all probability arrived at by comparing seasoned foreign timber, the only kind that can be got here, with green colonial timber, the only kind that is used. The white pine timber of Otago is in my opinion equal, if not superior, to Baltic white deal for all the purposes for which the latter is adapted, and its supposed inferiority is due entirely to defective seasoning.

White pine is not durable in any situation where exposed to damp or frequent changes from wet to dry. It will not last two years in fencing posts or house blocks; even rails and beams of bridges that are clear of the ground decay in three or four years, the least moisture retained in a joint or mortice brings rapid destruction. The heart-wood is durable, but there is so little of it, and there is so much danger of using sap instead, that no advantage can be taken of its good qualities. I show a piece of white pine heart-wood taken from a large log that has been felled many years at Deborah Bay. It is still in good preservation. Some of the piles in the George-street jetty, Port Chalmers, are of white pine. They are eaten away to a third of their original diameter by the *Limnoria*, but the timber has not suffered much from natural decay. Although soft and weak, the fibre is still intact. Mr Kirk says that white pine in Wellington and other places in the North is subject to the attack of a minute double-winged insect, but so far as I can ascertain it has no such enemy in Dunedin.

This timber is known in all the provinces except Otago by the native name of "kahikatea." I think we should adopt it also, not only on account of being more euphonious, but for the reason that so many timbers in other parts of the world are called white pine.

Dacrydium.

Otago possesses three members of this genus, which is a small one confined to the Southern Pacific; they consist of a large and a small timber tree, and a mountain shrub. According to Gordon, there are only two large timber trees of this family out of New Zealand; one frequents the mountains of Sumatra, and the other is the famous Huon pine of Tasmania.

No. 6. Red Pine—Dacrydium cupressimum. This is the most plentiful of the pines, and the most used timber tree in Otago; it is found in all the low-lying forests round the coast from Waikouaiti to Martin Bay. It grows to a height of one hundred and fifty feet, with a clear straight trunk up to eighty feet high and five feet diameter. A log recently taken at random on the Orepuki Railway measured fifty-five feet to the lowest branch; it was four feet three inches diameter at the butt, three feet six inches diameter at a height of forty feet from the ground, and four feet three inches diameter at the top. At Catlin River mature trees measure about forty feet long by two feet six inches to four feet diameter; those from sixty to eighty feet, of which there are a large number, do not generally exceed eighteen inches in diameter. The logs that came from Pine Hill are usually about twenty feet long, and from eighteen inches to two feet six inches thick. Red pine trunks have little taper, they are almost cylindrical from the ground to the lowest branches; the base is usually furnished with buttresses that run eight or ten feet up, consequently the trunk is not round for that distance. The bark is rough and scaly, and of a dark brown colour; it comes off in large flakes every year, which in course of time forms a huge mound of a peaty nature round the tree. This mound ignites readily when dry, so is possibly the cause of many bush fires. Young red pine is noted for its beautiful green foliage, which droops in feathery tassels like larch or willow; but, as the tree grows old, the foliage becomes stiff and erect like the other native pines. An ordinary-sized tree reaches maturity in about 500 years, and young plants make wood at the rate of about a foot per annum. Seedlings are very tender and difficult to rear when removed from their native forests, and large trees are easily killed by stripping a ring of bark near the roots. The bark of the red pine is good for tanning, and the juice of the young branches was made into beer by Captain Cook; but I have not heard of its being utilized in the same way by any other white man.

This timber has a very large proportion of sap-wood which is not well defined. There is little or no heart in trees under eighteen inches in diameter, a size that is frequently cut into market stuff. The following notes give the quantity of sap-wood in a number of large trees at Orepuki.

No. 1.—4′ 6″	diameter,	8	feet from ground	had	10	inches of sap.
2.—4′ 0″	,,	10	,,	,, ,,	4½	,,
3.—3′ 7″	,,	40	,,	,, ,,	4½	,,
4.—3′ 6″	,,	20	,,	,, ,,	6	,,
5.—3′ 0″	,,	40	,,	,, ,,	4	,,
6.—2′ 8″	,,	9	,,	,, ,,	4	,,

The trunk of No. 1 was forty-six feet long. Three feet logs from Pine Hill, Water-of-Leith, and Blanket Bay, at Messrs. Asher and Co.'s yard, show from three to four inches of sap. One tree nineteen inches in diameter had only nine inches of heart. At Catlin River, where this tree seems to grow remarkably well, the proportion of sap-wood is smaller than near Dunedin;

three-feet trees have only about three inches of sap, which is tolerably well defined, and the heart shows at an earlier stage of growth.

Red pine frequently grows with a twist in the trunk, and more sap-wood on the one side than on the other, consequently the timber is cross-grained and irregular in strength and consistency; mature trees are also subject to heart shakes and cracks. This defect is occasionally a want of cohesion between the annual rings in the inner core of three or four inches, but oftener it consists of a straight crack from three to nine inches long, filled with gum or resin. This opening is of little moment in straight logs, but it renders the whole centre unserviceable for sawing up when the timber is twisted. The state of the bark is a good indication of the ripeness of red pine; trees in vigorous growth have large dark-coloured scales that adhere closely at certain seasons, and those of mature age have short light-coloured scales, easily removed at any season of the year.

The colour of red pine timber is very variable; it ranges from light yellow to deep red, and there is generally a handsome figure in boards. It is the third in order of strength of our Otago pines, but is more irregular in grain than black pine or miro, consequently is less trustworthy in beams. Red pine is much used in house framing and general carpenter-work, for which it is well adapted; but on account of being harder and more brittle, and more given to shrink irregularly, it is not equal to white pine for flooring, weather-boards, and internal joiner-work. Red pine is much prized as a furniture wood, some of its figures being remarkably beautiful. When well fitted and seasoned, it stands as well as most foreign timbers that are used for this purpose.

The heart of red pine is durable; any quantity can be got in the forest quite fresh after lying for ages, but in consequence of its small size, and the danger of using sap instead, we must treat the whole tree as perishable. The ordinary red pine of the market is very liable to decay in any exposed situation. A survey peg which I put into the ground at Tokomairiro in August, 1869, was quite rotten in April, 1872. Beams eighteen inches by fifteen, put into the Southland railway bridges in 1863, were a mass of putrefaction in 1868; nothing but a crust about half an inch thick remained solid, and this was in the most favourable situation possible, for there was no planking on the bridges, and no mortice holes or checks on the upper side of the beams. Although not nearly so bad, a similar state of things was observed in the old Bell Tower, Dunedin, erected in 1864, and pulled down in 1872; some of the timbers were fresh in the middle, but all were rotten at the joints.

Rimu, the native name of this tree, is now tolerably well known in Otago. So if professional men and timber merchants would only encourage its use, it would soon supersede the vague conventional term of "red pine."

No. 7. Yellow Pine—Dacrydium colensoi. This tree is only found in small quantities on Pine Hill, Mount Cargill, and other east coast ranges, but is tolerably plentiful on the west coast.

It is a small tree seldom exceeding forty feet in height, with a trunk twenty feet long and two feet six inches in diameter. It is remarkable in having frequently two distinct kinds of foliage on the same tree, that on the lower branches being flat and pendulous, and on the top ones round, rigid, and erect. The bark is like that of young red pine, but the timber is quite different. It is of a clear yellowish colour, with little sap, straight in the grain, dense in texture, and solid throughout; altogether one of the finest looking of our Otago pinewoods.

The tree contains a large quantity of resinous matter, which cannot be expelled by artificial drying with hot air. It burns freely, emitting a dark bituminous smoke, and a strong smell exactly like the knots of larch. Some Scandinavians near Mount Cargill attempted to extract pitch from the yellow pine, but I do not know if they succeeded. It is from this resinous property in the timber that the settlers' name of tar-wood is derived.

Yellow pine is employed in the North Island for ordinary building purposes, but on account of being scarce and of a small size it is little known in Otago as a timber tree. The durability of the wood is undoubted. Three-inch saplings used as piles in a Maori pah at Waimate are still as fresh as when driven 80 years ago. This wood seems admirably adapted for turning and other work of a similar kind where evenness of grain and density are desiderata.

No. 8. Celery Pine—Phyllocladus trichomanoides. The genus to which the celery pine belongs only embraces three timber trees, one each in Borneo, Tasmania, and New Zealand. Our specimen is common in the northern provinces, and at high altitudes on the west coast, but rare on the east coast of Otago. There are, however, a few trees to be met with in the vicinity of Dunedin and from the Clutha southwards.

The tree grows to a height of from fifty to sixty feet, with a straight clear trunk two to three feet in diameter for two-thirds of the distance. It is a remarkably handsome plant of the true pine shape. The leaves are quite different from the other conifers of Otago. Instead of a mere cluster of thin foliage, the tree is covered with large well-defined leaves like the common celery plant, from which the name is derived, but of a brownish colour. The bark is smooth and solid, dark on the surface, and of a uniform brown colour inside. It is known to be good for tanning, and the natives use it as a dye. The wood is soft, straight grained, tough and flexible, with little sap, but subject to heart decay. The colour is somewhat like miro without the irregular blotches.

This timber has not to my knowledge been used in Otago. It is suited to any and all of the purposes to which the other pines are applied. According to Mr. Kirk its durability is undoubted. He gives it as high, if not a higher place than totara.

Birches.

The next most important class of softwoods is the birches, or more correctly beeches. They are, botanically, true beeches, consequently would be classed with the hardwoods in England, but as the majority of the New Zealand trees yield very soft timber, I have kept them with the softwoods. The birches are the most plentiful of the Otago timber trees, and at the same time the least known, consequently they require careful consideration at our hands. They belong to the genus *Fagus*, which has one representative in Great Britain, the common beech, and a few more in other temperate countries. This genus in turn belongs to the same botanical order as chestnut, oak, hazel, and hornbeam.

As already stated the birches occupy almost exclusively the forests of the interior, and are abundant on the west coast, but rare on the east. There are no large trees in the vicinity of Dunedin, but they occur with more or less frequency in all the seaboard forests south of the Taieri.

As will be seen by the tables, the utmost confusion prevails among the common names of the birches. There are scarcely two districts, a few miles apart, in which the same name is applied to the same tree, and a similar result may be obtained by consulting two bushmen in the same bush. With the view of obviating this difficulty Mr. Kirk suggests "the adoption of new names based on the obvious" characteristics of their foliage. For *Fagus fusca*, tooth-leaved beech; for *Fagus solandri*, entire-leaved beech; and for *Fagus menziesii*, round-leaved beech." On first sight I thought this a capital arrangement, and did my best to establish it, but a fuller acquaintance with the trees convinced me that it was unsuitable. The difference between the leaves in many localities is too small to be noticeable by anyone but a scientific expert, and under any circumstance the peculiarity that is relied on for identification is not always the leading feature in the leaf. For instance, the teeth in some of the leaves of *F. fusca*, from Lake Wakatipu, are so small that they are only seen on close inspection. Indeed they might easily be confounded with the leaves of *F. solandri*, from the Five Rivers Plain, which are nearly as large. The latter are entire, but have a curious horizontal corrugation in the margin that gives them the appearance of being toothed. The leaves of *F. menziesii*, although round, are not always so conspicuously round as some leaves of *F. solandri*, and the nicks in the former are in many cases so like the teeth of *F. fusca* that they cannot be distinguished by popular eyes. From this it will be seen that the names of the birches are still in an unsatisfactory state. Failing good native names, of which there are none that I know of, I would suggest the retention of the most common Otago names, which seem to be based on the appearance of the wood and the tree itself:—For *Fagus fusca*, red birch; for *Fagus solandri*, black-heart birch: and for *Fagus menziesii*, silver birch. The red birch timber is invariably red; black-heart birch is frequently white, but it has always black streaks, and the heart is generally all black. Silver birch has, when young, a silvery bark like the English birch, and the wood, although sometimes of a reddish color, has generally a silvery tinge, and always a silvery grain. It might be advisable to change to the correct botanical name of beech, as suggested by Mr. Kirk, but the other is so well established throughout the colony that there would be some difficulty in doing so, and as some of the trees are very like the old country birches, the name is tolerably appropriate.

No. 9. Silver Birch—Fagus menziesii. This species is the most common on the east coast. It exists with the other two in the inland forests, and, according to Dr. Haast, it is the only one between Wanaka and the west coast.

It is a tall slender tree, frequently eighty feet long in the trunk, but seldom exceeding three feet diameter at the base; the average diameter at Catlin River, Tuapeka Mouth, and the Blue Mountains, is about two feet. The stem is straight and cylindrical, and free from branches, and the top is sound and compact, so the whole plant has a remarkably handsome appearance. Mr. Buchanan says that *F. menziesii* sometimes attains a diameter of twelve feet; but this and other remarks on the timber leads me to believe that he refers to *F. fusca.* The bark in young and in middle-aged trees is very thin, seldom exceeding a quarter of an inch; the colour is silver-grey, with numerous horizontal markings like cherry, hazel, and the English birch; the outer layer also peels off as in those trees. When the silver birch reaches maturity, or is allowed to stand beyond that stage the bark gets darker and rougher, and the horizontal markings disappear: but its ultimate thickness seldom exceeds half an inch, and it is never cut up into deep close vertical furrows like the bark of red birch. The leaf is from a quarter to five-eighths of an inch in length, rather thick and stiff, but without external ribs or veins; the margin is cut into by a small double notch with straight edges. The tree reaches maturity in from 150 to 300 years, and grows freely under cultivation; young plants shoot about a foot per annum. The silver birch is so tenacious of life that the removal of a ring of bark does not kill large trees.

The growing timber is remarkably free from heart-shakes and other defects of a similar kind. Trees that have stood long after reaching maturity occasionally show a small core of decayed wood in the centre; but it is so small, and occurs so seldom, that it can scarcely be called a defect.

It is difficult to determine the proportion of sap-wood in silver birch; young trees are of a uniform colour and texture from the pith to the bark, and the wood gets gradually darker and harder towards the centre in old trees, so that a sharp line of distinction between heart and sap cannot be struck; perhaps three and a half inches of sap-wood on a two feet tree will be a fair average. The colour of young timber is a pinkish-white, with occasional reddish streaks and knot-like spots. The heart in old trees is deep pink or light red, verging towards the outside into the same tints as the young wood; both kinds have a peculiar silvery lustre—this is easily recognized when once known. The wood of silver birch is even grained, soft, flexible, and tough, and not given to excessive shrinkage or warping;—perhaps there is no other timber in New Zealand so suitable for internal joiner-work and mouldings; it is also admirably adapted for tubs and other light coopers' work, and should answer for making patterns. Altogether, this is one of the most useful soft woods in Otago.

Silver birch timber is not durable in any situation where exposed to damp, or alternations from wet to dry; in this respect it is about on a par with white pine. I show a section of a tree rotten quite through after lying felled for four years in the West Taieri Bush, and a similar result was obtained under the same conditions in twelve months on Inch Clutha; further, a tree that had been cut, but left leaning against another, was completely worm-eaten in that time. I have had similar evidence from the Blue Mountains, and we have negative proof in the absence of old trunks in the forest; so silver birch must be set down as a perishable timber.

No. 10. Red Birch—Fagus fusca. With the single exception of kauri, this is the largest member of the vegetable kingdom in New Zealand. It is the chief occupant of the interior and west coast forests of Otago, and occasionally descends in small patches and individual trees to sea level on the east coast. It affects light soil on shingly plains or the mountain side, and grows in open bush with little undergrowth. The other two kinds of birches occur in the same forest, which seldom contains any other timber in large quantities. Mr. M'Arthur estimates that 80 per cent. of the trees in the Burrwood Forest are red birch.

The tree grows to a height of from eighty to one hundred feet, with a trunk, free of large branches, fifty to eighty feet long, and three to eight feet diameter; occasionally, however, it attains the enormous diameter of ten to twelve feet at the base. Mr. Surveyor Innes states that the Wakatipu red birches range from three to four feet six inches, but he has seen them at Te Anau from seven to nine; and six to eight feet trees are frequently met with on the Five Rivers Plain. The Burrwood Forest timber is about the same size as that at Lake Wakatipu, but the few trees on Inch Clutha are much smaller; the trunks average from twenty to thirty feet long, and two to three feet in diameter. Two red birch logs from the Blue Mountains, recently measured at the Inch Clutha Bridge, were respectively thirty-five feet long by two feet four inches in diameter, and thirty-eight feet long by two feet in diameter; they were both quite cylindrical, straight, and sound throughout. The trees in a small patch of bush at West Taieri average about four feet diameter.

The bark of young red birch is somewhat like that of mature silver birch, but on old trees it is from half an inch to an inch and a quarter thick, of a dark reddish-brown colour, very rough on the surface, and cut up into deep vertical furrows as close as they can be. The leaf is of an oval shape, from three-eighths of an inch to an inch and a half long, very thin and flexible but provided with projecting ribs or veins. The edge is serrated at regular intervals with generally a curved indentation, but they vary very much. Dr. Hooker says that Mr. Travers sent him leaves of *F. fusca* that were quite entire, and I have seen specimens from Lake Wakatipu in which the teeth were only noticeable on close inspection. The smaller leaves of red birch can scarcely be distinguished from the large ones of silver birch, but the whole foliage of the former is more open, spreading, and pendulous than that of the latter. Although there is sometimes very little difference in the leaves, and even in the appearance of the wood of *F. fusca* and *F. menziesii*, there is always a great difference in the quality of the wood. Mr. Kirk a short time since kindly identified a number of specimens for me; I could see very little difference in some that he had referred to as separate species, but the correctness of his classification was afterwards verified in a very remarkable manner: Two trees were found in the West Taieri Bush that had been felled on the same day four years ago—one was rotten and the other quite sound. Their foliage, which still remains intact, is to the casual observer the same, but, on comparing them with Mr. Kirk's specimens, the rotten tree is found to be *F. menziesii*, and the sound one *F. fusca*, a result entirely in keeping with the respective characters of the timbers.

Red birch, like its congeners already described, grows freely under cultivation, and reproduces itself rapidly in its native forest. A tree four feet diameter is estimated to be from 300 to 350 years of age. The timber is free from twists or bends, but is subject to heart decay, like cedar and totara. All the larger trees that have passed maturity are more or less affected in this way.

This timber is generally of a uniformly reddish colour throughout, with little or no figuring or markings. It is straight grained and splits freely, but not nearly so smooth as silver birch. The sap-wood is of a dirty yellow colour, and well defined; it ranges in thickness from two to three inches in four feet trees, but those grown on swampy land have much more. Red birch is the strongest of native softwoods tested at the New Zealand Exhibition: according to these tests it is nearly 60 per cent. stronger than English oak. It has also a great advantage over many of the other Otago timbers that stand heavy strains in being so uniformly straight grained and fibrous as to give good warning before breaking. Like its near relation English oak, this timber shrinks very much in seasoning, as will be seen by Table III. I found boards to contract as much as one-tenth of their width. This shows the absolute necessity of having the timber thoroughly well seasoned, but it is otherwise no serious defect, for notwithstanding the excessive shrinkage there was little warping in the boards.

On account of its superior strength, red birch is better adapted for beams and general framing than any other Otago softwood, and it is equal to all except white pine and silver birch for general joiner-work. In reporting to the University Council eighteen months ago on the subject, I said that red birch was "not suitable for internal furnishing of houses." This opinion was based on the idea that it became very hard with age. I now find that such is not the case. The hard samples turned out to be kamai, and a number of old red birch specimens since obtained are all tolerably soft and flexible. In addition to the uses just mentioned, this timber is suitable for piles, sleepers, and other engineering purposes. In short, it is more capable of universal adaptation than any other Otago timber.

Our experience in Otago of the durability of red birch is comparatively limited. It has hitherto been little used, except as fencing in Upper Southland, and for building purposes in the Wakatipu district, but its lasting qualities have been fully tested and universally acknowledged in the northern provinces. The well-known Waiau-ua bridge, erected by Mr. Blackett in Nelson thirteen years ago, entirely of this timber, is still perfectly sound, and fencing posts in Wellington are in the same condition after fifteen years use. Mr. Cameron, of the Dome Station in Southland, informs me that he has seen red birch posts quite sound after standing for fourteen years in the ground; and twenty miles of fencing erected by him on the Five Rivers Station, in 1867-8, is still in good preservation. I also show the following examples as proofs of the durability of red birch.

1st. Piece of split timber that has lain in the West Taieri Bush for ten years.

2nd. Portion of fencing post, eight years in the ground, at Tuapeka Mouth.

3rd. Section of tree that has been felled in the West Taieri Bush for four years,

All of which are still quite sound and fresh.

No. 11. Black Heart Birch—Fagus solandri and F. cliffortioides. Dr. Hooker says that although very similar these plants are distinct species, but the only difference he makes is in the shape of the leaf. Mr Kirk, in a note to me, says, "I do not know *Fagus cliffortioides* apart from *F. solandri.*" We may therefore assume that they are identical, at least so far as their economic value is concerned.

Black heart birch is found in the same forest as the other two, but is particularly plentiful on the west coast. There is also a considerable quantity at the Blue Mountains in the Pomahaka district. In size this tree occupies an intermediate place between the red and silver birches. It grows to a height of from seventy to one hundred feet, with a straight, clear trunk fifty to eighty feet long, and two feet six inches to five feet diameter. Two trees lately measured at Tuapeka Mouth were respectively seventy-two and seventy-four feet from the butt to the lowest branches. Two logs from the Blue Mountains, now lying near Stirling, measure respectively forty-seven feet long by two feet two inches in diameter, and thirty-four feet long by three feet nine inches in diameter. They are both quite straight and cylindrical, and without crack or other flaw from end to end. The trunks from which these logs were cut measured fifty or sixty feet, but there are many in the same bush eighty feet high to the lowest branch.

Judging from the annual rings, this is the fastest growing tree in Otago. A trunk three feet in diameter is estimated to be 150 years old. In some cases there are only three or four rings in an inch, which shows it to be a growth almost equal to that of oak, elm, or beech, the fastest growing English trees. Black heart birch grows well under cultivation. There are a number of healthy young plants in private gardens in Dunedin. So far as I can ascertain, this tree is not subject to heart-shake or decay.

Black heart birch has, when young, a thin smooth bark of a light grey colour, like kamai, and quite free of the horizontal markings that occur in silver birch. It gets darker, rougher, and thicker with age like the latter, but never attains to the thickness or roughness of the red birch bark. The leaf of this tree is easily distinguished. It is of an oval or pear shape from one-quarter to seven-eighths of an inch in length, and entire on the edge. The size of the leaf does not change with the growth of the tree, but the same forest produces all sizes. The largest and smallest specimens I have seen are both from Five Rivers.

The wood of the black heart birch is quite different from that of its two congeners. It is of a grey or yellowish ground colour, with dark streaks, and heart coarse in the grain, stringy and very tough. Some samples resemble very much English elm, and others English ash. The heart-wood generally runs in star-like points towards the circumference, and there is frequently a well-defined and handsome figure in the boards. Full-grown trees have from one and a half to three and a half inches of sap all round.

The strength of this timber has never been tested. It will belie its appearance very much, if not found to be one of the strongest in New Zealand. It is remarkably stringy and tough. Black heart birch is rather hard and stiff for joiner work, but is well adapted for framing and similar purposes where strength is required. Some of the figured samples would make handsome furniture.

The lasting properties of this timber have never been thoroughly tested. It has been scarcely tried at all in Otago, and the experience in other provinces is very limited. Dr. Hector instances a fence in the province of Wellington that was in good preservation, after being erected 20 years, which is the only record I know of its durability.*

This completes a description of the known Otago trees that yield building materials in the proper sense of the term. There are many smaller trees and shrubs capable of producing useful and ornamental woods, but their consideration would extend my paper beyond reasonable limits, so I must leave them out.

Recapitulation.

In recapitulating the leading points of my subject, it will be necessary to revert shortly to the general properties of timber referred to at the outset, and consider the peculiarities of our native products in the order then given.

Table No. II. gives the ordinary dimensions, amount of sap-wood, and approximate age of the principal Otago trees. It shows that class for class they are equal in size to those in other countries. The kowhai, rata, manuka, kamai, and black heart birch are on an average as large, if not larger, than oak, ash, elm, and beech, the English timbers for which they are substitutes, and with the exception of yellow pine and cedar, all our pines are considerably larger and more productive than their European and American prototypes. In like manner we show that the growth is more rapid in New Zealand than most other countries that produce ordinary building timber; consequently the reproduction of native trees, if it can be successfully accomplished is more profitable than the introduction of foreign ones.

The proper season for felling timber in New Zealand is not yet fully determined. The late Mr. Balfour said "probably it may be found that

* N.Z. Parl. Papers. 1872. G. 16, p. 7.

midsummer is the best;" but Mr. Kirk gives a decided opinion in favour of winter felling. He fixes April to August as the most suitable time in all the forests south of Banks Peninsula. I have no doubt Mr. Kirk is correct in considering this the season in which the trees are freest of sap, for the distinctness of the annual rings in most Otago timbers shows a decided period of repose in the growth. Still it is quite possible that a similar condition exists during the two summer months, December and January, and I would have little hesitation in including them in the felling season. I have instituted a series of experiments with the view of assisting in determining the season when the trees contain the minimum quantity of sap; it consists in observing the strain required to tear off strips of bark in each month of the year. The experiments will not be complete for six months, so I cannot give the results in this paper, but will do so on a future occasion if it is found to be worth publishing. The only well authenticated proof I have obtained of the superiority of winter felling in New Zealand is given in Mr. Horman's fence at Makerewa, already referred to. All the black pine posts erected in the winter of 1861 are still in good preservation, while those felled and erected a few months subsequently were more or less decayed some years ago. Assuming that ripe trees only are felled, and that none of the sap-wood is used, the time for felling timber is, within certain limits, of secondary importance to its subsequent seasoning and desiccation. The simplest way of obtaining a fair amount of seasoning in New Zealand would be to bark the trees in spring, cut them in the following winter, then slab the logs and let them lie in a running stream for a few weeks, or, what is better, let the sawn scantlings be submerged. There is little trouble in doing this when the timber is cut up in the bush as at Catlin River and Southland. After having the sap washed out in this way, the timber should be thoroughly dried under cover in open shed.

Table III., which gives the results of some experiments I made, shows the absolute necessity of seasoning;—it gives the weight of water in a cubic foot of green timber, and the transverse shrinkage in boards twelve inches square and half an inch thick. The results may be accepted as a fair indication of what will be obtained in practice, for the samples were picked heart-wood, cut radially to prevent warping; but they were taken from green logs and subjected to severe drying at a fire, and in the hot air of the Turkish baths. It will be seen that the greatest contraction is in ribbon-wood, next the red birches, and after that the hardwoods generally; the least is in black and white pine. It is worth noticing that English oak and New Zealand red birch, members of the same botanical family, are both given to excessive shrinkage. I should add that the results in Table III. are not higher than would be obtained from European and American timbers of the same class.

As the twelve-inch samples were too short to test the contraction endwise, I did so by fixing long three by half-inch green battens in the sun on a wall. After being exposed for four weeks in exceptionally hot, dry weather they were found to have shrunk as follows :—

White pine and totara	... 0·30	of an inch in 20 feet.
Red pine	... 0·23	,, ,,
Kauri	... 0·11	,, ,,

Of course the kauri was somewhat drier than the others to commence with. There is no record of similar experiments having been made with the timber of other countries, so a comparison cannot be instituted. I believe, however, that our timbers do not shrink more endwise than foreign ones of the same class. The importance of seasoning timber has hitherto been very much overlooked in New Zealand. Instead of using well dried heart-wood from mature trees that are felled at the proper season of the year, we put into our houses wet sap-wood from young trees that are felled when most convenient, probably in their juiciest state ; and, to increase the evil, the timber is painted at once, so that all the juices are retained to ferment, and thus breed corruption. It frequently happens that the timber for some of our best buildings is standing in the forest after the work has been commenced. Colonial timbers have fallen into disrepute solely on account of being used in a green state alongside foreign ones that are well seasoned. As a matter of fact, many of the latter are considered worthless in their own country for the same reason. It may therefore be set down as an axiom that no timber is good in the country that produces it.

The late Mr Balfour conducted a series of experiments on the strength of New Zealand woods at the N.Z. Exhibition of 1865. So far as they went these experiments were very satisfactory, but he himself admitted that they were not exhaustive, and suggested the further investigation of the subject by the General Government. A collection of timber specimens was made for this purpose in 1872, but the experiments have not yet been made. In reporting on the subject Mr Balfour said :—" New Zealand woods compare very fairly with those which we have been accustomed to consider as standards, the absolute strength of very many being above that of British oak, and all being stronger than elm. * * * New Zealand woods are certainly for the most part short in the grain and break with little warning. There are a number of valuable exceptions, but it will be observed that the ratio of safe load to breaking weight is high, which to a great extent compensates for this peculiarity." Mr. Balfour's experiments were made with pieces twelve inches long and one inch square, supported at one end. I observe that Mr. Laslett, who tested the strength of most of the principal woods in the world for the Admiralty, used pieces six feet long and two inches square, supported at both ends. As his results will probably be the standard in future, any further experiments in New Zealand should be on the same scale. Mr. Brunton, C.E., Invercargill, tested four samples each of black pine and totara on ten feet bearings. One of the former was eight, and all the others four, inches square. The large black pine piece broke with six and three-quarter tons, and the average breaking weight of the smaller pieces was—for black pine, twenty-three and a half hundred-weights; and totara, twenty and three-quarter hundred-weights. When worked out in the same manner, this makes black pine fifty-three per cent, and totara thirty-one per cent. weaker than the mean of Mr Balfour's experiments with small samples. Table No. IV. hereto appended, gives the main results of Mr. Balfour's experiments put into a more popular form than the one he adopts, which is intended for professional men. My table simply gives the "weight," "strength," "elasticity," and "toughness" of the principal Otago timbers, with examples of well-known varieties from other countries.

The fifth and last table that I have prepared is intended as a guide in the selection of native timber for special purposes. It gives an abstract of the properties and uses of the various kinds referred to in the paper.

In conclusion, I claim to have shown that Otago, and New Zealand generally, is well provided with good timber suitable for all the purposes of the constructive and mechanical arts. How then is it that we import £130,000 worth annually from foreign countries? I shall leave the question to be answered by the political economist, for I can see no valid reason for the anomaly. I can only view the fact as a grave reflection on our enterprise.

TABLE I.

Hardwoods of Otago.

No.	Popular Name.	Synonyms.	Authority.	Remarks.
1	Black mapau—			
		Pittosporum tenuifolium ..	Hooker ..	Botanical name.
		Kohuhu	Maoris ..	According to Colenso.
		Tawhiwhi	,, ..	,, ,, ,,
		Tarata	,, ..	,, ,, Lindsay.
		Tipau	,, ..	,, ,, Buchanan.
		Maple	Settlers ..	Occasionally so called.
2	Black mapau—			
		Pittosporum colensoi	Hooker ..	Botanical name.
		Mapauriki	Maoris ..	According to Cunningham.
		Tipau	,,	,, ,, Buchanan.
		Maple	Settlers ..	Occasionally so called.
3	Turpentine—			
		Pittosporum eugenioidos ..	Hooker ..	Botanical name.
		Tarata	Maoris ..	According to Colenso.
		White mapau	Buchanan	Almost as common as turpentine.
		Maple	Settlers ..	Occasionally so called.
4	Red mapau—			
		Myrsine urvillei	Hooker ..	Botanical name.
		Tipau	Maoris ..	According to Colenso.
		Mapau	,,	,, ,, ,,
		Maple	Settlers ..	Occasionally so called.
5	White mapau—			
		Carpodetus serratus	Hooker ..	Botanical name.
		Piripiriwhata	Maoris ..	According to Cunningham.
		Tawiri	,,	Balfour, quoting Buchanan in Jurors', N.Z. Exhibition. Not seen elsewhere
		Kohu-kohu	,,	
6	Manuka—			Also native name, Colenso.
		Leptospermum scoparium ..	Hooker ..	Botanical name.
		Kahikatoa	Maoris ..	According to Colenso.
		Tea or ti tree	Settlers ..	.. .. ..
		Red manuka	,,	.. .. ..
7	Manuka—			Also native name.
		Leptospermum ericoides ..	Hooker ..	Botanical name
		Manuka-rau-riki	Maoris ..	According to Colenso.
		Rawiri	,,	,, ,, Kirk
		Tea or ti tree	Settlers ..	.. .. ..
		White manuka	,,	.. .. ..
8	Rata—			Also native name, Lyall.
		Metrosideros lucida	Hooker ..	Botanical name
		Ironwood	Settlers ..	.. .. ..
9	Kowhai—			Also native name, Colenso.
		Sophora tetraptera	Hooker ..	Botanical name.
		New Zealand acacia	Settlers ..	According to Colenso.

TABLE I.—*(Continued.)*

Hardwoods of Otago.

No.	Popular Name.	Synonyms.	Authority.	Remarks.
10	Fuchsia—			
		Fuchsia excorticata	Hooker ..	Botanical name.
		Konini	Maoris ..	According to Buchanan.
		Kohutuhutu	,,	,, ,, Colenso.
		Kotukutuku	,,	,, ,, Colenso.
11	Broadleaf—			
		Griselinia littoralis	Hooker ..	Botanical name.
		Pukatea	Maoris ..	According to Colenso.
		New Zealand laurel	Settlers ..	Frequently used in Australia.
12	Kamai—			Proper spelling of native name.
		Weinmannia racemosa	Hooker ..	Botanical name.
		Tawhero	Maoris ..	According to Lyall
		Karmahi..	,,	,, ,, Hector.
		Towai	,,	,, ,, Colenso.
		Tawai	,,	,, ,, Cunningham.
		Black birch	Settlers ..	So called at Catlin river.
		Red birch	,,	,, ,, in North Island and South Otago.
13	Pokako—			Also native name, Colenso.
		Elæocarpus hookerianus ..	Hooker ..	Botanical name.
		Hinau	Maoris ..	According to Cunningham.
14	Pokako—			Also native name, Colenso.
		Elæocarpus dentatus	Hooker ..	Botanical name.
		Hinau	Maoris ..	According to Raoul.
15	Ribbon-wood—			
		Plagianthus betulinus	Hooker ..	Botanical name.
		Whau-whi	Maoris ..	According to Hector.
		Lace-bark tree	Settlers ..	,, ,, Buchanan.
16	Ribbon-wood—			
		Hoheria populnea variety of *angustifolia*	Hooker	Botanical name.
		Howhere..	Maoris ..	According to Colenso.
		Houi	,,	
		Whau-whi	,,	
17	Ribbon-wood—			
		Pennantia corymbosa	Hooker ..	Botanical name.
		Kaikomako	Maoris ..	According to Colenso.
18	Grass tree—			
		Panax crassifolium	Hooker ..	Botanical name.
		Horoeka	Maoris ..	According to Colenso.
		Lance-wood	Settlers ..	.. .. ..

TABLE I.—*(Continued.)*

Soft Woods of Otago.

No.	Popular Name.	Synonyms.	Authority.	Remarks.
1	Cedar—			
		Libocedrus bidwillii, or *Libocedrus doniana*	Hooker ..	Botanical name.
		Kawaka	Maoris ..	Applied to *Libocedrus doniana*, according to Colenso.
		Pahautea	,,	Applied to *L. bidwillii*, according to Colenso.
		Moko-piko	,,	,, ,, according to Bidwill.
		Totara-kiri-kotukutuku ..	,,	Applied to *Libocedrus doniana*, according to Mantell.
		Arbor vitæ	Settlers ..	.. .. ..
		Cypress	,,	.. .. ..
2	Miro—			Also native name.
		Podocarpus ferruginea	Hooker ..	Correct botanical name.
		Podocarpus spicata	..	Erroneously so called in Jurors' Reports N.Z. Exhibition.
		Toromiro	Maoris ..	.. .. ..
		Black pine	Settlers ..	Old name now obsolete.
3	Totara—			Also native name.
		Podocarpus totara	Hooker ..	Botanical name.
4	Black Pine—			
		Podocarpus spicata	Hooker ..	Correct botanical name.
		Podocarpus ferruginea	..	Erroneously so called in Jurors' Reports N.Z. Exhibition.
		Matai	Maoris ..	Now coming into use as a popular name,
		Mai	,,	According to Cunningham
		Black rue	Settlers ..	According to Hector and Buchanan.
5	White Pine—			
		Podocarpus dacrydioides ..	Hooker ..	Botanical name.
		Kahikatea	Maoris ..	According to Colenso.
		Kaikatea	..	Probably a corruption of the preceding name.
		Swamp pine	Settlers ..	In North Island.
6	Red Pine—			
		Dacrydium cupressinum ..	Hooker ..	Botanical name.
		Rimu	Maoris ..	Now becoming popular also.
7	Yellow Pine—			
		Dacrydium colensoi	Hooker ..	Botanical name.
		Manoao	Maoris ..	According to Colenso.
		Silver pine	Settlers ..	So called on West Coast.
		Tar-wood	,,	,, ,, in vicinity of Dunedin.

TABLE I.—*(Continued.)*

Softwoods of Otago.

No.	Popular Name.	Synonyms.	Authority.	Remarks.
8	Celery Pine—			
		Phyllocladus trichomanoides ..	Hooker ..	Botanical name.
		Tanekaha	Maoris ..	According to Colenso.
		Toa-toa	,,	,, ,, ,,
9	Silver Birch—			Most popular name in Otago.
		Fagus menziesii	Hooker ..	Botanical name.
		Tawai	Maoris ..	According to Colenso.
		Tawhai	,,	,, ,, ,,
		Towai	,,	,, ,, Balfour.
		White birch	Settlers ..	Frequently so called in Otago.
		White kamai	,,	So called in South Otago.
10	Red Birch—			Common throughout Otago.
		Fagus fusca	Hooker ..	Botanical name.
		Hututawhai	Maoris ..	According to Kirk.
		Towai	,,	,, ,, Balfour.
		Tawai	,,	,, ,, Bidwill.
		Tawhai-rau-nui	,,	,, ,, Colenso.
		Black birch	Settlers ..	So called in the Northern provinces and by Balfour, but not in Otago.
		Red Kamai	,,	So called in South Otago.
11	Black Heart Birch—			
		Fagus solandri, or *Fagus cliffortioides*	Hooker ..	Botanical names.
		Tawhai	Maoris ..	According to Colenso.
		Tawai-rau-riki	,,	,, ,, Geological Survey.
		White birch	Settlers ..	Commonly applied when the timber is mostly white
		Silver birch	,,	Occasionally so called.

TABLE II.

Approximate Dimensions and Growth of the Principal Timber Trees of Otago.

Popular Name.	Botanical Name.	Ordinary Length.	Dimensions Diameter.	Approximate Age.	No. of Annual Rings in an Inch.	Thickness of Sap-wood.
		Feet.	Inches.	Years.		Inches.
Manuka ...	*Leptospermum ericoides*	30 to 60	12 to 24	100 to 250	20	½
Rata	*Metrosideros lucida*	30 to 40	24 to 48	200 to 450	19	½
Kowhai ...	*Sophora tretaptera*	20 to 40	18 to 36	140 to 270	15	1 to 3
Broadleaf ...	*Griselinia littoralis*	15 to 25	36 to 72	340 to 700	19	2
Pokaka ...	*Elæocarpus hookerianus*	60	30	200	14	4
Cedar ...	*Libocedrus bidwillii*	20 to 40	18 to 42	150 to 400	15 to 28	1 to 4
Miro... ...	*Podocarpus ferruginea*	20 to 50	18 to 36	150 to 300	20	3 to 12
Totara ...	*Podocarpus totara*	20 to 80	36 to 60	470 to 800	26	3 to 6
Black pine ...	*Podocarpus spicata*	20 to 40	24 to 42	270 to 400	23	2 to 4
White pine...	*Podocarpus dacrydioides* ..	40	30 to 48	370 to 600	25	12
Red pine ...	*Dacrydium cupressinum* ...	20 to 80	30 to 48	400 to 650	27	3 to 6
Celery pine	*Phyllocladus trichomanoides* ...	30 to 40	24 to 36	280 to 400	23	1½
Yellow pine	*Dacrydium colensoi*	5 to 20	30	300	21	1
Silver birch	*Fagus menziesii*	20 to 80	20 to 45	150 to 330	12 to 19	3½
Red birca ...	*Fagus fusca*	20 to 60	20 to 48	130 to 300	10 to 17	1 to 4
Black birch	*Fagus solandri*	50 to 80	24 to 45	80 to 180	6 to 9	3

TABLE III.

Seasoning of Otago Timbers.

Popular Name.	Botanical Name.	Weight per Cubic foot, Green. Pounds.	Weight of Moisture in Cubic Foot of Green Timber. Pounds.	Weight per Cubic Foot, Seasoned. Pounds.	Shrinkage in Boards 12in. Square by ½in. thick.	Remarks.
Turpentine ...	*Pittosporum eugenioides* ...	69·216	29·232	45·074	0·70	
Rata	*Metrosideros lucida*	72·041	15·401	63·314	0·65	Old log.
Kowhai ...	*Sophora tetraptera*	79·019	27·860	57·767	0·93	
Broadleaf ...	*Griselinia littoralis*	70·971	22·745	52·511	0·50	
Kamai	*Weinmannia racemosa* ...	61·377	27·617	38·717	0·80	Mean of two—heart of log partly seasoned.
Pokaka... ...	*Elæocarpus hookerianus* ...	57·929	22·875	38·368	0·53	Old log partly seasoned.
"	" "	63·491	33·229	32·919	0·50	Green.
Ribbon-wood...	*Pennantia populnea*	59·842	28·059	39·386	1·22	
Kauri	*Dammara australis*	45·709	8·105	39·830	0·34	Out of log partly seasoned.
Cedar	*Libocedrus bidwillii* ...	47·750	22·978	28·611	0·35	
"	" "	61·405	38·163	26·306	0·72	
Miro	*Podocarpus ferruginea* ...	70·189	31·121	44·215	0·72	
"	" "	73·321	33·949	44·426	0·62	
"	" "	71·554	32·486	42·827	0·54	
"	" "	62·208	21·291	47·482	0·86	Partly seasoned.
Totara	*Podocarpus totara*	49·783	17·012	36·310	0·60	
"	" "	56·715	19·138	42·228	0·68	Old block.
"	" "	50·482	16·368	37·603	0·57	
Black pine ...	*Podocarpus spicata*	75·534	30·456	46·862	0·23	
" " ...	" "	77·798	32·948	47·508	0·34	
White pine ...	*Podocarpus dacrydioides* ...	38·921	11·698	28·636	0·30	
" " ...	" "	43·899	16·896	29·505	0·52	
Red pine ...	*Dacrydium cupressinum* ...	43·117	11·533	34·294	0·48	From Taieri Mouth.
" " ...	" "	71·136	34·004	42·775	0·82	
Yellow pine ...	*Dacrydium colensoi*	55·461	11·952	46·162	0·35	
Celery pine ...	*Phyllocladus trichomanoides*	47·170	17·503	31·588	0·38	Mean of two, old logs partly seasoned.
Silver birch ...	*Fagus menziesii*	52·621	26·269	28·446	0·45	
Red birch ...	*Fagus fusca*	39·620	7·574	40·358	1·17	
" " ...	" "	58·176	29·084	34·124	0·92	
" " ...	" "	41·000	7·244	40·648	0·23	Old sample.
Blk. heart birch	*Fagus* {*solandri*, *cliffortioides*} ...	53·485	16·738	40·292	0·54	

TABLE IV.

WEIGHT AND STRENGTH OF OTAGO TIMBERS, WITH ENGLISH AND FOREIGN EXAMPLES.

	Popular Name.	Botanical Name.	Weight, per cubic foot, dry, according to Balfour.	Strength.	Elasticity.	Toughness.	Remarks.
	OTAGO TIMBERS.		W	S	E	T	
1	Black Mapau	*Pittosporum tenuifolium*	60·14	243	215·2	114·08	
2	Red Mapau ...	*Myrsine urvillei*	61·82	192·4	169·88	92·94	
3	White Mapau	*Carpodetus serratus* ...	51·24	177·6	166·86	54·64	
4	Manuka ...	*Leptospermum ericoides*	59·00	239	239·5	116·58	
5	Rata	*Metrosideros lucida* ...	65·13	196	244·2	94·23	
6	Kowhai ...	*Sophora tetraptera* ...	55·11	207·5	198·05	79·19	
7	Pokaka ...	*Elæocarpus dentatus* ...	35·03	125	200·7	97·65	Doubtful, being the result of one experiment only.
8	Cedar	*Libocedrus bidwillii* ...	39·69	120	136·7	32·43	
9	Miro	*Podocarpus ferruginea* ...	49·07	197·2	230·24	128·05	
10	Totara ...	*Podocarpus totara* ...	35·17	133·6	124·6	58·85	
11	Black Pine ...	*Podocarpus spicata* ...	40·74	190	156·22	90·86	
12	White Pine ...	*Podocarpus dacrydioides*	30·43	106	127·1	49·07	
13	Red Pine ...	*Dacrydium cupressinum*	39·25	140·2	143·38	79·66	
14	Silver Birch...	*Fagus menziesii*	38·99	158·2	116	62·04	
15	Red Birch ...	*Fagus fusca*	48·62	202·5	219·5	87·28	
	ENGLISH AND FOREIGN EXAMPLES.						
16	Australian Iron Bark		70·92	282·7	297	192·31	
17	„ Blue Gum		60·66	214·8	259·6	191·78	
18	English Oak		55·96	128·5	127	105·36	According to Barlow.
19	„ „		51·72	176·4	257·3	150·79	„ Laslett.
20	„ Ash		46·19	169·2	180	115·96	„ Barlow.
21	„ „		46·00	188·5	331·6	133·90	„ Laslett.
22	Memel Deal		36·77	144·25	116	...	„ Barlow.
23	English Beech		43·37	129·66	195·8	134·58	„ „
24	Riga Fir		46·46	89·9	167·7	79·95	„ „
25	„ „		33·81	131·2	435·4	221·76	„ Laslett.
26	English Elm		34·21	87·9	82·2	74·63	„ Barlow.
27	„ „		34·87	86	145·15	99·51	„ Laslett.
28	Kauri		34·31	157·42	417·46	338·86	„ „
29	„		38·96	165·5	181·27	92·98	„ Balfour.

NOTES ON TABLE IV.

The "strength" given in column S is the weight in pounds required to break pieces twelve inches long and one inch square supported at one end and loaded at the other.

"Elasticity" is the greatest weight in pounds carried with unimpaired elasticity, divided by the deflection caused by it in inches, the specimen being the same size and loaded as above.

"Toughness" is the breaking weight given in column S divided by the deflection caused by it in inches at the instant of rupture. By this method the lowest tabular number indicates the greatest toughness.

RULE.—To find the breaking weight of a beam from the table, multiply together eight times the breadth of the beam in inches, the square of its depth in inches, and the tabular number S, the result divided by the distance between the supports in feet gives the breaking weight in pounds distributed over the entire length of the beam.

Example.—A kowhai beam twelve feet long between the supports, twelve inches deep and six inches broad, will break with 53 tons 7 cwts. 16 lbs., thus—

$$\frac{8 \times 6 \times 12 \times 12 \times 207{\cdot}5}{12} = 119{,}520 \text{ lbs.} = 53 \text{ tons } 7 \text{ cwts. } 16 \text{ lbs.}$$

When the load is confined to the centre, the beam breaks with half this weight.

TABLE V.

PROPERTIES AND USES OF OTAGO TIMBERS—APPROXIMATELY IN ORDER OF SUPERIORITY AND FITNESS.

Durability.	Strength.	Elasticity.	Toughness.	Weight.	Lightness.	Hardness.	Softness.
Kowhai	Black Mapau	Rata	Cedar (?)	Kowhai	Cedar	Rata	Silver Birch.
Broadleaf	Manuka	Manuka	White Pine	Black Pine	Silver Birch	Manuka	White Pine.
Fuchsia	Kowhai	Miro	White Mapau	Miro	White Pine	Fuchsia	Cedar.
Black Pine	Red Birch	Red Birch	Totara	Rata	Celery Pine	Grass Tree	Celery Pine.
Totara	Miro	Black Mapau	Silver Birch	Red Pine	Pokaka	Kowhai	Red Birch.
Cedar	Rata	Pokaka	Kowhai	Broadleaf	Red Birch	Broadleaf	
Kamai	Red Mapau	Kowhai	Red Pine	Turpentine	Red Pine	Kamai	
Red Birch	Black Pine	Red Mapau	Black Pine	Yellow Pine	Totara	Black Pine	
Yellow Pine							
Celery Pine							
Rata and Black Heart Birch are also believed to be durable, but their durability is not fully proved.	Black Heart Birch, place not determined	Broadleaf, place not determined.					

TABLE VI.

PROPERTIES AND USES OF OTAGO TIMBERS—*(Continued)*.

ENGINEERING PURPOSES.

Piles.	Beams.	Sleepers.	Planking.	Framing, Implements, and Wheelwrights' Work.	Teeth and Bearings.	Patterns.
Kowhai	Red Birch	Black Pine ..	Black Pine ..	Manuka	Rata	Silver Birch.
Black Pine	Black Heart Birch	Totara	Black Heart Birch	Kowhai	Kowhai	White Pine.
Kamai	Black Pine ..	Red Birch	Kamai	Rata	Manuka	Cedar.
Totara	Rata	Kamai	Red Birch	Black Heart Birch	Broadleaf	Celery Pine.
Black Heart Birch	Kowhai	Cedar		Black Pine ..		
Rata						
Red Birch						
Cedar						

BUILDING PURPOSES AND FURNITURE.

Fencing and House Blocks.	Framing.	Beams and Joists.	Flooring and Weather Boards.	Internal Joiners' Work.	Furniture.
As per Durability List, Table V.	All the Pines and Birches.	Red Birch	White Pine	Silver Birch	Kamai.
		Black Heart Birch ..	Silver Birch	White Pine	Black Heart Birch.
		Miro	Red Birch	Red Birch	Miro.
		Black Pine	Red Pine	Celery Pine	Red Pine.
			Totara	Cedar	Rata.
				Totara	Kowhai.
				Black Pine	Pokaka.
				Miro	Mapau.
				Red Pine	Red Birch.
					Manuka.

Art. XI.—*On the Durability of Matai Timber.* By John Buchanan.

[*Read before the Wellington Philosophical Society, 29th July, 1876.*]

Plate III.

On a recent visit to Otago my attention was called to a large prostrate tree on a piece of new cleared bush land near Mount Cargill, North-east Valley, Dunedin.

The circumstances which prove that this tree has been exposed for at least 300 years, in a dense damp bush, under conditions most favourable to decay, and the fact that it is still sound and fresh, are worthy of record as showing the great durability of some of our New Zealand timbers.

The proof of the actual time which has elapsed since this tree fell rests on the fact that its trunk is enfolded by the roots of three large trees, which must have grown from seed after its fall. The three enfolding trees are all *Griselinia littoralis*, three feet six inches in diameter. They have been recently felled with the axe, and their growth rings count over 300, thus approximating 300 years, during which the enclosed timber has remained so fresh and sound that it has since been split into posts for fence stuff.

The most casual visitor to the New Zealand bush must have observed the rich epiphytical growth of young plants on fallen trees. After a few years these begin to throw their roots on both sides, and take hold of the earth, thus gradually enfolding the prostrate trunk in the process of growth.

A microscopical examination of the timber of the fallen tree proved it to be *Podocarpus spicata* (matai). The measurement of the trunk is 135 feet long, and three feet in diameter at the base; and as the sap-wood and branches are gone, it must have measured when alive at least 160 feet in height, with a diameter of four feet.

The wood is close grained and heavy, and of a dark reddish-brown colour, and the yearly growths very narrow and numerous, showing 88 rings to an inch. The semi-diameter being eighteen inches gives for heart-wood alone a period of 1586 years,* and with sap-wood growths added at the lowest estimate, a total age for this tree of 1880 years. If to this again be added the 300 years during which it has lain prostrate, we have a period of 2180 years, within which no great disturbance of the forest has taken place in the immediate neighbourhood of Dunedin.

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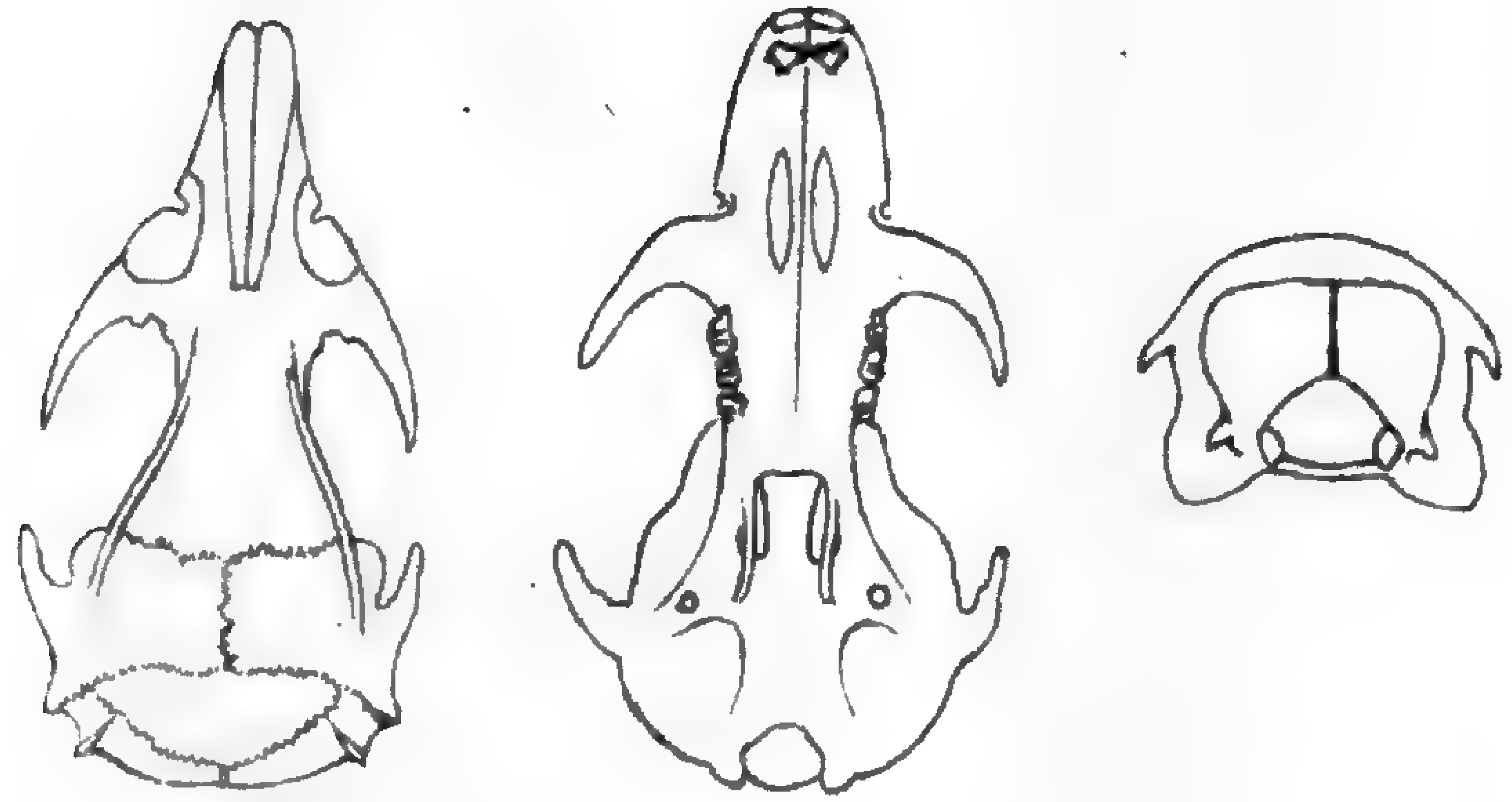
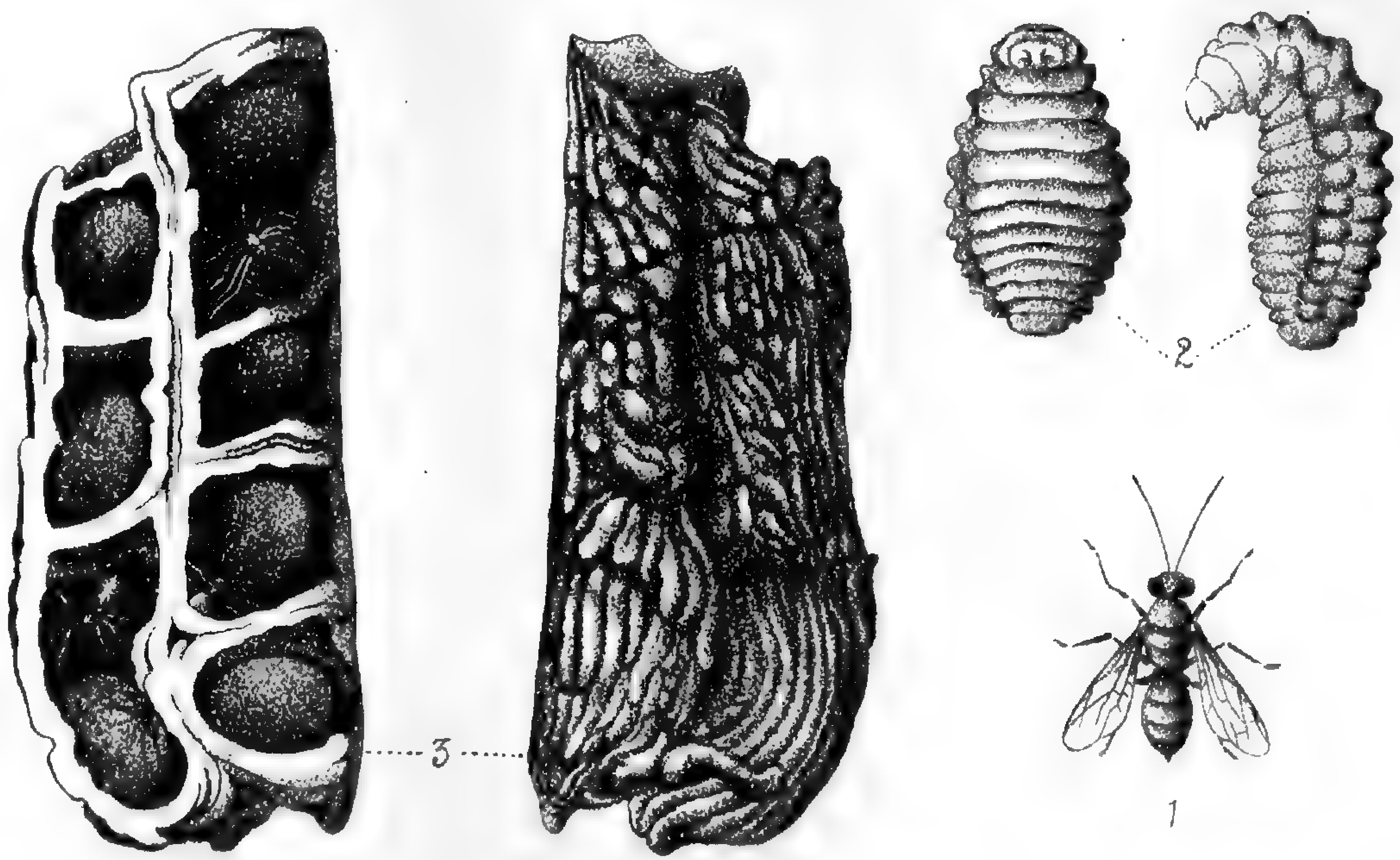
* Calculated on the accepted experience in Europe of annual rings of growth for coniferous trees.

OLD MATAI TREE



SKULL OF MAORI RAT.



NEW ZEALAND MASON WASP.

J.B. del. et lith.

ART. XII. *On Charring Timber as a Protection from* Teredo.

By JOHN BUCHANAN.

[*Read before the Wellington Philosophical Society, 25th November, 1876.*]

THE purpose of the following notes is to call attention to some portions of charred piles presented to the Colonial Museum by the Hon. G. M. Waterhouse. They were taken from a wharf in Tasmania by Mr. Watson, and forwarded by him to Wellington with an accompanying letter, which contains matter of much importance at the present time in New Zealand, regarding the advantages of charring piles for wharves or other constructive marine works. As explained by Mr. Watson, and also as shown by the specimens, charred piles thoroughly resist the boring of sea-worms, thereby ensuring durability to the works concerned. Specimens are also sent, showing the destructive action of the worms on uncharred piles of the same species of *Eucalyptus*.

The protection of timber by charring from marine worms appears to have been a very ancient practice, and sometimes with complete success. As an instance of this, charred piles have been found in a sound state in the Thames, below London, the driving of which is accredited to the Romans. It is strange therefore that this well-known method of protecting timber has not been more frequently adopted.

Charring fence posts to ensure durability is also a common practice, but is often brought into disrepute through ignorance of its particular use in this case, which is only to prevent beetles boring the post at the surface of the ground, or, as it is called, between wind and water. Charring must be well done in this case. So much is the necessity for thorough charring that an intelligent idea of the use of the process is essential to success in the practise of it.

In charring timber as a protection against marine worms or land beetles, it should always be borne in mind that the charring offers only a mechanical obstruction to the boring apparatus of the worm or beetle; hence the necessity of deep charring, and not merely blackening the timber. The opposition offered to the hard mandibles of the worm is exactly similar to that which would be found if an attempt were made to bore with an auger into thick fibrous bark; and, indeed, if the bark be left on and charred, the obstruction would be more efficient.

It has been proved in Australia that the bark alone, without charring, is a sufficient protection against marine worms, but not, as stated by some, in virtue of its juices. There is always, however, a tendency in driving piles with the bark on that it strips off; but as the process of charring would make it cling close to the wood, or even become semi-united, the advantage of charring with the bark on is obvious.

On the whole the method has much to recommend it—both simplicity and cheapness, with a guarantee of success based not only on the present Tasmanian experience but on the experience of ages, charring timber as a means to durability dating back to the highest antiquity.

An opinion has been imported from Western Australia, in connection with the reported appearance of worm-borings in the Jarrah piles of a recently constructed work at Onehunga, "that the action of the worm will be confined to the sap-wood." The experience gained by the Auckland wharf confirms the correctness of this opinion in the case of totara piles, but in this case, before the mature timber was reached and the ravages of the worm checked, the totara piles were reduced to six inches diameter, when the wharf had to be renewed. A most important question is thus introduced. Would it be safe to trust to the amount of mature timber in any of the Jarrah piles imported. Certainly many of those now in Wellington are young trees. I am of opinion that no Jarrah piles fifty feet in length should be less than two feet diameter at the top, and it would increase their value here if the additional weight was squared or rounded off in Western Australia.

I have also to draw your attention to a portion of a pile from a Maori pah, presented by the Hon. Mokena Kohere to the Colonial Museum. The interest attached to this specimen of timber, the yellow pine or Manoao of the natives, *Dacrydium colensoi*, Hook., is its great age. The history attached states that this pile was taken from an old native pah at Tapuaeharuru, on the Omapere Lake, Bay of Islands district. This pah, according to native history, was built about fourteen or fifteen generations ago, by an old Maori warrior named Hua, so that it must be several hundred years old.

This species of *Dacrydium* is found throughout the colony, from the north of Auckland to Otago, but never in great quantity, the average size being two and a half to three feet in diameter, and occasionally five to six feet in diameter.

The specimen is perfectly sound, close grained and heavy, the chief feature of interest attached to it being the complete destruction of the sap-wood by weathering, and the small amount of heart-wood or mature timber remaining being only five inches diameter. It may be concluded that this specimen has either formed part of a very young tree, or the sap-wood of this species of *Dacrydium* forms a large portion of the timber. At the same time it proves that the sap-wood of even the most durable New Zealand timber trees is of little value, and should either be removed or protected in some manner by charring or otherwise.

Letter from Mr. Watson to the Hon. Mr. Waterhouse relative to the charring of timber :—

"Hobart Town, June, 1876.

"Sir,—Believing that you take an interest in all matters connected with the prosperity of New Zealand, I take the liberty of addressing you on a subject of considerable importance to the colony—namely, the construction and maintenance of her harbour works.

"For some years past I have continually heard of the destructiveness of the ship-worm to the piles forming the wharves and piers; but I was rather surprised on reading a small publication compiled in New Zealand in 1875, and containing reports of several gentlemen on the durability of New Zealand timber, to find the immense expenditure to which the Government have been subjected in consequence of the damage done to the piles by these worms. For the last seventeen years the Hobart Town Marine Board, at my suggestion and under my superintendence, have had the piles used in the construction of their works put through a process of charring, and have found it to answer admirably. Some seventeen years ago I was employed by the Government here to superintend the building of what is called the New Wharf, in this harbour (the old one, which had been erected about fourteen years before, having been quite destroyed by the ravages of the worms on the piles). The plans, etc., for its erection were all prepared in the Public Works office, and it was intended to have all the piles to be used in the construction of the wharf coppered; but on an estimate of cost being made the intention was abandoned. I then proposed a plan which, from my experience, I considered would answer the purpose of stopping the ravages of the worm—namely to char the piles, the expense of which is not more than ten shillings a pile. This being a new process, and apparently so simple a remedy, it was not at first entertained by our engineering department, and the contractor had orders to proceed with the construction of the wharf. They had driven about six of the new piles well coated with coal tar, when on my examining one of the old piles when drawn out, I found it was charred, but on one side only. It had evidently been a fallen tree, and a bush fire had passed over the upper side of it, the other side being most likely embedded in wet scrub, or in the ground. The charred side was quite perfect, but the worm had completely eaten away the other side of the pile. On this being brought before the department, instructions were at once given to the contractor to char all the remaining piles to be used in the work. I am forwarding you two samples of portions of piles taken from that wharf, on which I will note particulars. One is a piece of the first pile that was driven without charring, the other from a pile which was charred and driven a week or so afterwards. I also forward a third piece taken from an old pile which had been driven uncharred about eighteen years ago. This, I think, will show that the worm is equally destructive in the Derwent as elsewhere.

"If it is not taxing your time too much, I will give you a short account of how I gained my experience with reference to the benefits of charring piles, and will make a few general remarks. (I may remark, in passing, that my experience was rather dearly bought, as the vessel alluded to was uninsured.) About twelve years before the New Wharf was built, I had bought an old whaler of about 300 tons, intending to make a sheer hulk of her. The necessary alterations were in course of being made, when by some means she took fire in the night, and was burnt to the water's edge. The mainmast had been burnt to less than twelve inches in diameter, when after being burnt through at the deck it fell overboard. In making up a raft of old masts for the men to work upon at ships when hove down, this was put in with others. After being about four years in use they became so eaten away that the raft was broken up, and, to my surprise, the old masts, which had been fully twice its diameter, were eaten away to a less size than it, although they had been well coated with hot tar before being put together. The charred spar came out as fresh as the day it was put in, so that on my undertaking to superintend the building of the wharf I considered the process of charring would answer better than the coppering, the expense being so trivial. Since that time I have had the sole charge of the planning and building of all the piers and wharves here. A new pier that was built for the steam-boats about ten years since, the piles of which were all charred, are as perfect, to all appearance, as the day they were driven—a standing proof of the utility of this process. I will send a sample from one of its piles with the others. The top of this pier is watertight without caulking, and is subject to the continual traffic of horses, drays, etc. Some of the main planking was removed lately for inspection, and the beams and main planking were found to be as sound as on the day they were laid. The top is formed with a double thickness of planking, and well coated with chunam between.

"We are just now about completing another new pier about 310 feet in length by 52 feet in breadth, with a curved top nearly the same as a ship's deck. It will be watertight, and have scupper-holes to let the water off. It is formed on about 300 piles, the outer ones of 75 feet in length. It goes into 40 feet of water, and the cost will be about £5,500. By the top being made watertight, the top planking beams and pile-heads will last many years; otherwise no wood in the world would stand the weather above ten or twelve years.

I have no doubt but that your New Zealand timber would, from the accounts I have read of it in the publication referred to, answer every purpose. I notice it complains of our Blue Gum not lasting. At this I do not wonder, and much question if the timber alluded to is Blue Gum at all. I have seen timber shipped from here as such that was utterly worthless for exposed works.

"We have made many changes from the old plan of wharf-building, saving a considerable expense, and ensuring a greater stability and more durability in the upper portion above the water, the particulars of which would occupy too much space in this letter. But should your Government be inclined to try the experiment, I shall be most happy to furnish them with further particulars.

"His Excellency Mr. Weld has paid a visit to the new pier and witnessed the process of charring, and, I believe was very favourably impressed with its utility. At the same time he inspected the specimens taken from piles charred and not charred, and which are the same pieces as those I am forwarding to you.—I am, etc.,

"JOHN WATSON, late Shipbuilder.

"The Hon. G. M. Waterhouse, Esq."

ART. XIII.—*State Forestry: Its Aim and Object.*

By CAPTAIN CAMPBELL WALKER.

[*Read before the Otago Philosophical Society, December 21, 1876.*]

SINCE I became connected with the Indian Forest Department, twelve years ago, the question has very frequently been asked me, "What do you do? What *is* State Forestry? Do you plant trees, or cut them down?" And one fair correspondent, writing since I came to New Zealand, asked tersely, "Have you planted a tree yet?" Now, it is not easy in a few words to give an exact definition of what Forestry, and especially State Forestry, really is, and what are the duties in which the forest employés should be engaged; and I have generally replied that I could not reveal the secrets of my craft. I propose pursuing a contrary course this evening, and hope, ere I finish, to initiate you, even though it be only in the first degree.

The "Gardeners' Chronicle" of 5th August last, defined *practical* forestry as distinct from fanciful or ornamental, as "the art and practice of growing the largest quantity of the most valuable wood or timber upon the smallest area of ground in the shortest period of time." And this is doubtless a sufficiently accurate definition of the art as applicable to private estates; but in framing and working out any comprehensive scheme of *State* Forestry, for the benefit not only of the present but future generations, many other considerations present themselves.

The welfare of the community and country at large (not merely of individual sections) has to be carefully considered at each step, whilst at the same time care must be taken not to interfere unnecessarily with local privileges and vested interests, which time may have sanctioned, though the law has not.

In my "Reports on Forest Management," which have been republished by the Government of this colony, I give the following description of scientific forestry:—"The main object aimed at in any system of scientific forestry is, in the first instance, the conversion of any tract or tracts of natural forest, which generally contain trees of all ages and descriptions, young and old, good and bad, growing too thickly in one place and too thinly in another, into what is termed in German, a *geschlossener bestand* (close or compact forest), consisting of trees of the better descriptions, and of the same age or period, divided into blocks, and capable of being worked —*i.e.*, thinned out, felled, and reproduced or replanted in rotation, a block or part of a block being taken in hand each year.

In settling and carrying out such a system, important considerations and complications present themselves, such as the relation of the particular block, district, or division, to the whole forest system of the country; the requirements of the people, not only as regards timber and firewood, but straw, litter, and leaves for manure, and pasturage; the geological and chemical formation and properties of the soil; and the situation as regards the prevailing winds, on which the felling must always depend in order to decrease the chances of damage to a minimum; measures of precaution against fires, the ravages of destructive insects, trespass, damage, or theft by men and cattle. All these must be taken into consideration and borne in mind at each successive stage. Nor must it be supposed that when once an indigenous forest has been mapped, valued, and working plans prepared, the necessity for attending to all such considerations is at an end. On the contrary, it is found necessary to have a revision of the working plan every ten or twenty years. It may be found advisable to change the crop as in agriculture, to convert a hardwood into a coniferous forest, or *vice versa;* to replace oak by beech, or to plant up (*unter bau*) the former with spruce or beech to cover the ground and keep down the growth of grass. All these and a hundred other details are constantly presenting themselves for consideration and settlement, and the local forest officer should be ever on the alert to detect the necessity of any change and bring it to notice, no less than the controlling branch should be prepared to suggest what is best to be done, and conversant with what has been done and with what results, under similar circumstances, in other districts and provinces."

The State Forester has also to think of climatic considerations and the permanent supply of timber, or what the French call *bois de service*, for the use of public departments, considerations which do not necessarily enter into the calculations of private individuals—conserving natural forests or forming plantations. Mr. Brandis, the Inspector-General of Forests to the Government of India, on a recent occasion said—" Forest administration in India has two main objects: 1st. The formation, protection, and gradual improvement of the public forest domains; 2nd, Consistently with the steady improvement of the forests, to make as much timber, wood, and other forest produce available as possible for the requirements of the country and for export trade, and thereby to produce from these domains as large a surplus revenue as is compatible with the maintenance and increase of their productive powers." Perhaps no better general definition of the aim and object of State forest administration could be given. An argument often used against State forests and planting, and State Forest Departments, is that, if profitable, private individuals may be trusted to do it in their own interests. The fallacy of this argument has been repeatedly exposed by writers on forest subjects, and very clearly in a *brochure* entitled " L'Amenagement des Forêts," by A. Puton, Inspector of Forests and Professor of Forest Legislation at the Forest School at Nancy. He shows that whilst coppice woods, with a rotation of only 20 years, yield 2½ cubic metres valued at 20 francs (16s. 8d.) per hectar (2½ English acres) per annum, timber forests, with a rotation of 120 years, yield 5¾ cubic metres valued at 81 francs (67s. 6d.) per hectar per annum; but on the other hand, owing to the comparatively small amount of capital in soil and timber required under the former, as compared with the latter system, the return by the former is four and a-half per cent. against only two per cent. by the latter. Hence it is found that almost all private proprietors in France and elsewhere adopt the former system, and grow coppice woods, which give a quicker and larger money return, and were it not for the State and Communal forests managed under the latter system producing a greater volume of timber, and of large dimensions, the supply for naval purposes and public works would fall far short of the demand, whilst climatic considerations would be entirely overlooked. Having thus explained as briefly as possible what forestry, and particularly State forestry, really means, I proceed to state how operations are initiated and carried out in Germany and France—the countries in which the science is furthest advanced—the general principles being applicable to all countries and climates, for, as the Inspector-General of Forests in India writes in his preface to the Report on Forest Management already quoted :—" At first sight it may seem a somewhat bold and fanciful idea to expect Forest Officers from India to profit by studying forestry in Europe under a climate totally different, and in forests composed of other kinds of trees; but actual experience has shown that the professional knowledge acquired in European forests is of great practical use in India. There is hardly a question or difficulty of importance which arises in connection with forest administration in India, whether in regard to forest rights, or the working or regeneration and improvement of the forests, which has not been dealt with over and over again by foresters in Europe." When a forest is about to be taken in hand and worked systematically, a surveyor and aluator from the forest staff are despatched to the spot—the former working under the directions of the latter, who places himself in communication with the local Forest Officer (if there be one), the local officials, and inhabitants interested, and obtains from them all the information in his power. The surveyor first surveys the whole district or tract, then the several blocks or sub-divisions as pointed out by the valuator, who defines them according to the description and age of the timber then standing, the situation, nature of soil, climate, and any other conditions affecting the rate of growth and nature of the crops which it may be advisable to grow in future years. Whilst the surveyor is engaged in demarcating and surveying these blocks, the valuator is employed in making valuations of the standing crop, calculating the annual rate of growth, inquiring into and forming a register of rights and servitudes with a view to their commutation, considering the best plan of working the forest for the future, the roads which it will be necessary to construct for the transport of timber—in fact all the conditions of the forest which will enable him to prepare a detailed plan for the future management, and the subordinate plans and instructions for a term of years, to be handed over to the Executive Officer as his "standing orders."

A complete code of rules for the guidance of the valuator has been drawn up and printed, in which every possible contingency or difficulty is taken into consideration and provided for. Having completed their investigations on the spot, the valuator and surveyor return to head-quarters and proceed to prepare the working plans, maps, etc., from their notes and measurements. These are submitted to the Board or Committee of controlling officers, who examine the plan or scheme in all its details, and if the calculations on which it is based be found accurate, and there are no valid objections on the part of communities or individuals, pass it, on which it is made out in triplicate, one being sent to the executive officer for his guidance, another retained by the controlling officer of the division, and the original at the head-quarters office for reference. The executive officer has thus in his hands full instructions for the management of his range down to the minutest detail, a margin being of course allowed for his discretion, and accurate maps on a large scale showing each sub-division of the forest placed under his charge. All these details are naturally a work of time, and we cannot hope even to introduce, still less to mature, such a system in New Zealand for many years to come, but let us consider how we shall set about initiating and approaching it. The first step would be for the forest employés to ascertain accurately what are Government forests, and class the whole forest land of the colony under State, Communal (*i.e.*, reserved for the special use of communities, municipalities, educational endowments, etc.), and Private. The State forests would then be divided into reserved and unreserved, the former to constitute the permanent source of supply of timber, and include tracts at the head waters of rivers, tops of mountains, etc., the removal of the forest from which might affect very injuriously the climate and water supply of the whole country. The proportion of this reserved forest to the total area, or head of population, must of necessity vary very much according to circumstances, but I am inclined to consider that three per cent. originally proposed in Sir Julius Vogel's Forest Act for this colony should be the minimum of State reserve. In the German Empire the area of land under forest is twenty-five per cent. of the total area, of which one half, or twelve and a half per cent., is State forest, the area of forest, public and private, per head of population being ·348 hectars, or about three-quarters of an acre per head, but the proportion of this area per cent. and head of population varies widely in the several kingdoms and provinces of the Empire. In comparatively young colonies like New Zealand, we must not forget to provide for the requirements of a future dense population, bearing in mind that in the case of forests, perhaps more than in any other, it is much easier to keep and improve what we have got than to create it anew when required. The unreserved State forests would be open for settlement and supply of timber and firewood, a scale of royalties or seignorages to be paid to the State Forest Department, being drawn up, and licenses issued by the forest officials when necessary, in the case of forest tracts not being sold outright. Communal forests would be supervised by the officers of the State Forest Department, and managed to the best advantage, all surplus of receipts over expenditure being handed over to the community or endowed body. It is not intended to interfere in any way with the third class or private forests. The professional or purely technical labours of the forest department would then really commence, and be directed to the State reserved forests, of which forest surveys, valuations, and working plans would be prepared, and the annual yield disposed of to the best advantage, special care being taken to maintain and augment the capital in timber and annual yield by reproduction, whether natural or artificial. I must now explain what is meant by "natural reproduction," and how it is effected. Natural reproduction implies the regeneration of any tract of forest from the seeding of the old trees, as distinct from planting out from nurseries, or sowing of seed collected in other localities. It is not possible, with all descriptions of trees—and in the case of many the operation has to be aided by turning up the soil, transplanting of seedlings from one portion to another, etc., so as to secure some degree of uniformity in the young crop. Whenever practicable, natural reproduction has many advantages over artificial or planting—the cost is reduced to a minimum, and the growth is certainly not inferior to that of trees artificially reared. The operation requires care and study of the nature and requirements of the species which it is desired to reproduce, the soil and climate in which the forest is situated, and all other local conditions.

I find that the popular idea is that New Zealand forests cannot be reproduced naturally, and that even the mature and half-grown trees will disappear or die off if the wood-cutter enters, or even if cattle and sheep are permitted to graze. With the short experience which I have of the forests of this Colony, I cannot be too careful not to dogmatise or place my opinion directly in opposition to that of those well qualified to judge, but, from what I have seen, I think I am justified in pronouncing the popular opinion to be, as is so often the case, a popular error, resulting from insufficient knowledge of the science of arboriculture and consideration of cause and effect. At any rate this is the case with regard to some descriptions of New Zealand trees. I readily grant, what is true not only of the forests of New Zealand but all over the world, that if we suddenly let floods of light and air into an indigenous forest, and deprive the trees left standing of the shelter and support of others with which they have been brought up from their earliest childhood, the result will be decay and death; and in the same manner natural reproduction will not take place, or take place only very partially, and so tardily that the young growth will be choked by a dense mass of undergrowth, weeds, and grass, into which fire will probably enter and complete the murder of the young seedlings. I go farther, and believe that the New Zealand forest, as a rule, is particularly sensitive to the sudden action of light and air, and from many of the trees being surface rooted, suffers, perhaps more than that of other countries, from the entrance of cattle and sheep. It is also impatient in a marked degree of the effects of fire, but all this does not prevent certain species reproducing themselves even now, and will not, I hope and believe, prevent our carrying on the systematic working and natural reproduction of the indigenous forests on the general principles of forest craft, although it may require some years of careful observation and experiment to ascertain how best to apply them. Natural reproduction is affected by a gradual removal of the existing older stock. If a forest tract be suddenly cleared, there will ordinarily spring up a mass of coarse herbage and undergrowth, through which seedlings of the forest trees will rarely be able to struggle. In the case of mountain forests being suddenly laid low, we have also to fear not only the sudden appearance of an undergrowth prejudicial to tree reproduction, but the total loss of the soil from exposure to the full violence of the rain when it is no longer bound together by the tree roots. This soil is then washed away into the vallies below, leaving a bare or rocky hillside bearing nothing but the scantiest herbage. We must therefore note how Nature acts in the reproduction of forest trees, and follow in her footsteps. As Pope writes—

> "First follow Nature and your judgement frame
> By her just standard, which remains the same,
> Unerring." * * * *

Acting on this principle, foresters have arrived at a systematic method of treatment, under which large tracts of forest in Germany and France are now managed. The forests of a division, working circle, or district, are divided according to the description of the timber and the prevailing age of the trees, and it is the aim of the forester gradually to equalise the annual yield, and ensure its permanency. With this object he divides the total number of years which are found necessary to enable a tree to reach maturity, into a certain number of periods, and divides his forest into blocks corresponding with each period or state of growth. Thus, the beech having a rotation of 120 years, beech forests would be divided into six periods of twenty years each, that is to say, when the forest has been brought into proper order there should be as nearly as possible equal areas under crop in each of the six periods, viz., from one year to twenty, from twenty to forty, and so on. It is not necessary that the total extent in each period should be together, but it is advisable to group them as much as possible, and work each tract regularly in succession, having regard to the direction of the prevailing winds. When a block arrives in the last or oldest period, felling is commenced by what is called a preparatory or seed clearing, which is very slight, and scarcely to be distinguished from the ordinary thinning carried on in the former periods. This is followed by a clearing for light in the first year after seed has fallen (the beech seeds only every fourth or fifth year) with the objects of—1st, preparing the ground to receive the seed; 2nd, allowing the seed to germinate as it falls; 3rd, affording sufficient light to the young seedlings. The finest trees are, as a rule, left standing, with the two-fold object of depositing the seed and sheltering the young trees as they come up.

If there be a good seed year and sufficient rain the ground should be thickly covered with seedlings within two or three years of the first clearing, nature being assisted when necessary by hand sowing, transplanting from patches where the seedlings have come up very quickly, to the barer spots, and other measures of forest craft. When the ground is pretty well covered the old trees are felled and carefully removed, so as to do as little damage as possible to the new crop, and the block recommences life, so to speak, nothing further being done until the first thinning. The above is briefly the whole process of natural reproduction, which is the simplest and most economical of all systems, and especially applicable to forests of deciduous trees.

The period between the first or preparatory clearing to the final clearing varies from ten to thirty years, the more gradual and protracted method being now most in favour, particularly in the Black Forest, where the old trees are removed so gradually that there can scarcely be said to be any clearing at all, the new crop being well advanced before the last of the parent trees is removed. This approximates to "felling by selection," which is the primitive system of working forests in all countries, under which in its ruder form the forester proceeds without method, selecting such timber as suits him, irrespective of its relation to the forest increment. Reduced to system, it has certain advantages, especially in mountain forests, in which, if the steep slopes be laid bare, area by area, avalanches, land-slips and disastrous torrents might result, but the annual output under this system is never more than two-thirds of that obtained by the rotation system, and there are other objections which it is unnecessary to detail in this paper, which have caused it to be rightly condemned, and now-a-days only retained in the treatment of European forests under peculiar or special circumstances.

I now turn to the important subject of "artificial reproduction," or the raising of crops of timber by artificial sowing or planting. It is not within the scope of this paper to describe the various methods of sowing and planting, or to pronounce any opinion as to which are the best, or the most suitable for New Zealand. The special necessities and requirements of each case must always be carefully considered before planting operations are commenced, and with a climate and conditions so varied as they are in this Colony, it would be absurd and misleading to attempt to generalise on this point. The situation, soil, rainfall, purpose and species, should all have careful consideration before any money is spent, even in the formation of a nursery. Having decided what to sow or plant, and how to do it, let me strongly recommend its being done *well*, with great care, and without stint of money at the commencement. Liberality, or even what may seem extravagance in this direction, will certainly prove true economy in the end. If sowing is to be adopted, let the land be thoroughly well prepared; in most cases, especially in that of fern land, it will be found that the soil is sour, and must *weather* for some months, or even a year, before fit to receive the seed. Let the seed be of the best, and bear in mind that although most tree seeds, if kept dry, will remain good for an indefinite length of time, if they are once moistened sufficiently to cause them to swell, they will mmediately rot, unless sufficient moisture be supplied to foster germination, and growth; and spare no pains to sow it evenly in the ground. I may state that of the two methods of sowing in rows or drills, and broadcast, I prefer the latter, the land having been well turned up with a sub-soil plough, and harrowed, the harrow being passed over again after the seed is sown. I find the results from this method better than from sowing in rows or even dibbling in the seed at intervals. Sowing broom seed with that of the Eucalypti has been found to answer well in Canterbury, and recommends itself as giving shelter to the young trees, besides which it can be utilized as firewood; but be careful not to put in more broom than tree seed, as I have seen done, and do not mix the Eucalypti with other descriptions, unless it be the Tasmanian blackwood (*Acacia melanoxylon*), as they do not admit of congeners. By attending to these and similar simple rules, excellent results may be obtained from sowing the Eucalypti, as may be seen from inspection of some tracts thus treated in Canterbury, notably at the Reformatory at Burnham, where the cost is estimated at thirty shillings per acre, without including the fencing. Do not be afraid to let the trees grow up very thickly for the first few years, they will soon thin themselves, or a light thinning about the fifth year will be all that is required. Of course, bare spaces may be filled up in the first or second year, by transplants from portions where the seed has germinated freely, but it is scarcely possible in a plantation grown from seed to secure that regularity or evenness of growth attained by transplanting from nursery beds—*i.e.*, planting, as compared with sowing *in situ*. In the case of all trees grown for ornament, of the more valuable descriptions, or indeed wherever the results aimed at will well repay the expense, I am strongly in favour of the planting-out system. In adopting this method, too much care cannot be taken with regard to the nursery treatment. The Germans speak of the seedlings whilst in the nursery beds as "in the school," and that expresses exactly how they should be considered and treated. The great aim and object of nurseries, which is perhaps too often lost sight of, is to establish, harden, and root the young plants in a comparatively small area, where they can be watered and attended to in a manner which becomes impossible, except at an enormous expense, after they are planted out. If the seedlings are to be put out close by in the garden, and treated like flowers, we may, of course, plant them out direct from the seed, or mother bed, but whenever they have to be removed to a distance, or planted as forest trees, they should be transplanted more or less frequently, cut over or root pruned, according to species and nature, so as to induce and ensure a healthy growth of rooty fibre to enable them to stand the shock of transplanting, and derive sufficient nutriment from the soil whilst establishing themselves in their new and permanent habitat. I have laid much stress on this point, because, as I have already remarked, I fear that nursery treatment is sometimes not understood, or neglected, in New Zealand, which has been the cause of much vexatious disappointment and loss of good time and money with regard to seedlings sold or distributed from nurseries and public gardens. In planting for ornament, where expense is not so much an object, I would recommend good large pits to receive the young trees when well established in the nursery. They will then come away much quicker, and the result will well repay any extra expense. In forming plantations on a large scale, one cannot, of course, afford this, and with really well-rooted trees, a small hole made with a crowbar in land previously ploughed should suffice, and has been found to do so by Mr. Firth, of Auckland. Indeed, I do not see why, with some species, such as the larch and Scotch fir, we should not be able to adopt the Scotch system of slitting or notching them in when planting under favourable conditions as regards situation and climate. As with sowing, do not be afraid to plant too close. It is extra labour and extra cost both of labour and material, but we *cannot* rear good timber trees if planted out far apart. It is much better to have them rather too thick at first and leave them alone to thin themselves, even though they become a little spindly, when, however, a little artificial thinning should be resorted to; but experience teaches us that far more plantations are ruined by over thinning than by too little. Pruning and lopping of forest trees is now almost universally condemned and abandoned. I would never trust a pruning-knife in the hands of any but the head forester, and only in his after he has shown himself competent to use it by letting it lie idle as much as possible. Regarding the species most suitable for planting, as with the particular method to be adopted, much must of necessity depend upon the circumstances and locality, and in a general paper like this I might only mislead if I attempted to prescribe. Those who *have* experience know better than I do what will and what will not grow in their own locality, and to those who have not I would recommend their making special reference, stating the soil, situation, object, etc. Should the State Forest Department be maintained it will be one of the the duties of the local forest officers to give such information and assistance when asked. But at present, as I have said, it would be premature on my part to attempt to lay down any general rules. I would, however, certainly not try planting any of the indigenous descriptions—though we may do so in the department as matter of experiment and for guidance. We all know the rapid and successful growth of the blue gum, especially near the sea, where it is not subject to sharp frosts; also of the *Pinus insignis* and *Cupressus macrocarpa*, the latter of which especially recommends itself to my mind for shelter on sheep runs. All the Californian Coniferæ appear to do well in this colony, and for beauty none can surpass the *Abies douglasii*, *Pinus sabiniana*, *benthamiana*, and other varieties from that region. The Himalayan varieties—*P. excelsa*, or Bhootan pine, and *Cedrus deodara*, also flourish, and are worthy of attention both from the value of their timber and their ornamental appearance. In bringing to a close the subject of planting, it may interest you to know what has been the result of some of our planting operations in India, chiefly with a view to showing their financial results so far as can at present be ascertained. The Chunga-Munga plantation, in the Punjaub, has an area of 7000 acres, commenced in 1865, contains chiefly Indian blackwood (*Dalbergia sissoo*). The expenditure up to the end of 1873 had been £26,000, including £5000 spent during the first five years in unsuccessful experiments. £5000 had been received from petty thinnings (firewood), and minor produce, grazing dues, etc. From a careful valuation, and calculations made in 1873, it is estimated that the expenditure up to 1881, when the capital account closes, will be £97,000, and the value of the plantation be then £170,000. In considering the above results, it must be borne in mind that the rainfall in the district is *under fifteen inches*, with great heat in summer, and sharp frosts in winter. The whole plantation has to be irrigated from a neighbouring canal, being debited with a charge of four shillings per acre per annum, for the use of the water alone. Another important fact must be mentioned, viz., that, whereas the land on which the plantation stands was formerly almost valueless, and would not fetch an annual rental of two shillings per acre; twelve shillings, and even twenty shillings per acre is now readily obtainable, and the former has been offered for the whole or any portion when cleared. The rents mentioned, of course, include the water rate of four shillings per acre per annum. This plantation is intended eventually to cover 30,000 acres, and will undoubtedly prove a great success, both as regards direct financial profit, a supply of timber and firewood, which is much required, improving the soil and rendering it fit for cultivation with cereals, and ameliorating the climate. The Nelambur Teak plantations in Madras Presidency cover 3000 acres, the oldest portion having been planted 30 years ago. The total expenditure, including purchase and lease of some 19,000 acres of land from a native Radj, has been £30,000, and the receipts from thinnings, etc., £10,000. These plantations were valued last year at minimum rates at £150,000, and Colonel Pearson lately officiating as Inspector-General of Forests in India, estimated their value when mature at no less than two millions sterling. The plantations of Australian Eucalypti (chiefly the blue gum), and acacias in the Nilgiri Hills, Madras, extend to nearly 1000 acres, have cost £4,000, and yielded £2,000 since 1860, when they were commenced. I cannot give an estimate of their value; but in the case of one small plantation (60 acres) of *E. globulus* and *marginata*, planted in 1870, we made a very light preliminary thinning last year, and recouped a quarter of our total expenditure on it. The trees in this plantation, planted at six feet apart, average thirty-five feet in height, and nine inches in circumference, and the whole plantation is even and well grown. The thinnings yield excellent poles and firewood, and the timber of the Eucalypti and *Acacia melanoxylon* is found to be excellent.

From one to two hundred acres are to be planted annually to replace the indigenous forest which is of no value as timber, but is cleared for the firewood supply of the settlement, and extension of tea and coffee cultivation. The seed, which we obtain from Victoria, is sown in January, the seedlings transplanted in March or April, and "put out" during the first rains in June, in small pits six feet apart. No further care is required. The plantations of *Casuarina equisetifolia*, the she-oak of Australia, on the sandy seaboard, and river banks in the Madras Presidency, promise to be exceptionally successful, and the results merit the attention of foresters in all parts of the globe, the estimated yield per acre, which has been carefully calculated and checked, being unusually high—four times that of the best forests in France—and the plantations being situated on tracts of pure sand, hitherto quite valueless and unproductive. The wood is chiefly used for firing, and the Government plantations were mainly intended to secure an adequate supply for the railway locomotives in the absence of coal. The cost per acre varies from £4 to £10 in different districts, including all charges up to the time of clearing for the first time, which will be done after the short term of eight years on an average, so rapid is the growth. The yield varies from twenty-two tons of engine fuel, valued at £13, to fifty-four tons valued at £32, according to the method pursued, which has varied in several districts as regards the number of trees to the acre, age when felled, etc. So much for the financial results of well considered and carefully carried out planting operations in other countries. Their advantages in affording an adequate supply of timber and firewood and improving the climate should also not be lost sight of. If, for instance, we can succeed in creating blocks of artificial forests throughout the mining districts of Otago, from which I have just returned, the advantages both direct and indirect, will, I am sure, be readily admitted by all who have visited that treeless region. Much has been written on the subject of the influence of forests on rainfall, springs or streams of water, and the humidity of the atmosphere generally. I do not think we can consider it proved that their existence or non-existence influences in any appreciable degree the *total* rainfall of a district, although they probably do cause the clouds to precipitate their moisture in certain localities.* As to their favourable influence in the case of springs and streams there is little doubt, and many instances could be quoted from Von Humboldt, Marsh on "Man and Nature," and other standard works. They not only prevent excessive evaporation, but, by their presence and action, render the flow of water more regular and permanent, thus preventing disastrous floods and torrents during the winter or rainy season, and long droughts in summer. Their removal from mountain tops and hill sides cannot but be regarded as an evil, often followed by the most disastrous results. So much has this been found to be the case in France that they are now engaged in a gigantic work of replanting the slopes of the Alps and Pyrenees, which had been cleared in former years for grazing. Those replantings are to extend over 200,000 English acres, to cost £400,000, and the work is estimated to extend over 140 years, which is considered "not an unreasonable time to undo the work of twenty centuries." Only fourteen years of the 140 have as yet expired, and £40,000 has been expended in replanting ("reboisements") at the points most threatened, and, I am glad to learn, with the best results. Extensive planting is also being carried on in the Landes, and district of the Gironde.

The latest contributions to our forest literature on the subject of the influence of forests on climate, is, I think, given in the reports of the Forest Conference held at Simla in October, 1875, in the shape of a translation from a paper by M. J. Clavé, which appeared in the *Revue Des Deux Mondes*, from which I extract the following:—"There are four separate actions of nature through which it may be said that forests influence, in some way or other, the physical conditions or climate of a country. 1st. There is a *chemical* action through the leaves in decomposing the carbonic acid of the air. 2nd. A *physical* action in retaining moisture in the earth, and in checking the violence of the wind. 3rd. A *physiological* action in transmitting to the air through the leaves

* Hof Rath Wex, in a paper on the "Decrease of water in rivers and springs," communicated to the Vienna Geographical Society in 1875, states that the decrease of water in the Elbe and Oder has been seventeen inches; in the Rhine, twenty-four; Vistula, twenty-six; and Danube, at Orsova, fifty-five inches in fifty years.

a portion of the moisture which the roots draw from the earth. 4th. A *mechanical* action through the roots, in retaining in its place the earth, especially on the sides of mountains and hills." The writer then proceeds to examine each action in detail, and deduces conclusions favourable on the whole. He admits that "the action and influence of forests on the climate and physical condition of countries is yet but imperfectly understood." And concludes: "It seems to have been clearly proved that whenever countries have been denuded of trees their climate has been radically changed. Not to quote again the case of France, Asia Minor may be quoted as a country which in the era when it was covered with forests was richly cultivated, and supported easily a high rate of population, but which at the present day, owing to the destruction of the forests, has become so arid that the crops fail to come to maturity, and thousands of human beings are now perishing from hunger and want." Before concluding, I must say a few words with special reference to the New Zealand forests, and give some indications of the nature of the proposals which, so far as I can at present judge, I shall lay before Government with my report in March next. I need scarcely premise that my estimate of the value of New Zealand forests is based on actual inspection and comparison with those in other countries, and that the Government are in no way pledged to accept my proposals for the organization and working of the State Forest Department, though I shall endeavour to make them such as they may with confidence recommend during next session to the Honourable House for adoption. I think very highly of your New Zealand forests. The kauri and puriri in Auckland, the totara in Hawke Bay and Wellington, the red, black, and white pines and cedar of the South Island, are timbers of their class second to none in the world. They still exist in considerable quantity and large dimensions, and if we adopt proper measures in time, a permanent yield may, I am confident, still be secured. Then we have the so-called black, red, and white birches, the kowhai (*Sophora tetraptera*), etc., useful for general purposes, and several descriptions, such as the rewa-rewa (*Knightia excelsa*) or honeysuckle, of great value as furniture or ornamental woods. I have not yet visited the West Coast, but, from what I am told, there is to be found there alone a supply of good timber for many years, if not centuries, to come. I daresay many would call it an inexhaustable supply, but we foresters maintain that there is no such thing as an inexhaustable supply so long as the forest is under no control, is being trenched upon at haphazard, and without any data or regard to the annual increment of timber. In fact, so long as we are working in the dark, without any knowledge of the extent of our capital or annual income in wood, I think many of the New Zealand timbers never have had a fair chance or trial, being felled at all seasons of the year, and utilized at once, without seasoning. As Mr. Kirk writes in his report on the durability of New Zealand timbers in constructive works :—" The disadvantages attending winter work in the bush have led to the anomalous fact that by far the larger portion of timber used in New Zealand is felled during the spring and summer months, and this has given rise to the erroneous idea that some of our best timbers—the kauri, totara, and others—season imperfectly, contracting in length and breadth long after they are used. * * * Exactly similar results would attend the use of the best European and American timbers under similar circumstances." I admit that serious objections may be raised against some of the species, both as regards durability, shrinking, etc., and I confess that there are some conditions, both as regards the supply and demand, commercial value, rate of growth and reproduction, which I have not as yet fully mastered, and with regard to which, so far as I can learn, no reliable data are on record. Speaking broadly, however, I repeat that I have formed a high opinion of the New Zealand forests, and I think, if the public will permit us, we shall make a very valuable property of what we reserve, and secure a fair and steadily increasing revenue from what we dispose of. It has, I am aware, been argued by some that the £10,000 per annum appropriated under the existing " State Forest Act " is inadequate for planting purposes, and that, as the colony cannot afford to supplement it, or even to spend that sum, the whole thing had better be dropped. Now, I am very glad to have the £10,000 appropriation for the first few years as a reserve fund to draw upon, but I don't intend to trench much upon it, and any scheme which I may bring forward will be based on the principle that the forest department should be entirely self-supporting, the revenues derived from existing indigenous forests in the hands of the Crown being made sufficient to cover all expenditure for establishments and working, gradual formation of plantations, etc., etc., the surplus, after defraying all the above charges, being Colonial Forest Revenue. This is the system which we have gone on in India, where we took over a forest property in a much more dilapidated condition than that of New Zealand, and burdened by the immemorial rights and privileges of a native population, numbering upwards of 200,000,000; and have nevertheless, I am proud to say, paid our way, formed extensive plantations, and already secured an annually increasing surplus of revenue over expenditure. I wish especially to guard myself against forming or expressing Utopian or too rosy views on this subject, and I can have no interest in over-estimating the value and importance of the forests, as it is very improbable that I shall be able to remain as conservator, even if the Government and the House should wish to retain my services beyond the year for which they are at present lent. I do not pretend that we are going to clothe barren hill sides and desert plains with trees in a year, or even several years, or that the indigenous forests are at once to pay off your colonial debt, but I do say and think that, with proper management, we should be able to plant wherever necessary, secure a permanent and improved supply of timber for the use of individuals and public departments, and retain an intact and gradually improving forest property, whose capital value *may* represent your national debt, and the income derived from which *ought* to go *far* to meet the interest thereon. I think I am justified by what I have seen in considering that this *may* be done, but it can only be done by the public and its representatives in the House regarding the question of forest conservation as a national or colonial one, and not from a merely local point of view. Whatever is done must, of necessity, be done in the interests of the colony at large, that is to say, of the public, and the only reason for State or Government interference and direct action is that damage to forests cannot be repaired in a day, nor can they, if once destroyed, be replaced in a year like a crop of wheat. Even a generation is, as a rule, too short to grow good timber, and you will, I am sure, admit that of all people colonists are the least likely to look beyond the present time or generation. The Secretary of State for India, writing in 1863, makes the following remarks bearing upon this point:—"To forests, from their nature, the usual maxim of political economy which leaves such undertakings to private enterprise cannot be applied. Their vast extent, the long time that a tree takes to reach maturity, and the consequence that few persons live long enough to obtain any, and more especially the highest, returns from expenditure even once in the course of their lives, are proofs of the necessity that forest management should be conducted on permanent principles, and not be left to the negligence, avarice, or caprice of individuals, and therefore point to the State as the proper administrator, bound to take care that in supplying the wants of the present generation, there is no reckless waste, no needless forestalling of the supply of future generations. This is matter of experience, not in India only, but in all other countries of the world." I have, you will kindly bear in mind, nothing to do with colonial politics—abolition, separation, or federation. The views and principles of the present, past, and future Governments of the colony have no legitimate bearing on my duty, which is at present to submit a report on my inspection of the New Zealand forests, with proposals for their management and conservation. Those proposals, so far as I have given them shape in my own mind, will consist in—1. The absolute reservation of a comparatively small proportion of the unalienated forest area. 2. The gradual disposal of the timber and forest products on the remainder of the waste forest lands to the best advantage. 3. The formation of Government plantations wherever we can do so without risk of financial loss, or it is proved that they are absolutely essential to the public good. 4. The encouragement of planting by private proprietors by liberal grants of land in lieu of planted area. Under such a system the whole forest revenue will of course be colonial, and the expenditure be quite irrespective of the county or district, being in fact greatest in the first instance in those contributing the minimum of forest revenue, viz., in creating forest where none at present exists. This is, I think, the only feasible plan of action, and I hope that the Government may see their way to support it, and that the House may approve thereof with such modifications as they may think fit. We can then set to work in a systematic and regular manner with our forest valuations and demarcations, and work district by district. These things cannot be done in a day, but they can be done in time, even in what are considered the most inaccessible places, by perseverance and patience. I have now to thank you for your patience in listening to this paper, which has been written at intervals, and as a rule after a long day in the saddle or on the coach—which must be some excuse for its imperfections and shortcomings. It makes no claim to be exhaustive, or to convey any instruction on forest subjects in detail. My only aim has been to explain, ever so meagrely, what is the aim and object of State Forestry, and, therefore, of the Government in proposing to introduce it, and how it is carried out. If I have succeeded in popularizing the subject, and interesting any of you in it so far as to make you desirous of following it up by studying for yourselves some of the many excellent works on the subject, written chiefly in French and German, I shall be well satisfied, and consider that our time this evening has been well spent.

ART. XIV.—*On Hedges and Hedge Plants.* By J. C. CRAWFORD.

[*Read before the Wellington Philosophical Society, 25th November, 1876.*]

A GREAT want at the present time in New Zealand is the efficient supply of proper plants for live fences, more perhaps in the way of shelter than of protection, because perhaps no live fence in this country will keep out cattle determined to effect a breach.

In Great Britain various plants are used for field hedges, but only two of these may be considered to be in general use, viz., the white thorn and the beech, and of these the thorn is the most generally planted. Neither of these plants seem to be suitable generally for New Zealand hedges. The thorn no doubt grows luxuriantly on good soil, but of late years it has become so infested during the summer by the well-known grub, which eats its leaves, that it becomes unsightly to look at, the smell is disagreeable, and the plant must become gradually weakened and eventually destroyed by the damage done to its leaves. On poor ground the thorn does not thrive in New Zealand. It soon becomes hide-bound and cankered, and does not then make a good fence.

It does not seem likely that the beech will be successfully grown in this country, either for a hedge or for timber. The ravages of a grub seem to be too much for its constitution.

Another plant, the gorse, is much used in some parts, but is subject to serious objections. The danger of its spreading and taking possession of the adjoining land makes its use by no means desirable, and as it will burn green the light from the match of a passer by may at any time destroy the fence. It is desirable to find something better than gorse.

Now, I think the nursery gardeners ought to show a little originality. They ought to set their wits to work to find out the best hedge plants suitable for the country. They should make experiments and try the plants of various countries, instead of merely raising thorns.

I have forgotten to mention the holly. This can hardly be called a plant for a field hedge. It makes no doubt a capital garden hedge, and if it would only grow a little quicker it would answer all purposes admirably, but it is so slow of growth that for general purposes it is unsuitable.

Although I hold that it is the duty of professional gardeners to find out and supply the best hedge plants, I will venture to name some which have come under my notice, and which may answer the purposes of giving shelter. To make a paddock safe from intrusion a wire or other fence will in this country always be required in addition.

The *Escalonia densa* I find to be a very hardy shrub, and it stands the sea breeze well. It grows readily from cuttings, and might be supplied cheap in consequence. Stock do not appear to touch it, and it is very pretty both in leaf and in flower. Its weak points are in deficiency of strength in the wood, in having no thorns, and, as far as I have seen, not ripening its seed in this country. Therefore if always grown from cuttings it may suddenly die out.

The *Ake-ake* grows readily from cuttings and is very hardy, but I am afraid that horses or cattle may eat it. As I have heard the point disputed as to which is *Ake-ake* and which *Ake piro*, I may mention that the plant I mean has a silvery and corrugated leaf.

The plant, however, which strikes me as being most suitable for a hedge plant is the *Hakea asicularis*. It grows readily from seed, indeed I may almost say that every seed is sure to germinate, and it seeds freely. It is so well protected by formidable thorns that it would require a very courageous animal to face it. It grows with rapidity in favourable situations, and with fair rapidity in more barren places, and it stands clipping.

An *Olearia* which grows on the soft ground of the Peninsula might perhaps be grown with advantage as a shelter hedge. In favourable situations it grows very thick and close, and sometimes to a height of seven or eight feet. Live stock do not touch it, and it is difficult to kill, either by burning or by cutting. It has, however, no protection in the way of thorns, and it is subject to the same disadvantages as the *Tauwhinu (Casinia retorta)*, viz., that it seeds very freely and is apt to spread; but still not nearly to the same extent as the latter plant.

Few farmers in New Zealand have any idea of the time, the labour, and the expense required to produce a good hedge. In my part of Scotland, in an elevated situation, it requires about nine years to rear a thorn or beech hedge into a secure fence. During this period it must be be fenced on both sides, if stock is kept in the adjoining fields, and it must be dug about the roots and cleared from weeds and grass twice a year. In lower and more favourable situations, I suppose four or five years would be required. After the fence is established, it ought, besides being pruned, to be cleared of weeds about the roots at least once a year. This is a point never attended to in New Zealand, and consequently the lower branches get rotten, and the hedge becomes open at the bottom. Whatever plant we may eventually adopt for our hedges in New Zealand ought to have fair play, and be kept free from weeds and grass.

In forest planting in New Zealand we find that we must have recourse to exotic trees. Those of the country seem generally unsuited for articial plantation. Accustomed to grow naturally in close proximity, thus sheltering each other, they seem unable to stand the greater exposure to air and light when planted by man. There may be other reasons, but it is sufficient to point out that practically they are found unsuitable. Trees from California, from the Himalaya, from Japan, from Australia take their place, and perhaps grow better than those from Europe. If we find the trees from these countries succeed so well, may we not look to the same countries to supply a good hedge plant?

I have seen wonderful hedges of the bamboo at Singapore. They were perhaps rather too high and too close, thereby excluding the air too much. The small black bamboo seems to grow well in this country, but it is hardly the plant we require.

What we want is a hardy plant of rapid growth, which will stand clipping; which, if possible, shall be protected by thorns; and which will not be subject to the attacks of insect life. Whoever shall succeed in introducing this plant will deserve the country's thanks. The Osage orange has been tried by many of us, but, I think, with unsatisfactory results. It does not stand the sea breeze, and it is in leaf for a comparatively short time of the year. We want something better than the Osage orange.

Possibly from California or Oregon we might obtain the plant we require, and with greater facility than from other countries, on account of the regular communication.

There is a common New Zealand shrub, or tree, which may be made useful for shelter, viz., the Ngaio: but to bring it into common use for a hedge plant it must be raised in nurseries, and thus established with good roots before planting out. So long as we have to depend upon getting young plants from the outskirts of the bush, the greater number of them will be sure to die off after being transplanted. This will not suit for hedge planting, as the preliminary expense of preparing the ground is thus thrown away.

The Ngaio is very hardy, is improved by pruning and clipping, and does not seem to be eaten by horses or cattle; but I am informed that sheep will eat it, although I have not myself observed them to do so.

Art. XV.—*Lime as Manure: Its Beneficial Effects when applied to the Cultivation of the Soil.* By D. Hay.

[Read before the Auckland Institute, 2nd October, 1876.]

Common limestone is composed of carbonate of lime, 95·05 parts; water, 1·68; silica, 1·12; alumina, 1·00; oxide of iron, ·75 per cent. The Whangarei limestone, which is said to contain from 96 to 97 per cent. of carbonate of lime, is therefore of superior quality. Lime from its strong attraction for carbonic acid and moisture may thus also be beneficial by affording a supply of both these to plants. Lime exists in nature and in the soil in a state of combination with carbonic acid. Limestone, however, before it can be rendered friable must first be burnt and reduced to a quick or caustic lime. In this state, on the addition of water, it readily pulverizes, and greedily absorbs carbonic acid from the atmosphere. Very few limestones or chalks, however, are pure, the primary marbles and calcareous spars being the exception. Clay, flint, magnesia, iron, and other salts are in a greater or less quantity found mixed in limestones. Slacked lime is a combination of lime with about a third of its weight of water, and is called a hydrate of lime, and when this hydrate, by exposure to air, becomes a carbonate, the excess of water is expelled. When freshly burned or slacked lime is mixed with any moist fibrous vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water. By this kind of operation lime renders matter which was before comparatively inert, nutritive; and as charcoal and oxygen abound in all vegetable matters, it becomes at the same time converted into carbonate of lime. Marls, and and chalk have no action of this kind on vegetable matter. They destroy worms and other tender-skinned vermin, and they prevent the too rapid decomposition of substances already dissolved, but in other respects their operations are different from that of quick lime. Lime marls, and even shell sand produce wonderful effects on peat soils by absorbing the gallic acid which they contain, and promoting the decomposition of the woody matters.

All soils having a deficiency of calcareous earth, and which do not effervesce with acids, are improved by lime, either mild or quick lime. Sandy soils are improved more than clay. When a soil deficient in calcareous matter contains much soluble vegetable matter, the application of quick lime should always be avoided, as it either tends to decompose the soluble matters, by uniting to them carbon and oxygen so as to become mild lime, or it combines with the soluble matters and forms compounds having less attraction for water than the pure vegetable substance. The case is the same with regard to most animal manures, but the operation is different in different cases, and depends upon the nature of the animal matter. Lime forms a kind of insoluble soap with oily matters, and then gradually decomposes them by separating from them oxygen and carbon. It combines likewise with the animal acids, and probably assists their decomposition by abstracting carbonaceous matter from them, combined with oxygen, and consequently it must render them less nutritive. It tends to diminish likewise the nutritive powers of albumen from the same causes, and always destroys to a certain extent the efficacy of animal manures, either by combining with certain of their elements, or giving them new arrangements. Lime should never be applied with animal manures unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with common dung, and tends to render the extractive matter insoluble; and with almost all soft animal or vegetable substances lime forms insoluble composts, and thus destroys their fermentive qualities. Such compounds, however, exposed to the continual action of the air, alter in course of time: the lime becomes a carbonate, and the animal and vegetable matter enter by degrees into new compounds suited for vegetable nourishment. In this view lime presents two great advantages for the nutrition of plants: the first, that of disposing certain insoluble bodies to form soluble compounds; the second, that of prolonging the action and nutritive qualities of substances beyond the time during which they would be retained if these substances were not made to enter into combination with lime.

Lime has been employed as a fertilizer from a very remote period: both Cato and Pliny attest the use of it by the Roman cultivators.

The chemical uses of lime to vegetation may be divided into two parts: first, its direct action on vegetable matter; secondly, its chemical operation on the matters contained in all cultivatable soils. In its direct action as a food, or constituent for plants, its uses are of the greatest importance, for hardly a single plant has yet been analyzed in which the presence of lime has not been detected, in combination with an acid. It is found in the commonly cultivated crops of the farmer in very varying proportions: thus the ashes of the oat plant contain more than five cent. of lime. In two pounds weight of the seeds of wheat are found about 12 grains of carbonate of lime; in the same quantity of rye, about 13·4 grains; in barley, 24·8 grains; 33·75 grains in the oat; and 46·2 in the same quantity of rye straw. It abounds also, with magnesia, in the wood of trees. The ashes of the oak contain about 32 per cent. of earthy carbonates; those from the poplar, 27 per cent.; of the mulberry, 56 per cent. The proportion of lime found in plants varies with the composition of the soil on which they are produced. There are very few soils fit for cultivation from which this earth is entirely absent; and its addition is found by the farmer to promote the fertility of most barren lands. The attraction of lime for the aqueous particles of the atmosphere is considerable, and is, therefore, not without its uses in this respect to vegetation.

The chemical action of lime is also very considerable: mixing with the heavy adhesive clays, it renders them much more friable, less liable to be injuriously acted upon by the sun, and much more readily permeable by the gases and vapour of the atmosphere. It renders them—the cultivator tells you—"more easily workable." And again, the action of lime upon the organic substances always more or less contained in the farmer's soils, is very considerable. This benefit is not merely confined to the vegetable remains in the land, but it extends with equal energy to the dead and the living animal matter with which, in a countless variety of forms, the land is tenanted. There are few substances more destructive to grub-worms, animalculæ, etc., than lime; and where these are destroyed by lime, the soil is, as a natural consequence, enriched by their remains. On soils which abound with sulphate of iron—which is commonly the case with those which contain an excess of peat—the action of lime is not only beneficial in decomposing or rendering soluble the mass of inert vegetable remains, but the lime decomposes the sulphate of iron, and, uniting with its sulphuric acid, forms the well-known fertilizer, the sulphate of lime, or gypsum, of commerce.

The quantity of lime used per acre of necessity varies with the soil, and the expense with which it is procured. The heavy clay and peat soils require the largest proportions; the light lands need a much smaller quantity to produce the maximum benefit. The proportion commonly used on the clay soils in the midland counties of England is 100 bushels per acre; and 25 bushels per acre on light soils. In Scotland they apply sometimes as much as 360 bushels per acre; in Ireland much larger quantities are successfully employed; and on some of the peat mosses in the North of England more than 1,000 bushels have been used with good effect; but, however, the employment of such large quantities can rarely be justified.

ART. XVI.—*Notes on Quartz Crushing at the Thames.**

By J. GOODALL, C.E.

[*Read before the Auckland Institute, 27th November, 1876.*]

I HAVE recounted on a prior occasion the chief errors of quartz crushing as practised on the Thames. I shall now endeavour to show how a great many of them may be avoided even by mechanical means of manipulation, that is without using chemical re-agents. Battery managers in general know too little of chemistry to look with favour on any process of gold saving dependent on chemical means.

That a vast amount of gold is lost yearly all over the world for want of proper means of saving it, is only too evident from the accounts contained in all metallurgical books recently published that treat on gold. It has been ascertained that 50, 60, and 70 per cent. are common losses. That even this has been exceeded on the Thames, a case that came under my notice fully proved. The directors of the "Golden Crown" mine, which at the time I speak of was a large producer, were desirous of ascertaining the relative merits of two rival batteries, so as to get their quartz crushed at the better establishment. To accomplish this they sent 50 tons of quartz to each mill. Special care was taken that the loads from the tip were sent alternately to each place, so as to equalize the quality of the quartz as much as possible. In the one battery, as well as I can now recollect, the quartz was crushed with quicksilver in the boxes, passed over quicksilver plates, then through Chilian mills, then over short blanket strakes. The blanketings and what remained in the Chilian mills were then passed through the amalgamating barrel. The total product of the 50 tons at that battery was less than 25 ounces, or under one-half ounce to the ton.

* For previous Paper by Author see "Trans. N. Z. Inst.," Vol. VIII., p. 176.

At the other battery the quartz was crushed with quicksilver, passed over quicksilver plates, then over shaking tables, then through Wheeler pans, and the amalgamation finished in barrels. The results from the battery and silver plates, from the shaking tables, and from the pans, were kept separate, making three distinct parcels. Each of these gave the astounding result of over one-half ounce to the ton, the entire crushing of the 50 tons amounting to nearly 80 ounces. But this was not the entire result, as the resultant tailings were allowed to settle in pits, and being treated in Wheeler pans at a subsequent date, yielded ten ounces more. Had not such a fact come under my direct notice I would barely have believed the statements of books. A great deal of the mischief is caused by the miners themselves, who having seen crushing done in other countries perhaps a few years ago, will not submit to any new form of manipulation, however good, unless it be as cheap as the old system, or as cheap as that of any other battery on the same field. In the instance above where the battery that had shaking tables and Wheeler's pans, had saved over three times the amount of gold, the cost of crushing would have amounted to twice that of the other, but as that would not be given in general, the shaking tables and pans had to be discarded so as to be able to compete with the neighbouring mills in price. It is the price of crushing that has been looked to, not the yield.

The great fault of crushing at the Thames is, I believe, using large quantities of quicksilver in the battery boxes; but to convince a Thames miner of that fact, would, I believe, be an impossibility. They are generally very prejudiced in their opinions of gold saving. I remember once a miner wished to bet with a battery manager that the quicksilver used in his battery was light weight, and that a bottle full of it would only weigh half that of a bottle fresh from the shop, and therefore not so good for gold saving as new silver. His reason for the assertion was, that, at the battery referred to, they did not replace their quicksilver often, and that it got lighter by constant use. As the absurd bet was not taken up, the miner took his crushing to another mill, imagining that, as the bet was not taken up, he was right. This may be an extreme case, and I mention it merely to show what the quartz crusher has to contend with occasionally. In general, the crushing batteries at the Thames are well built, and are effective. They will put through as much material and last as long as any others in the world. The groundwork, therefore, is good; but, in my opinion, the manipulation is defective. I have already mentioned that the system generally adopted now is crushing with a large amount of quicksilver in the boxes, and using very fine punched gratings. I consider the use of quicksilver in the boxes and the use of fine punched gratings are both erroneous.

The quicksilver and amalgam in the boxes, being continually battered, passes away as floured quicksilver, even floating on the water, the heavier particles rolling off the plates. This is amply proved by the great loss of quicksilver that is experienced constantly, and by the quantity that has been washed out of waste tailings. What remains in the battery is sickened, and is unfit for amalgamation, and thus allows the gold to escape. The reduced material then passes over the quicksilver plates, and then over blanket strakes, which are often washed. The blanket tailings are then amalgamated in large berdans, having a loose and a drag ball. In this process gold and quicksilver are not only lost, but a great deal of power is wasted, thereby increasing the cost of the produce of gold. It is difficult to reduce any material to a fine state by stamping—beyond a certain amount: in quartz, we may presume, to less than one-sixteenth of an inch in diameter; down to that it is comparatively easy, by the use of coarser gratings than those now used. It would be an easy matter to grind the coarse tailings by a separate grinding machine. I would further recommend the use of wire gratings, instead of punched sheets. Wire gratings, although not so strong as the other, will admit of a better flood, and the extra trouble of replacement would be well compensated for by the extra amount of work done. Another great fault is the amalgamating in the berdans, where great loss is experienced in gold, quicksilver, and power. The drag grinds the berdan more than the tailings, and converts a part of the quicksilver and amalgam into floured particles that readily pass away.

Having described what, in my opinion, are the defects of the present system, I would recommend the following treatment to utilize the present appliances, with some small alterations and a few additions Crush the quartz (after it has been puddled to get rid of the clay that exists in mullocky leaders), coarsely, without quicksilver, in the battery, using wire gratings, having, say, 81 holes to a square inch. Save as much gold as possible by the quicksilver plates and ripples. The tailings should then be gathered in pits, and passed through grinding machines, or passed direct from the silver plates through the grinding machines. When the tailings are fine enough, they should be amalgamated in barrels, or any other gentle system of amalgamation. One berdan should be sufficient for a large establishment, and it should be reserved for the cleaning of amalgam only. The whole of this could be easily arranged, and it would cause less work than is now entailed in working a battery, and I am confident a great deal less power will be necessary, and more gold saved.

Art. XVII.—*The Comparative Atmospheric Pressure of New Zealand and Great Britain (considered in reference to Dr. Newman's theory of Physical Deterioration)*.* By Charles Rous Marten, F.R.G.S., F.M.S., M.Sc.M.S.

[*Read before the Wellington Philosophical Society, 26th November, 1876.*]

1. In a paper entitled "Speculations on the Physiological Changes which obtain in the English Race when transplanted to New Zealand," read before this Society on the 30th September last, the author, Dr. Newman, in a very ingenious argument, endeavored to show that in consequence of certain deficiences in the soil and climate of New Zealand, the English race may be expected to deteriorate, both physically and mentally, in future generations. Thus, if Dr. Newman's theory be correct, children born in New Zealand of parents who have migrated hither from Great Britain should be inferior both physically and mentally—taken on an average—to their progenitors, while their descendants in like manner, should deteriorate still further. Dr. Newman goes on to state that indications of this degeneration are even already visible.

2. The alleged deficiencies in the New Zealand soil and climate, to which this supposed deterioration is attributed by Dr. Newman, consist mainly in an insufficient proportion of phosphates as regards the soil and a diminution of atmospheric pressure in respect to the climate. The former of these two points it is not intended to discuss in this paper, the question being one rather for a geological or chemical treatise. Moreover, as Dr. Newman gives us reason to hope that the threatened degeneration from this cause may be averted by so simple and pleasant a prescription as an occasional whitebait dinner or an oyster supper, this aspect of the case may be dismissed.

3. The other hypothetical cause of this hypothetical deterioration must be dealt with more seriously, inasmuch as no course of diet or medical prescriptions would supply greater atmospheric pressure, did any deficiency exist, as it could additional phosphorus, if the soil lacked the needful proportion of that element. It becomes therefore a matter of some moment as affecting the future of this colony, to ascertain whether the atmospheric pressure of New Zealand be really inferior to that of Great Britain as alleged.

* See Newman, Art. V., p. 37.

4. First, let us understand clearly Dr. Newman's arguments on this head. As I understand him, his contention stated in syllogistic form is as follows :—

Major premiss—Children born in countries where the atmospheric pressure is less, have a tendency to be inferior to those born where the atmospheric pressure is greater.

Minor premiss—In New Zealand the atmospheric pressure is less than in Great Britain.

Conclusion.—*Ergo*, children born in New Zealand should be inferior to those born in England.

5. There is also an implied argument *á priori*, that inasmuch as this last condition has been observed to exist in certain cases, and as such an effect would be produced by the cause stated in the *major premiss*, *ergo*, such cause exists. This last argument it is unnecessary to notice on the present occasion.

6. The object of this paper is, simply, to disprove the *minor premiss* of Dr. Newman's implied syllogism, and this I hope to be able to do, by showing on indisputable evidence that so far from the atmospheric pressure in New Zealand being less than that of Great Britain, it is in reality appreciably greater.

7. In support of his theory, Dr. Newman correctly states, on the authority of Captain Maury, Dr. Buys-Ballot, and other undoubted authorities in meteorology, that the mean barometric pressure is generally lower in the Southern Hemisphere than in corresponding latitudes of the Northern Hemisphere. This is a fact well known to meteorologists, and thoroughly recognized. At least, if not a "fact" strictly speaking, at any rate all the trustworthy observations hitherto taken tend to prove this to be the case. Mr. Buchan, the Secretary of the Scottish Meteorological Society, in his very able and valuable treatise on this subject,* a standard work which gives the results of observations at 500 different places, situated in almost every part of the globe. From these observations he has constructed a series of yearly, half-yearly, and monthly isobaric charts. In these charts the marked discrepancy between the barometric conditions of the two hemispheres is shown very clearly. In the Northern Hemisphere the isobars follow a most irregular and eccentric course, whereas in the Southern Hemisphere they flow almost in straight lines. It must be remembered, however, that owing to the greater

* "The Mean Pressure of the Atmosphere over the Globe," "Transactions of the Royal Society of Edinburgh," Vol. XXV., p. 575.

area of ocean in the latter hemisphere, not only are there fewer local disturbing causes in the shape of spacious continents and lofty mountains, but also the observatory sites are proportionately fewer. Hence the Southern isobars are in many cases merely arbitrary and approximate lines drawn from one point, at which continuous trustworthy observations have been taken, to another similar point perhaps 5,000 or 10,000 miles away, as from the Cape of Good Hope to New Zealand, the intermediate points being furnished by casual intermittent observations made by passing vessels. It is possible that permanent observations, could they be established in as many situations as in the Northern Hemisphere, might necessitate considerable alterations in the isobars at present accepted. However, taking the existing isobars as a standard, we find that whereas the isobar of 30 inches follows a mean latitude of about 42° in the North Atlantic Ocean, the latitude of the same isobar in the South Pacific is only about 35° Similarly, the isobar of 29° 70 inches is found at a mean latitude of about 60° north, and only 48° south. The very low pressure prevalent in the vicinity of Cape Horn is a meteorological feature well known to navigators.

8. All this of course only goes to prove that the mean pressure is less in the Southern than in the Northern Hemisphere. Such in fact might have the form of Dr. Newman's *minor premiss*, and so stated undoubtedly it would have been irrefragable, but in that case, as the middle term of the syllogism would have been undistributed (it not being shown that the rule included New Zealand as compared with Great Britain), the argument must have fallen to the ground. The real question is—not whether the pressure in New Zealand be less than in the corresponding northern latitudes, but whether it be less than that of England, from whence, to use Dr. Newman's words, the English race is transplanted.

9. Dr. Hahn, of Vienna, in his Essay on the Climate of New Zealand,* says: "It is a well-known fact that the pressure of air decreases very rapidly towards the Pole in the Southern Hemisphere. We find this confirmed in New Zealand, where the medium pressure of air at the level of the sea, between 37° and 46° S. latitude, decreases from 29·981 inches to 29·804 inches; whereas in the Northern Hemisphere in these latitudes the pressure of air remains between 30·009 and 30·001 inches."

10. Dr. Hahn is not quite accurate here. Reference to the isobaric chart will show that the isobar of 30 inches, which in the Southern Hemisphere lies entirely between latitude 32° in the South Atlantic Ocean, and 40° in the Indian Ocean, in the Northern Hemisphere varies most remarkably,

*Meterological Report, N.Z., 1873, Hector, p. 77.

descending to latitude 30° in the North Pacific Ocean, rising to 55° in North America, descending again to 40° in the North Atlantic, then rising very gradually to latitude 65° in Asiatic Russia, next descending again suddenly to 30° at the starting point.

11. The point, however, is not material to the present argument, excepting so far as it goes to show the existence of such large barometric curves in the Northern Hemisphere where numerous observations have been taken, so that it would not have been an unreasonable hypothesis to suppose the existence of similar curves, if less extreme in degree, in the Southern Hemisphere, where observations are but few. Thus even had New Zealand been in the same latitude in the south as Great Britain in the north, and granting the diminished pressure of the latter hemisphere, it would not have been at all impossible that this colony nevertheless might have enjoyed an atmospheric pressure as large as that of Great Britain.

12. Fortunately, however, authentic observations made in both countries are accessible, and being made under known conditions and with trustworthy and verified instruments are readily intercomparable. Those taken in New Zealand under the auspices of the Meteorological Department, (superintended by Dr. Hector,) comprise the barometric records of fourteen stations, distributed with tolerable evenness over the entire length and breadth of these islands, from Mongonui in the north (latitude 35° 1′) to Southland (latitude 46° 17′), and from Napier in the east (longitude 176° 55′) to Hokitika in the west (longitude 170° 59′), and extending over an average period of about ten years.

13. In order to constitute a fair comparison between the two countries, I have selected the same number of stations (fourteen) in England, Scotland, and Ireland, so distributed as to embrace all parts of the kingdom. Thus in England I have taken Greenwich (London) Liverpool, York, Durham, Clifton, Worthing (Sussex), Stonyhurst (Lancashire), and Helston (Cornwall), at all of which places observations have been made and recorded by the Meteorological Society of England, from whose published returns I have compiled the averages shortly to be quoted. In Scotland I have taken Glasgow, Elgin, and Culloden, where observations are taken similarly for the Scottish Meteorological Society, and published in the journals of that body. The stations in Ireland are Dublin (observations made by Captain Wilkinson, R.E., at the Ordnance Survey Office), Belfast (observations taken at Queen's College), and Armagh (observations by Dr. T. R. Robinson at the Observatory). All these observations are, like those in New Zealand, for a period of about ten years, and in both cases are reduced uniformly to a temperature of 32° Fah. at sea level. The results thereof are entirely comparable.

14. They are as follows :—

Great Britain.	N. lat.	Inches.	New Zealand.	S. lat.	Inches.
Elgin	57° 38′	29·790	Southland.. ..	46° 17′	29·803
Culloden	57 30	29·765	Dunedin	45 52	29·873
Glasgow	55 53	29·792	Queenstown ..	45 2	29·987
Durham	54 46	29·810	Christchurch ..	43 32	29·871
Belfast	54 36	29·882	Bealey	43 2	29·805
Armagh	54 21	29·722	Hokitika	42 41	29·932
York	53 58	29·872	Cape Campbell ..	41 50	29·968
Stonyhurst ..	53 51	29·807	Nelson	41 16	29·901
Liverpool	53 25	29·889	Wellington ..	41 16	29·890
Dublin	53 22	29·886	Wanganui ..	39 56	30·070
Greenwich ..	51 28	29·925	Napier	39 29	29·917
Clifton	51 28	29·809	Taranaki	39 3	29·933
Worthing	50 49	29·956	Auckland	36 50	29·930
Helston	50 7	29·977	Mongonui	35 1	29·977
Mean	..	29·848	Mean	..	29·918

Difference in favour of New Zealand, 0·07.

15. Hence it is plain that the mean atmospheric pressure of New Zealand, instead of being lower than that of Great Britain, is ·07 inch higher, and so disappears the clever but illusive theory built upon the contrary assumption. In comparing the foregoing tables, it is curious to note that the barometric means at the respective English and New Zealand stations of lowest latitude are precisely identical, but the mean, although the highest in great Britain, is not so in New Zealand. The means of the three Scotch observatories, *en revanche*, are considerably lower than that of Southland, which is the minimum New Zealand mean. It is also noticeable that whereas the lowest latitude of any English observatory is 50° 7′ viz., Helston, in Cornwall, the highest latitude of any New Zealand observatory—that of Southland, for twelve years under my personal charge, and, I believe the most southern in the world—is only 46° 17′. Thus, the most polar New Zealand observatory is 3° 59′ nearer the Equator than the nearest English one, while the nearest New Zealand observatory is no less than 15° closer.

16. Dr. Newman's *major premiss* I do not intend to discuss in the present paper, although the correctness of his assumption is open to considerable argument. This is the case more especially, inasmuch as it is based to a great extent on another assumption—that pressure increases or diminishes conversely with the degree of atmospheric humidity. A long series of careful hygrometrical observations proves conclusively not only that the two atmospheric conditions are not necessarily correlative, but that often a marked barometric depression is associated with an equally marked atmospheric dryness; at all events, so far from the surface of the earth as

observations can be carried; while a rapid barometric rise, and an influx of moist air also, are frequently coincident. The misapprehension obviously arose from the general acceptance of the theory that the lower pressure of the Southern Hemisphere, as compared with the Northern, is due to the larger relative area of ocean in the former, But that the presence of aqueous vapour is not the only, or even the chief source of deficient pressure, can be proved beyond dispute. Comparison of barometric readings after the subtraction of the vapour tension will show this plainly. A very cogent illustration, however, is afforded by the tables already quoted, which show the pressure to be 29·932 at Hokitika, and only 29·871 at Christchurch, or ·061 in favor of the West Coast, notwithstanding that the latter has a mean humidity of ·86, as compared with ·77 at Christchurch, which, moreover, is to leeward of Hokitika as regards the prevailing wind. Hence the atmospheric pressure seems actually to diminish instead of increasing as the air loses its moisture. The truth appears to be that the atmosphere is subject to disturbances more or less analogous to those of the ocean—waves, currents, eddies, and even tides, produced by causes and governed by laws as yet only imperfectly understood, but wholly irrespective of excess or deficiency of aqueous vapour, whose presence or absence probably is oftener the effect than the cause.

17. There are many other climatological characteristics of New Zealand related directly or indirectly to the subject of Dr. Newman's able essay, and I purpose treating of them on a future occasion. In the present paper I have simply endeavoured to prove—and I trust I have succeeded in the attempt—that whether Dr. Newman's speculations as to the probable degeneration of the English race in New Zealand be well founded or not—for the sake of our adopted country we must hope the latter—at any rate deficient atmospheric pressure does not enter as a factor into the problem.

ART. XVIII.—*On the Longitude of Wellington Observatory.*

By VEN. ARCHDEACON STOCK, B.A.

[*Read before the Wellington Philosophical Society, December 9th, 1876.*]

A BRIEF account of the establishment of a longitude for the Wellington Observatory will be found, it is hoped, interesting for the present meeting of the Society, and as a record for future reference.

Some twenty-five years ago, H.M. ships "*Pandora*" and "*Acheron*" came to Australia for the express purpose, amongst other duties, of fixing the longitudes of different points in New Zealand, both ships being well provided with chronometers of the best construction.

The point of departure in Sydney harbour was Fort Macquarrie, which was assumed to be in longitude 151 14′ 00″ E. Pipitea Point, in Wellington Harbour, was placed in longitude 174° 47′ 53″ E., difference being 23° 33′ 53″, or 1h. 34m. 15·533s.

It has been since ascertained that there was error in this assumed longitude for Fort Macquarrie, and that Fort Macquarrie is 2·63 seconds E. of Sydney Observatory.*

The longitude of Sydney Observatory was taken as 10h. 04m. 53·9s. E. Wellington Observatory is 3300·2 feet W., by measurement from Pipitea Point, or 2·88 seconds.

These data thus gave result :—

		H.	M.	SEC.
Sydney Observatory		10	04	53·9
Fort Macquarie	+			2·63
		10	04	56·53
Difference	+	1	34	15·533
		11	39	12·063
Pipitea Point from Observatory	−			2.88
		11	39	09·183

This longitude is at present used at the Observatory. True time is there gained and corrected for this constant error 9m. 09·183s., so that the clock which drops the time ball shows always the same time as a clock stationed at 11h. 30m. 00s. E. There is this manifest advantage in this plan : a shipmaster has only to note the difference of his chronometer from 12h. 30m., when the Wellington ball drops, to gain a Greenwich date ; and so, observing from time to time, to gain the rate of his chronometer.†

In the early part of this year a communication was received from Dr. Russell, Astronomer Royal at Sydney, proposing to interchange signals between Sydney and Wellington. At an arranged time, at the ending of each fifteen seconds in five minutes, a key was pressed down, thus giving twenty signals ; and, after an arranged interval, twenty similar signals were received from Sydney.

Dr. Russell gives this as the result :—

	H.	M.	SEC.
From Wellington to Sydney	1	34	15·35
From Sydney to Wellington	1	34	16·6398
With mean	1	34	15·9949

I have no hesitation in saying that the signals from Wellington to Sydney are of more value than those from Sydney to Wellington, and that

* Capt. Nares, "Trans. N.Z. Inst.," Vol. VII., p. 504.

† Hector, "Trans. N.Z., Inst.," Vol. I., p. 48." *n.e.* p.

the former value is more likely to be true than the latter, for these reasons: I sent the signals from Wellington, and the evidence of all in the Observatory was that the key was pressed down synchronously with the fifteenth-second beats of the clock. The signals from Sydney were received by an assistant, whose cry at the movement of the flash, as the Sydney key was pressed down, was compared by me with the clock beats. Thus the second process passed through two observers. It is also vastly more difficult to receive than to send. It may be certainly presumed also that the Sydney observers were more practised in the work than those at Wellington, to whom the work was new. But the difference thus gained thoroughly establishes that obtained by the chronometers of the "*Acheron*" and "*Pandora.*"

* Fort Macquarrie — Pipitea Point *

1h. 34m. 15·533s.

* Sydney Observatory, 2·63 E. of Fort M. — Wellington Observatory, 2·88 W. of P. Pt. *

1h. 34m. 15·9949s.

The difference between the two values is only half a second; and if, as I think should be done, that value be allowed for superiority of the signals from Wellington to Sydney to those of the reverse way the two values will be nearly identical.

The value now given for the longitude of Sydney Observatory is 10h. 04m. 47·32s. This new value would give for that of Wellington Observatory 11h. 39m. 02·6s.

The value of Sydney Observatory, however, as gained from the Observatory of Melbourne is 10h. 04m. 50·61. This value gives for Wellington Observatory 11h. 39m. 05·893s.*

Major Palmer's value, gained by comparison of time difference between Wellington and Burnham (Burnham longitude being fixed after several months' observation), is 11h. 39m. 4·81s.†

These longitudes are therefore:—

	H.	M.	S.	
1.—	11	39	09·18	Wellington from Sydney, with old value of Sydney Observatory.
2.—	11	39	05·893	Wellington from Sydney and Melbourne Observatories.
3.—	11	39	04·81	Wellington from Burnham.
4.—	11	39	02·6	Wellington from Sydney, new value.

Confessedly no problem is more difficult than that of obtaining an absolute longitude by observation. Even with the instruments at the Royal

* Hector, "Trans. N.Z. Inst.," Vol. VII., p. 504.

† New Zealand Gazette, 30th March, 1876.

Observatories of Sydney and Melbourne there is a known error of 3·27 seconds between the two observatories. While then it would seem that the longitude for Wellington Observatory is in error, it would be better perhaps to adhere to the value now used, which only differs from the mean of the above values by 4·746 seconds—a difference too slight to be a cause of any danger to vessels arriving from long sea voyages, while for coastal navigation it is obviously desirable to maintain a local time in accordance with the longitude on the charts.

Art. XIX.—*Notes on some Ancient Aboriginal* Càches *near Wanganui*. By H. C. Field.

[Read before Wellington Philosophical Society, 9th December, 1876.]

I have compiled the following notes on an examination of some ancient aboriginal *càches* near Wanganui, not only because I believe they may be of interest to the Wellington Philosophical Society, but because I think it well that the result of any such investigation should be placed on record for the guidance of other explorers, and to facilitate the comparison of similar observations in different localities.

The coast between the mouths of the Wanganui and Kai Iwi rivers is formed throughout the greater part of its length of cliffs from 120 feet to 150 feet high, against the base of which the sea beats for so great a portion of every tide that it is only for an hour or two at dead low water that any one can pass below them. This of course necessitated the opening of tracks parallel with the coast line, and at some little distance from it, and such tracks have evidently been used from a very early period. The ground on the top of the cliffs is covered with sand dunes, extending to an average distance of a quarter of a mile inland. These dunes are, however, for the most part disposed in high ridges, extending diagonally inland at an angle of from 30° to 40° from the coast line. The cliffs are of the marine tertiary formation, and wear away very rapidly (at an average rate—so far as I can judge by nearly 26 years knowledge of them—of about six feet per annum), and the sand dunes are continually creeping inland, and covering soil previously occupied by vegetation, fern, flax, toi-toi, and grass. The actual ridges of sand often extend for a distance of half a mile, or more, inland; but between them the vegetation, on the other hand, often extends to within one or two hundred yards of the actual cliff. It is noticeable that as the sand covers up the vegetation, it seems actually to desiccate and destroy not only it, but also the soil on which it grows, so that when any surface afterwards becomes exposed by the sand being blown from off it, on the onward march of the sand, such surface always consists of the bare clay, with a few dried-up roots of fern, etc., traversing it. Ancient forests, with some of the trunks of the trees lying prostrate, and all their stumps standing erect, though broken off eighteen inches to three feet above the root, occur at three different levels, viz., at about 20 feet, 70 feet, and 120 feet above high-water mark: and even the highest of these has been submerged, and covered to a depth of several feet with marine deposit. Owing to the route along the base of the cliffs being only practicable during so short a portion of the tide, and my not having been along it for many years, I cannot say whether these forest layers show in any place one above the other, and thus indicate separate periods of depression and upheaval, or whether they may have merely grown on terraces of different heights, and been all submerged at one time; but I may note, that while the lowest layer consists of mixed timber of moderate size, the second seems to be exclusively of manuka trees which cannot have exceeded six inches to eight inches in diameter, and appear to have been of scrubby growth, and the top one contains the butts of large Ratas and Totaras, such as could not now be found for many miles inland. These large trees in the top layer of forest have also, in many instances, evidently been destroyed by fire, but no trace of similar destruction has, so far as I know, been observed in the case of either of the lower layers. From having had, during the last 26 years, continued opportunities of noticing the appearance of stumps of trees which have been killed by fire, I am satisfied that the charred condition of the stumps in this upper layer of forest is the result of fires lighted while the trees were alive, though whether by human agency it is impossible to say with any certainty. My own impression is that these trees were burned by human beings: because had the forest been set on fire through volcanic action, I think the whole, and not merely detached large trees here and there, would have shown the fiery traces. And had the fires been kindled in the stumps, when they were exposed after upheaval, their partially rotted condition would probably have caused them to be utterly consumed, and at all events the earthy matter with which they are impregnated would have caused them to burn with a red ash, which always remains distinctly visible for very lengthened periods where swamp or sunken timber has been the material of a fire. I have noted the above particulars because they will serve to make the following more intelligible; and may further add that from the mouth of the Wanganui river to that of the Omapu stream, a distance of about five and a-half miles, there is not a single brook or watercourse flowing into the sea, though numerous springs ooze out on the beach, or trickle out of the face of the cliffs.

To come, however, to the immediate subject of this paper, it is right that

I should mention that Mr. G. Roberts, the Government Surveyor, when lately engaged in making a traverse of this portion of the coast, noticed at many places among the sand-hills, and particularly on places from which the sand had been blown off, large quantities of stones, such as Maoris use for cooking food in their *hangis*. In company with these were considerable quantities of charcoal and a very large number of fragments of bone, mostly those of Moas, but some which he fancied were human. He further observed that in their vicinity were many of those little groups of white quartz pebbles which are supposed to have been swallowed by the Moas for digestive purposes, and the constant occurrence of which in such groups of tolerably uniform size seems to indicate their having been emptied out of a bird's crop, or some similar receptacle. On closer inspection of these collections of cooking stores, he found among them some stone adzes, and observed a great many of the stone flakes such as savages use for knives, and for pointing arrows and spears. He likewise ascertained that the owners of the properties on which the stones were lying (or persons in their employ) had at different times picked up many articles of the above kinds at these places; and he, therefore, came to the conclusion that these deposits were of the same character as the kitchen middens of Europe, and might similarly repay the trouble of an examination. He, therefore, mentioned the matter to myself and others whom he thought likely to take an interest in such questions; and thus Mr. M. V. Hodge and I were led to devote the whole of yesterday to an examination of the deposits. The first places which we examined were on the immediate banks of the Omapu stream, a locality in which Mr. Roberts had mentioned that there were some extensive deposits, which, however, we failed to discover, no doubt from want of sufficiently definite directions as to their site. We found here only a few *hangis*, and these apparently of quite recent date, and not accompanied by anything worthy of notice. About half a mile nearer to Wanganui, however, we found near the top of the cliff a very large quantity (certainly many thousands) of cooking stones, spread over an area of nearly a quarter of an acre in extent, and among them were various articles such as Mr. Roberts had described. We noticed that a good many of the larger stones appeared to have been arranged in circles, or ovals, of from two feet to three feet in diameter; but at first we did not take much note of this, as we supposed such rings merely marked the outline of old *hangis*; and though we examined some of these, and found within them stone knives and pieces of basaltic stone, some of them partially shaped, mixed with charcoal and pieces of bone, some of which were certainly Moa bones, while others were jaw bones of large fish, and one apparently that of some animal, yet, the idea that these were *hangis* was so strongly in our minds that we failed to notice the fact that there was in each instance only the ring of large stones, and that the rest of the articles, which would in such a case have covered the bottom of the excavation, were wanting. These rings, also, were in all these instances imperfect, and the contents had been disturbed and scattered, either by some one (possibly Mr. Roberts and his men) who had examined them, or by the horses, cattle, sheep, and pigs which feed on the adjacent ground, and no doubt constantly pass over the place. At one end of the space, however, we saw a perfect circle of stones, which had evidently been only recently exposed by the sand drifting from off them; and an examination of the contents of this threw quite a new light on the matter. There was certainly some charcoal in the hollow which was surrounded by the stones, just as there was on all the surrounding ground, and there were sundry pieces of Moa bone and some fish jaws at the bottom of the hole; but the principal contents were of a very different kind. They consisted of a very fair stone adze (of grey stone, like chalcedony); a number of pieces of the black basaltic stone of which many old adzes are made, some quite rough, others roughly chipped into shape, and some of them partially ground; what looked like a broken piece of the cutting edge of a very large adze, and had probably been used as a knife or scraper; two or three dozen flakes, mostly of obsidian, but some of the basaltic stone, and one of them a brownish red stone with a vitreous fracture; and several pieces of petrified wood: not what is frequently so called—wood, covered with a coating of limestone—but a substance similar to what is known as opalized wood, in which the whole substance of the wood has become changed into very hard stone, while at the same time its whole structure, both as regards grain and fibre is unaltered. There could, in fact, be no question that the articles were the domestic implements of some ancient savage, or savage family, which had been purposely deposited where we found them, and been surrounded with the ring of stones to mark the place. And I have no doubt that the other, now imperfect, rings originated in the same manner, and had similar contents. Such stone implements as I have mentioned would not be used as cooking stones, and they had not been subjected to the action of fire, and, moreover, there were no other stones in the hole. When, too, the food is removed from a *hangi*, the stones remain at the bottom till required to be re-heated, and any bones thrown into the hollow lie upon them. If, when the stones are taken out, the bones fell to the bottom, they would be in contact with the burning wood next used to heat the *hangi*, and would of course be calcined. In the deposit we found, the bones were below the stone articles, and yet were not in the least burned. The whole character of the deposits and their surroundings seem to me to raise important questions, to which I will refer presently, after I have described the other similar deposits which we found nearer the Wanganui river. These occur at about ten different places in a distance of about three and a-half miles, and are of greater or less extent. Some of them have, like the first group, been buried in the natural surface of the ground, while others have, clearly, been sunk in the surface of the sand after it had attained a depth of several feet, as we found one *cáche* in process of destruction, owing to its occurring on the slope of the back end of a sand-hill which was being blown off, and the clay surface immediately in rear of this sand-hill was strewn with stones and other articles that had evidently been buried in *cáches* already destroyed. There were bones of similar kinds to those we had previously found, pieces of the adze stone, more or less shaped, and a great many stone knives, mostly of grey or black basaltic stone, though some were of obsidian. I also found a slightly curved club, of grey stone, having its transverse section oblong, with rounded edges, and its handle ground oval, so as to fit comfortably into the hand: and a large round stone, with a groove cut round it, which was probably intended as a sinker for a fishing line. In several cases the articles are scattered on the clay surface on which the stumps of the highest layer of forest trees are standing; but I could not find any indication of their having been actually deposited at that level: on the contrary, we observed that in each such case the marine deposit which had covered the stumps to a depth of several feet (as was evident from its remaining at that level close by), was of a soft friable nature, and broke up and wore away rapidly when exposed to the sun and wind and the trampling of animals, and we judged that the *cáches* had been formed on the natural surface when it consisted of this marine deposit, overgrown by vegetation; and that their contents had been scattered, and fallen to the level at which we found them, as the deposit wore away.

Now, as regards the origin and date of these deposits, and the persons by whom they were made: The first and most obvious idea that occurred to us was, that the spots at which they occur mark the sites of ancient camping places. But several considerations seem to show that this is not the true solution of the first question. In the first place, it is unlikely that persons travelling up or down the coast would have had so many different camping places in so short a distance, and all in such close proximity to an important settlement like Putiki pah. In the next place, Putiki is three miles inland, and as there is no tradition of any pah having existed lower down, and there was therefore no ferry below that point, the track leading towards Kai Iwi started at once from opposite the pah, and passed considerably inland of these deposits. If, therefore, these places were camps, they were used, not by persons travelling to and fro, but by some who stopped at them at intervals (probably certain seasons), for some purpose such as fishing. The fish bones and stone sinker, and the fact that the enormous number of cooking stones and knives at some of them apparently indicated that they had been used by considerable bodies of people, seem to countenance this theory; and the very manner of the deposits also, to a certain extent supports it. It appeared to us as if each family, on leaving, had collected such of their implements which they did not care to carry with them, and covered them up in a hole, and put a ring of large stones around to mark the spot, so that they might at once find them again on their return. And we thought that the reason why they had not been again taken from the holes was that, before their owners visited the spot next season, the drifting of the sand had covered the places, so as to render their recovery impossible. It will be observed that as the grinding of the stone adzes was effected by means of sand and water, the vicinity of sand-hills would offer greater facilities than other localities for the manufacture, and that hence the unfinished articles would be likely to be left behind, with a view to their completion at a subsequent date. As such articles, too, had an appreciable value to their owners and the neighbours, I think that, in this case we may fairly presume that the *tapu* was a recognised institution when the articles were deposited, and that some ceremony, or incantation was used in making the deposit, in order to protect it from spoliation. I have very strong doubts, however, as to this being the true solution of the origin of these deposits. It is very unlikely that camps occupied for lengthened periods, such as the summer season, even for fishing purposes, would have been formed so close within the line of the sand-hills as to be enveloped in a cloud of sand whenever there was any wind, and be liable to be overwhelmed and buried under the dunes as they advanced. Permanent camps, and indeed, almost any camps, too, would only be formed in close proximity to water, yet the first place we examined is fully a quarter of a mile from any accessible water, and all the others very much further—in some instances fully a mile. Even assuming that they were fishing camps, and that water for use at them was obtained from springs on the beach, yet, it is perfectly certain that when these deposits were formed the distance to such springs must have been enormously more than it has now become by reason of the wearing away of the cliffs, and it seems to follow that there must have been means of access to the beach which do not now exist, and which I see no reason for supposing existed at any such recent date as that at which I am inclined to fix the formation. There are no hollows down which tracks could have led to the shore from these points, and it does not seem reasonable to suppose that savages would scale cliffs 150 feet high; still less, continually provide fresh means for scaling them as they wore away, when, within a distance of a couple of miles on both sides (at the Omapu stream, and near the Wanganui Heads) there were easy natural slopes leading right down to the beach. There would be, also, no places in which canoes could be kept at the base of the cliffs, and there are no rocks, on which people could stand to fish from the shore. The idea, therefore, of these places being fishing camps seems to me to be untenable, unless the coast line has been upheaved nearly 150 feet, and the cliffs formed, since such camps were in use; and though the Maoris have a tradition that, when their ancestors landed in the island, the Wanganui valley, for many miles above the town, was an arm of the sea, yet, an upheaval of 50 feet would suffice to change such a condition of the coast to its present one, and the age of the timber growing in the valley indicates that no such upheaval ever has occurred within far more than the period stated. I think, in fact, that this tradition, and others respecting geological changes, are either Negretto ones—which have been handed down by the Maoris, rather than original Maori ones,—or that they show that some of the old Maoris had sufficient intelligence to perceive from the geological indications what changes must have taken place, and what must have been the state of certain localities at some previous, though possibly somewhat remote period, and that their pointing out this to their friends has caused the change to be handed down as a matter of history. Indeed, I see no other way of reconciling these traditions and the Maori genealogies (which last I believe to be in the main correct). Our first idea, too, as to the manner in which these deposits had been preserved (by being accidentally covered up by sand) was, I think, erroneous. From having particularly noted the changes in the position of several sand-hills since 1851, I estimate that they travel at the rate of about a chain in ten years, and probably travelled more slowly when they had more vegetation on them, and were less traversed by animals. The area over which the circles of stones at the first place which we examined are distributed extends fully two chains in the direction in which the sand travels; and it is, therefore in the highest degree improbable that the whole could have been covered by one season's gales, particularly as the sand-hill is only of moderate height; and had the savages on their return on any occasion found the windward portion of their deposits buried, they would, I think, unquestionably have been careful not to bury further treasures so near the enemy. This would have caused large intervals to occur between different sets of deposits in the same locality. But no such interval exists. On the contrary, the circles are distributed over the whole area very uniformly, at distances of a few yards only asunder; and this seems to me to show conclusively that the covering up of the deposits was not accidental. The idea occurred to me that these places might have been camps used by Natives engaged in catching the *titi*, or mutton birds, which would to some extent meet some of the difficulties. Such camps would only be used at night, in fine summer weather; and as the wind at such times is merely the light land breeze, no great annoyance from blowing sand would be experienced. As, too, the Natives would only retire from the camp during the day, to work at cultitions or other matters, and return again in the evening, their leaving their adzes, etc., only slightly covered up appears the more intelligible. It might also account for the camp being so near the cliff, and so far from water, as enough of the latter for the night's consumption might easily be carried up as the savages returned each evening. While, too, some of the party were catching the birds, others, who were to succeed them, might very likely be occupied in grinding the stone tools into shape. But this conjecture utterly fails to account for the articles remaining permanently deposited. For, even supposing the party to have been attacked and overcome during the day, some would no doubt escape and return. And, moreover, it would not explain such quantities of the rings and of the cooking stones, etc., being collected together; as I have no reason to suppose that *titi* were ever so numerous hereabouts as to lead such bodies of Natives to assemble for their capture as would appear to have mustered at these spots. After careful consideration, therefore, of the whole subject, I have come to the conclusion that these supposed camps are really the depositaries of articles belonging to the dead. We know that the northern Natives fancied that the souls of the departed took their flight from earth off a cliff at the North Cape; and probably other tribes held similar ideas respecting cliffs in their own neighbourhoods. We know that the Maoris had such a dislike to using articles that had belonged to a deceased person that, even within the last fifteen or twenty years, axes, spades, etc., whose owner was dead, were destroyed, and any hut within which a death occurred was at once burned. We know, moreover, that weapons and other valuables were buried with their owners. Now, it would be simply impossible to do this last where the owner had been killed and eaten by an enemy, as must have constantly happened in olden times in New Zealand; and it appears likely, therefore, that, in such cases, the property of the deceased would be placed near the place from whence his spirit was believed to have started on its journey to the other world. This would explain at once why the treasures were buried under the sand, as they would probably be purposely placed at the very foot of an advancing sand-hill, with a view to its covering them, and protecting them from desecration. The bones found with them might be those of food, intended for the departed; or may have been for their use in some other way. And the large quantity of scattered bones and cooking stones (particularly of the latter,) might be explained by the fact that on occasions of making such deposits, a funeral feast in honour of the dead may have been consumed: and that, as the cooking stones used on previous occasions would have been covered up, fresh ones were brought each time, and thus the present appearance of a very large number of people having visited the place would result from the successive visits of even a small *hapu*. The number of the supposed camps in so short a distance along the cliff might arise from each *hapu* having its own depositary. The surrounding of each deposit with a ring of stones might be a ceremonial observance intended to protect the articles till securely covered by the sand. Indeed, the only thing for which this supposition would apparently not account is the presence of the petrified wood. This, however, is just the sort of substance to attract the special notice of savages, and might perhaps be regarded as having a magical or supernatural origin or power; and though I have never heard of its being used by Natives in any way, or of its having been noticed as a product of any part of the Colony, yet I am satisfied that it was regarded as valuable in some respect, not only from the number of pieces of it in the deposits we visited, but from my having seen pieces, some years ago, which had been found in company with stone articles at Turakina. As regards the date at which, and the persons by whom the deposits were made, it is not easy to arrive at any definite conclusion. The sand-hills under which they have been buried, and which have again left them exposed after passing, are not more than from 30 to 40 chains long, which, at their present rate of progress, would give only from 300 to 400 years as the time that had elapsed since the deposits were made, and would make it appear that the Maoris were the depositors. On the other hand, the articles are of a ruder type (of course the unfinished state of many of them may to some extent account for this,) than any Maori tools or weapons I have ever seen; and some of the smaller stone flakes have the appearance of having been intended for arrow points rather than knives. This might, of course, be accidental; and, moreover, I never heard that the Australian blacks, to whom the New Zealand Negrettos were probably allied, used arrows; and had the latter done so, the bow would doubtless have remained in use as a Maori weapon. The petrified wood may perhaps throw light on this question, as I know it is found in Australia; and if the blacks there value it, and the Maoris do not, its presence in the *cáches* would tend greatly to connect them with the Negretto race.

I thought it well to make the above remarks as to the probable origin and date of the deposits, both with a view to assisting the members in discussing these questions, and enabling them to judge which theory accorded best with the circumstances and surroundings of any similar deposits known to them; and in order that any persons, who may meet with similar deposits elsewhere, may have their attention directed to such points, as may aid those who take interest in such matters, in arriving at a correct conclusion respecting them. I think it would be well if persons who take such interest, and who reside near the coast, should make a point of examining their coast line soon and occasionally, as most of the deposits near here have been disturbed by animals, or thoughtless visitors, and the whole of them will, in a few years at furthest, have fallen into the sea, through the wearing away of the cliffs, as I have little doubt that many have already fallen.

One fragment of a jaw which Mr. Hodge picked up contains a molar tooth, and is, he thinks, human. The supposed animal jaw he thinks is that of some canine; which would indicate that dogs of some kind existed in the Colony long before Captain Cook's time.

Art. XIX.—*Stray Thoughts on Mahori or Maori Migrations.*

By R. C. Barstow.

[Read before the Auckland Institute, 30th October, 1876.]

Two papers of great interest on the subject of "Mahori or Maori Migrations," and on "The Probable Origin of the Maori Race," have lately appeared—the former from the pen of Mr. W. H. Ranken;* the latter, by Mr. Vaux.†

Mr. Ranken's paper relates chiefly to the supposed earlier migrations of the race in tropical regions, and is very entertaining, embodying many valuable facts and traditions, which summarizing, he has fixed upon the Samoan or Navigator Group, containing amongst others the islands of Savaii and Upola, as the secondary starting point of the migrations which have peopled so many islands in the Pacific Ocean, spreading over a vast space of some 60 to 70 degrees both of latitude and longitude, comprising within its limits both this country and the Sandwich Isles.

Mr. Vaux, on the other hand, almost confines his subject to migrations to New Zealand, entering very minutely into the ethnological and linguistic affinities of our natives with those of other islands. Both these writers agree in maintaining that the intertropical migrations were made from west to east, in the teeth, as they admit, of the prevailing wind and current.

I have ventured to throw together a few facts and arguments, partly as criticizing, partly as supplementing, the above-mentioned papers. I will take Mr. Ranken's first.

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* In the "New Zealand Magazine" of July, 1876.

† Of Baliol College, Oxford, published in "The Trans. N. Z. Inst.," Vol. VIII.

I do not propose now to enter minutely into a discussion of the assumption that all the Maori or Mahori populations have been derived from the same stock as the Malay, or that even somehow—viâ Papua—Samoa may have received its first inhabitants, except that, whilst the similarity of speech and idiom prevailing throughout the whole of that part of the Southern Ocean with which we are now dealing demonstrates, I may say, to a certainty, that if all these races sprang at some time or another from a common origin, the discrepancies and differences between Malayan and Samoan forms of speech are so great as to cause a difficulty. The arguments would stand in this way: that as identity of language proves identity of race between Samoa and the rest of the islands, yet that difference of language between Samoan and Malayan is no bar to the supposition that Samoa was peopled by a race cognate with the Malay in addition to the change of tongue, for it is nothing less. There are only two per cent. of Malay words in Maori, and these are Javanese. The structure of the languages in formation, grammar, and pronunciation, is utterly distinct. The Mahori had lost the arts of writing and metallurgy, which were known to the Malay.

But having once established his people at Samoa, Mr. Ranken proceeds to distribute them, and relates several traditions bearing on this subject. One of these—the account of the voyage of Tangiia—seems feasible enough. The party sailed from Avaiki, Savii perhaps, to Tonga, then to Vavao; were blown away in attempting to return, got too far south, were caught by the westerly winds outside the tropics (22° 40′ S., 152° 20′ W.), and first made Rimitara, thence to Tubuai, again to Akau and the Paumotu Isles; on down the wind to Tahiti. Ultimately Tangiia moved on and settled at Rarotonga. Such a voyage, though a protracted one for a canoe, is natural enough with the ordinary winds. We have thus a legend of direct settlement at Rarotonga, of people who had themselves left Au Avaiki, said to be Savaii, at Samoa, and therefore would expect to find a great resemblance between the dialects of these two islands. Such, however, is not the case, the diversities between Samoan and Rarotongan being greater perhaps than between any two islands in the South Seas. Of course I mean islands peopled by the race of men of whom we are speaking.

I spent during the years 1844 and 1845 rather more than twelve months amongst the South Sea Islands, chiefly at Tahiti and the neighbouring island of Eimeo or Moarea, making several trips between these two places, the nearest portions of which are some eighteen miles apart. I usually made the voyages in whaleboats; and if leaving Papetoai, the chief settlement on Eimeo, for Papeiti, would start in the afternoon, pull some five miles to the eastern point of the island, and then, hauling up our boat, wait till near midnight for a land breeze, which would generally carry us six or seven miles on our way. The trade wind dies away near land at night, and a wind off the land takes its place for a space varying in proportion to the size of the island and the heat of the weather.

On one occasion we found at our stopping place, hauled up on the beach, a large double canoe, not made like the Mangaea or Aitutake double canoes, of two trees each fitting into and over one another at the centre, but built of many pieces of Tamanu wood, the largest probably not exceeding four feet in length by one foot in width, and of all kinds of shapes, sewn together with cocoa-nut fibre or sennet, and thus forming a pair of vessels of thirty-five feet or so in length (they were longer than the whaleboat), seven or eight feet in breadth, and five feet deep. These canoes were joined by beams across their gunwales, being some nine or ten feet apart. On the beams a platform, on which was a small hut of palm leaves. Each canoe had one mast, near the bows of one and near the stern of the other.

This canoe contained some nine or ten men, four or five women, and as many children, belonging to an island of the Paumotu Group, some 200 or 300 miles to the eastward. I forget the name of the spot. They had left their home in search of a party who had been blown to sea some time previously, and had visited many islands during their voyage—Huahine and Riatea among the number—without hearing tidings of their lost friends, and were now on their return home; having got thus far on their way back, they had hauled their canoe ashore, and were waiting for a fair wind for its continuance.

Our party went on that night, and I thought no more about that canoe, until rather more than six months later I again made the same trip, and to my astonishment at the same place was the same canoe. We learned that the wind had never changed in all that time but once, and then had reverted to its wonted direction by the time the craft was afloat. The people had lived upon fish and the cocoa-nuts, bread fruit, taro, faiis, and other vegetables which were to be had for gathering. One child had died, and another been born. I remember that I subsequently heard that they had departed.

I mentioned these facts to the missionaries living on the island—a Mr. Simpson, who having been master of a collier between London and the North was likely to notice changes of weather, and Mr. Henry, who was the survivor of the first missionaries to Tahiti, having sailed from England in the good ship "*Duff*," in 1796—and was told by them that occasionally the easterly wind blew the year through, unvaried save by three or four squalls of a few hours' duration, though in other years two or three weeks westerly wind in October to December was customary.

It must be borne in mind that Tahiti is beyond the range of the hurricanes which visit the Fijian seas. These islanders having lost their friends went to the westward to look for them, and had a tedious return voyage.

At a later period of my sojourn at Eimeo I heard of the arrival of some strange people in a canoe. I went to the settlement at which they were located to see them. These strangers were two men and two women, who having left the island in the Low Archipelago in which they dwelt, in a large canoe to obtain cocoa-nuts from some small uninhabited island in the vicinity, on their voyage back with their cargo, had all fallen asleep, drifted, lost their reckoning, and existing on the cocoa-nuts had in about a fortnight sighted Eimeo. One of the women married a Tahitian, and I think that the party had made up their minds to remain, and not again trust themselves to the winds and waves.

Nor is this prevailing east wind merely local. During my sojourn on the island of Eimeo, a Sydney vessel, a two-topsail schooner, named the "*Sarah Ann*," owned and commanded by a Capt. Dunnett, called in Taloo Bay. The Captain had been establishing parties for pearl shell fishing and cocoa-nut oil manufacture on several of the outlying islets, trading round elsewhere whilst these articles were being procured. On seeing me making preparations for starting in a whaleboat for Papeiti he cautioned me as to the risk I was running, telling me that just previously the oars of a boat belonging to one of his parties had been washed up on Tahiti, and as they had been lashed together, he on learning it, feeling anxious, had gone to Chain Island, and found that his mate left there in charge had gone away in a boat, and had not returned, and that he could get no trace of him beyond these oars at any of the islands about, and was obliged to conclude that the crew had perished.

Some months subsequently, on the eve of my departure from Tahiti, I met on the beach this mate, a Mr. Clarke, a mere skeleton to look at. He narrated his wonderful escape. I accidentally fell in with the story in print a little time back, and give it to you condensed as an illustration of what I have said as to winds :—

"The time for the return of the schooner had now expired, and being short of provisions I proposed with a boat's crew to visit Hanea, an island about forty-five miles south-west, to learn if any vessel had called from Tahiti ; if not, to proceed thither, a distance of about 250 miles. I got ready a Greenland whaleboat, and put in her 30lb. of biscuits, a small cooked pig, four gallons of water, and six young cocoa-nuts. On the 15th August, 1844, we left—four grown-up men, three youths, and myself. I had my dog with me and my chest. We had a nice breeze and soon sighted Taitea. The wind soon freshened and blew pretty stiff. At 10 p.m. I proposed, as the wind was fair and strong, to steer for Tahiti. They consented. We had no compass, so steered by the stars, as we supposed, due west. At 2 a.m. we shipped a sea which nearly filled the boat to the thwarts. We then lashed the oars, made a raft, and rode to it with four fathoms of native rope, and had some bread which we found soaked. In about two hours the rope parted, and we got broadside on. I could not induce the natives to jump overboard and secure the raft, there was so much sea on, and a sea filled us. I put the boat before the wind with the steer oar, and the natives baled. We had to run, and did so for three days. On the fourth, having my sextant and epitome, found we were 80 miles south of Tahiti, and supposed 150 miles to the westward. The weather now moderated, and I steered for north-west. Next day the natives insisted upon taking charge, and began steering after birds that passed. Our water was expended, but we caught a little during a shower. I allowanced the bread half a biscuit a day. On the seventh day they killed my dog, made a fire by rubbing two sticks, broke up some of the lining, and cooked the poor beast in the saucepan. I could not eat any. For five days now they steered west, hoping to make some island of the Hervey group. The water had been out two days, except a little mixed with brandy I had in a bottle, and with which I wet my lips at night. The natives now slept a great deal, and ran the boat about by day, lying to by night for fear of passing land. They would not follow my advice as to our course. On the nineteenth day our bread was completely expended, and the crew began howling and lay down to die. They now gave me charge, and I tried to get to the south, so as to reach Aitutaki. I had a little laudanum, I mixed a little with salt water and took it, easing my pain. On the 24th day the natives ransacked my chest whilst I was asleep, and drank some laudanum, castor oil, and sugar of lead, which were in it. Two slept 48 hours without waking after this. On the 28th day caught a little rain in a squall. One man became insane, and I induced the natives to give me up their knives and hatchets for fear he should do harm. I dropped them over the side and felt more comfortable. On the next day he died and was thrown overboard. On the 31st day a youth died, and on my going forward to do something with the jib, his father threw me overboard, but I caught the gunwale and clambered in. We had no more rain, and on the 35th day two more died. They had eaten the leather from the rowlocks and part of the sails. On the 36th day two more died and were thrown overboard, leaving only myself and another, and on the next day he succumbed. Being an enormously big man I had much trouble to throw him out.

"I was now alone and so weak I could not hold the steer oar, so I lashed it amidships, and laid myself down in the bottom of the boat. While lying there I heard something jump. I knew it was a fish, and, rousing up, I got a pearl hook that I had brought with me, and caught three albicore. I sucked their blood and swallowed their eyes, but could not eat the flesh—my throat seemed stuck together.

"It was now four days since the last native died, and the 40th of my voyage, when looking overboard I saw land, what I could hardly imagine, but supposed it must be the Navigators. It now fell calm and remained so two days, but on the 42nd day I saw ten canoes with five men in each, pull towards me. I raised my head over the side when I judged they were pretty close. They raised a cry of horror and pulled away. I beckoned to them, and intimated I wanted something to drink. They returned and gave me a cocoa-nut.

"One of the chiefs proposed to kill me—I understood this from their language, resembling that of Chain Island—but others said 'no.' Eight of them came with their paddles into my boat and pulled it ashore. I found that the island was Manua. I was kindly treated, and after a while went to Tutuila, and thence to Upolu. I found there a vessel, the "*Currency Lass*," bound for Tahiti. I was offered a passage. We sailed on the 30th January, 1845. We met with nothing but contrary winds. Our food and water was expended, and had only yams to eat for twelve days before reaching Atiu, and it took us 43 days to make Tahiti, 1,200 miles—just one day more than my voyage in the boat, which had been 100 miles longer."

Thus a boat without oars, steered first in one direction then in another, next left to itself, actually made the voyage from Chain Island to the Navigators in less time than a well-appointed vessel could make the return trip to Tahiti. The lost oars also had set from east to west.

You see the detention experienced by the double canoe, and the "*Currency Lass's*" tedious voyage from west to east, and how a canoe and open boat made the reverse voyages, as it were, on their own account, and all this took place in one twelve months. Cook found at Tonga a canoe which had drifted from Tahiti, and mentions finding at Wateoo three men, the survivors of a party, who having set out from Tahiti for Ulitea had been blown past their destination, and had fetched Wateoo, 200 leagues to the westward, and observes "that this serves to explain better than a thousand speculative conjectures how the islands of the South Seas had been peopled."

Had the question at issue been merely whether a single eastern island, say Tahiti, had réceived its inhabitants from a single western island, say Savaii, the facts of winds and currents prevailing, though not uniformly, would have less weight. A casual voyage against the wind could be performed, and the wind does change and blow from the westward at times, or, as we have seen, canoes getting to the south would find westerly breezes, and might, having run down their westing, haul up to the northward. The "*Bounty's*" crew went from Tahiti to Pitcairn. But there are hundreds of inhabited islands in the South Seas, and though it would be idle to suppose that all these were peopled by direct immigration from an original source, small parties, no doubt, leaving one island and occupying a neighbouring one. Yet the distinct groups or isolated islands, each requiring an independent colonization, are many, and it seems hard to admit that all these streams of immigrants came either from one small source, like the Navigators, or invariably against wind and current. Had there been in the latitude of the Paumotu group, an island as large as the one on which we are, to serve as a depôt on which an immigration from Samoa having once landed and then multiplied re-emigrated, and thus spread over all the intervening isles, the whole difficulty would vanish. But as a fact the islands most to the eastward are small, with the exception of the Marquesas, very small. Nukuhiva, the largest of the Marquesas group, is only eighteen miles long by ten broad, and most of the islands of the vast Paumotu and adjacent Archipelago, owing to want of food and water, cannot support a dense population.

To understand the subject properly it is necessary to consider the size of the various groups, their present population, and its amount in earlier times. Probably an estimate of one million would not be excessive for the total of the race a century ago, though now dwindled down to about the third of that number. We find then the following groups:—

Name.	Area, Square Miles.	Population.
New Zealand	100,000	30,000*
Friendly or Tongan Islands	Some 150 islands	25,000
Samoan or Navigator Islands	1,750	56,000
Cook's Islands..	..	5,000
Austral Islands	..	400
Society Islands	587½	21,000
Paumotu Islands	..	10,000
Marquesas Islands	..	20,000
Ellice Islands	..	700
Gilbert Islands	..	60,000
Phœnix Islands	..	..
Sandwich Islands	6,000	56,897
Marshall Islands	..	..

These populations, however, are the mere relics of former multitudes. Captain Cook, a most accurate observer, estimated the number of the people in this country at 200,000, and that was a century ago. The missionary bodies compiled a return in 1840, and gave 120,000 as the census

* According to official census, 1874, the Maori population was 45,470.—Ed.

of the northern island. In 1850 the Government published a return, carefully put together by Mr. Fenton, which, including the Chatham Islands, totalled 56,049. In 1870 another census accounted for only 37,000.

In Cook's time inter-tribal hostilities were frequent, and slaughter great. Tasman, in 1642, mentions seeing people in great abundance. Was the population even then larger than in Cook's day? Had it previously been larger still? Judging from the reception Tasman's crew received, the Maoris were addicted to fighting long ago.

So also of the Sandwich Islanders, by Cook set down at 400,000. An actual census in 1832 gave 130,315; another, in 1836, 108,579; in 1850 there were not 80,000 remaining; whilst the latest return makes the number 56,897.

The Society and Hervey groups have probably suffered a proportionate reduction in their inhabitants. A known loss, of large amount, is certain. Cook saw at Tahiti a review of 330 canoes, with crews numbering 7,760. Immense numbers of men were spectators, and all these were from a part of the island. Wallis and Bougainville corroborate the account of a large population.

Although bees swarm more readily from a small hive than from a large one, being driven thereto by want of space, so most of the human offshoots which have afterwards attained large proportions have first been sent out from small parent stocks: witness the Phœnician colonies; those from Greece, in Italy and Sicily: in recent times, the United States, Canada, Australasia, from our mother land; Brazil, from Portugal. Yet, in all these cases the people of the original home bore a much higher numerical proportion to its colonies than Samoa (with its limited area and people) would have done to the multitudes dispersed throughout the countless isles a century ago.

At what era did the progenitors of the former hosts quit Samoa in their canoes? How many ages must be allotted for the increase?

Let us turn now to the linguistic affinities. Mr. Ranken writes:—"The purity of race in Samoa is only one of many facts showing the first settlement in the South Seas to have been in Samoa. Their language shows it in the retention of the use of the 's'. No other Mahori dialect has it. Even the Tongans, in all their intimacy with Fiji and Samoa, have lost it. Language is limited by scenes, wants, objects, etc. As people spread into smaller communities, each isolated, their dialect became reduced and also fixed. There was no one to borrow terms from; not even use for all the words they had. Thus: a small colony leaving Samoa for a coral atoll, having only a few cocoanut trees, lost the names of every tree and bird in the Samoan forest; lost the names of distinctions, uses, customs, laws, and every term connected with these objects. And the words becoming reduced, sounds became fewer, and were modified by climate and surroundings. Being always in small scenes, it is no wonder that the dialects of the Pacific are meagre, and that the use of many words, and of the sibilant were lost. Only Samoans now, of all the Mahoris, retain the 's,' but it is remarkable that the New Zealanders, who, some think, only left Savaii some few centuries ago, must hardly have lost the 's' when first discovered by Europeans. For Dr. Marsden, who could only have acquired native names from Natives, in his visits to the country, speaks of the Chief 'Shunju' and the place 'Shukianga,' for names ever since known as Hongi and Hokianga." Thus far Mr. Ranken.

Much more weight could be allowed for resemblance or dissimilarity in language, had the Mahori race possessed any means of reducing to writing their respective dialects; but it must be borne in mind that we Europeans have fitted their sounds to our letters, and that this even has been done by different people with diverse accoustic perceptions: thus, two different people hearing the same individual pronounce the same word might spell it differently, many words they certainly would not agree upon using the same letters to express; and in instituting comparisons between vocabularies of the speech of different islands allowance must be made for this. As an instance, the word for "land," "whenua" in New Zealand, beginning with "wh" is "fenua," commencing with "f" in Tahiti, as spelled, yet the sounds are all but identical.*

Mr. Ranken contends that the Samoan emigrants lost their "s" on the coral atolls, having there no use for that letter; but how did the inhabitants of the rich islands of Tahiti, Rarotonga, Marquesas, Sandwich Islands, all alike lose it? Did the population which at one time crowded densely all these places undergo a preliminary term of probation on atolls till they dropped their "s"? Would rovers or cast-aways in canoes be likely to see only low reefs, and pass by, unobserved, islands many thousand feet high? If Samoa was the source of the second migration to the South Sea Islands, does it not seem more feasible that the "s" was introduced into their speech after their colonies had been thrown off, than that every colony without exception had dropped that one particular letter?

The Samoans have no "r," on what principle have New Zealanders, Tahitians, and Rarotongans, invented for themselves that letter. Samoans have neither "k" nor "w"; why are these letters in use amongst our Natives and the Kanakas of the Sandwich Islands? Were these three letters required by the dwellers on coral atolls for the purpose of expressing terms for which an "s" was inadequate, and therefore invented by them? Or, if derived, whence?

* Mr. Vaux gives due weight to these facts.

Now, as to the use of a sort of "s" amongst the native inhabitants of New Zealand. There can be no doubt that an "sh" or rather a sibillated "h" was in use, not throughout the islands, but among the Ngapuhi: a few years ago the older Maoris and early settlers in the north had this form of pronunciation strongly, our old charts even had "Shouraki" as the name of the gulf at the head of which we live. "Shoutorou" for the Little Barrier Island. The Mission Station on the Bay of Islands was called "Paishia," and many other instances could be cited. This sound, however, has gradually been falling into disuse with the Ngapuhi, partly owing to the large admixture of other tribes who were devoid of this expression of sound, caused by wars, notably "Shongis," and capture of slaves, from whom the bulk of the present people are descended; partly owing to this sound being unrepresented in the alphabet used by the missionaries in their books, only "h" indicating all aspirated sounds in the translation of the Scriptures and other works of general circulation, hence, probably in another generation, all trace of the existence of any articulation of an "s" will be lost from the New Zealand tongue.

But the tribes of this island had other distinctions in their speech. The Bay of Plenty tribes ignore the "ng" or nasal "n" using the plain "n" only, as the Tahitians and Sandwich Islanders. Again, in some words the Cook Strait people make their "k" almost if not quite a "g." Captain Cook, following the sound caught by his ear, spells Motukokaka, the perforated island off Cape Brett, Motugogogo, with three "g's". A "d," too, used to find a place in some words, early travellers terming our pine a "coudi." Mr. Maunsel affirms that the "r" should in some words be pronounced almost as a "d" or "l." Again, some tribes hardly have the letter "h" at all.

The Mori-ori of Chatham Islands, and some few scattered people on the west coast of the Southern Island, speak another dialect. The difference between the tongues of the two islands was noticed by Captain Cook. I would note here a custom which makes changes in the vocabulary of different tribes—that of a chief taking as a new name either some article of food or something used in the preparation of food. Thus should a chief take the name of "taro" some fresh word must be invented for that article, as to say that one was eating "taro" would be indeed a great *kanga* towards the chief, and amongst his own people the once familiar word would cease to be applied to the esculent.

Diversities of customs and habits as well as of speech are caused by circumstances. All the Mahori tribes dwell in islands, and use canoes and paddles as means of travelling. These latter differ as much as the patterns of tattooing. In the Sandwich Islands the handles are straight and the blades circular. Here the handles are crooked, the blades long, narrow, and pointed. Is this a mere matter of fashion, or is any reason assignable for the change? Timber here would be available for paddles of any width.

Captain Cook mentions that the double canoes he saw in New Zealand were like those of the Society Islands, and also that the "hongi" or nasal salutation was common to both countries. Though this latter practice still prevails in New Zealand, I cannot call to mind its existence in Tahiti when I was there. Likely enough the missionaries had set their faces against this as being a heathen custom.

Double canoes have been largely superseded at the Society Islands by outrigger canoes, that is a single canoe with a light ricker of "puron" wood in the place of the second canoe, as described by Dampier in use at Guam. Drake, in 1579, found at the Carolines, canoes with an outrigger on each side. Similar vessels were used by the Acheen Malays a century later. Double canoes do still exist at the Society, Hervey, and Paumotu groups, but I never saw one in this country, neither has the oldest white inhabitant, nor even any of the present Natives, though they have heard of their fathers having employed them.

Several causes may have contributed to the change. 1. The growth here of large pine trees from which single canoes of sufficient size could be made. 2. The unhandiness of double canoes in the rougher seas prevalent beyond the tropics. 3. The numbers of rivers and creeks unknown in coral islands but common here, many of which through narrowness would be inaccessible to double canoes.

Where are we to look for the prototype of the double canoe? Can we find it in Malaya? The only vessel with which I am acquainted of similar construction is the immemorial "balsero" of seal-skins, used by Peruvian fishermen. In default of seals the islanders, retaining the model, used wood.

Occasionally two canoes were lashed together in New Zealand that a temporary stage for fighting men might be supported between these, but this was quite another thing from a canoe intended to be permanently double.

Tradition tells us that seven canoes brought to this country the ancestors of the present Native inhabitants; and in compiling genealogies, the same number of generations appear to be allowed for the descent of any leading chief to his immigrant ancestor. But it is rather remarkable that one line of descent, as far as I know, is given for each canoe for seven generations. Chiefs of note of the present day always descend from the main stem of their respective canoes. Are not these earlier generations mythic?

Is it probable that the arrival of these seven canoes was simultaneous, or nearly so? Is it probable that their point of departure for New Zealand was the same? I should answer each question in the negative.

Captain Cook learned through Tupia, his Tahitian, that canoes from an island called by them Ulimaroa, to the north-west, had reached New Zealand subsequent to its settlement by themselves.

Some years ago, while travelling afoot through the north of this island, in company with an old chief well known for his store of Maori legends, I put the question to him as to whether cannibalism was a habit of the race before their arrival in New Zealand, or a custom having its origin amongst themselves subsequently to their arrival here? The reply was, that it began in this island. I asked, what was the beginning? This is the story:—"A chief at Hokianga had a pet *kaka*, of which he was extremely fond, as the bird was the best decoy ever known. One day a young man, playing with it, loosened it from its perch, and the bird flew away with the string attached by a ring to its leg. It flew some distance and alighted, the youth following it; and it repeated the process, attempting to get rid of the string with its beak. Whilst going on after the *kaka* the youth fell in with a friend on some outlying cultivation, and persuaded him to join him in the chase. It is enough to say that they followed the bird all day, as it stopped repeatedly; they hoping that the string might become entangled in the bush, and they might then secure it. Towards night the bird alighted in the forest, and the men, tired out, lay themselves down to sleep. Next day they found that while keeping their eyes on the *kaka* they had neglected to notice the route by which they had travelled, and had lost themselves in the dense bush. They walked all day, without food, still entangled in the forest, and passed a second night in it. On the evening of the third day they came to a small clearing, utterly strange to them, and found in it a *pataka* with some *kumera*. Of these they took some, and after eating them they fell asleep, worn out, but first resolving that at dawn they would provision themselves for their return. They slept too late, and saw on waking a strange man near the *pataka*. Afraid to show themselves, they retreated into the bush, and after a while they perceived that they were followed. Concealing themselves, they rushed upon the stranger as he was passing, and killed him, and, impelled by hunger, eat part of him then, and took more of the flesh to eat on the road. Ultimately they found their way back, bringing a hand of the man whom they had killed, and saying that a strange man had stolen away the *kaka*, and that they had chased and killed him. This was to conceal the negligence of the youth. It was *then first* that the people of Hokianga knew that there were other people on the island besides themselves." It was afterwards discovered that the person slain belonged to

Ngatimaru, now living at the Thames—but then at the north, and the place where he was killed was near the Ngaere, opposite the Cavalli Islands.

I have told you this legend, not on account of the incident of cannibalism, but as accidentally showing that Ngapuhi believed themselves to have been the only inhabitants of the island; and that, therefore, if all the seven canoes reached its shores from Savaii, their canoe should have been the first to arrive, or at any rate to start; that they had no knowledge of any prior migration likely to have landed in New Zealand; and yet, as Ngapuhi did not lose the "s," they ought to have been the latest arrivals here.

My views are, that though Savaii and Hawai are radically the same name, and have been applied respectively to islands so far apart as the Samoan and Sandwich groups, yet it is not in the least proved that either one place was settled from the other; that, more probably some former Hawai, or Savaii had its name transferred to each of these places, and that we have yet to discover the source from which these islanders sprang.

Looking again to the fact that some of the old pahs in this island have, standing on their embankments, or in their trenches, trees of at least two centuries growth, trees which the garrison of the pah certainly would not have allowed to grow in such positions (though they might have had trees within the pah itself,) for fear of loosening the palisadings as the wind rocked these trees; the areas of these pahs; the depth of their trenches, and height of embankments,* proving, when we consider the insufficiency of their tools, that large numbers of people were employed in their construction; the vast piles of *pipi* shells heaped up outside such pahs, even when situated some miles from the sea, and on elevated sites, incontestibly indicating a long period of occupancy: we have evidence to prove that many large pahs have been deserted for, say, two centuries; had been occupied for a great length of time; had required a large population already existing at the time of their construction. Pahs of this class, too, are thickly dotted over large districts.

Is it not a reasonable deduction that some centuries back New Zealand had already a large number of inhabitants? Look at Tasman's and Cook's accounts of the people at the time of their visits.

If we must believe that the progenitors of such multitudes came in seven canoes, how indefinitely we must put back the date of their arrival, and add to the fixed number of generations assigned by the Maoris as having existed since that time.

May not the New Zealand immigration have been simultaneous with,

* Cook mentions a ditch and bank at Mercury Bay, 22 feet inside, 14 feet outside; and another 24 feet deep.

produced by the same causes as, or be part and parcel of that amazing dispersion throughout the South Seas of a race which has peopled so many isles; a race which, wherever located, looks back to Hawai as its old ancestral home?

The New Zealand traditions allude to two distinct places called "Hawai." One may be "Savaii." The one used as a resting place on the way. Where was the original? In Malaya? How long did it take to develop the lithe and active but somewhat diminutive Malay into the sturdy and robust Maori of New Zealand, or into the grand colossal form of the Tahitian, the most magnificent in stature of the human race?

Did the descendants of miserable atollers construct the stone fortifications of Opara, the maraes of Raiatea, Tahiti, Eimeo and Marquesas, or carve the statues and build the walls on Easter Island, all of these being works of ages long past. No account of the erection of these places can be gathered even from tradition, so remote is their date. As to their character and workmanship even Mr. Ranken admits the "maraes or terraced enclosures for sacred purposes are exactly like those of Mexico and Peru. That of Pachacamac is a duplicate of that at Nukuhiva at Marquesas." Pachacamac stands on the sea coast some 25 miles south of Callao, and the style of masonry is identical.

I believe that we are too old-world in our ideas, and have got into the habit of looking to Asia for every migration, because the human race first sprung thence; but had not America ages before the time of Columbus attained a high degree of civilization, and supported a dense population? witness the ruined cities of Central America, the temples of Mexico, the fortresses and teocalli of Peru. These last we know were in many instances the work of the Toltecs, a race who, having for some centuries occupied a portion of the present country of Peru, were expelled thence a few years earlier than the Norman conquest of England, or rather more than eight centuries ago. What became of that nation no one knew. Gacilaso de la Vega, himself the son of a companion of Pizarro, and the sister of Huayna Capac, one of the last of the Aztec Incas, who was born at Cuzeo, and went to Spain in 1560, in his history of the Incas, compiled from the "guipus," or annals in the temple of the sun, states that though the Incas conquered subsequently the Aynnaru, Quichna, and other neighbouring nations, the Toltecs they never again heard of. Whence they originally came rests only upon a tradition assigning the year 591 as the time of their passing the Isthmus of Panama on a southwards migration.*

If it is urged that the voyage from the coast of Peru to the Marquesas would be too long for canoes; read Dampier's account, how the party of

* Prescott, in his "Conquest of Mexico," says 648.

200 buccaneers, amongst whom he was, went in 1688 from the coast north of Panama to the isles of Juan Fernandez in native "pirogues" or canoes, and returned again thence, attacking, unsuccessfully, Arica on the way. The distance from Panama to Juan Fernandez is fully as great as from Callao to the Marquesas.

If it is merely an accidental coincidence that somewhere about the same period one people entirely disappeared from the shores of Peru, and that another people, arriving from the opposite side of the world, built on the islands to leeward of the Peruvian coast, places of worship in exact resemblance of those erected by the missing nation, and adopted similar human sacrifices; the coincidence, if coincidence only it be, is most wonderful.*

Art. XX.—*On the Remains of a Dog found by Capt. Rowan near White Cliffs, Taranaki.* By Dr. Hector.

[*Read before the Wellington Philosophical Society, 9th December, 1876.*]

The universal spread of the dog throughout all parts of the world that have at any time been inhabited by man is one of the most interesting facts in the natural history of our race. From the earliest times man has made the dog his companion and servant, and as a consequence of this long continued culture and control, the qualities and capabilities of the dog have been developed not only in an extraordinary degree, as compared with any other animal, but also in a most diverse manner, the diversity depending to some extent on the habits and necessities of the section of the human race that developed the breed.

The remains of dogs are of frequent occurrence among the bones found in the old Maori *umus*, and the statement by Captain Cook, as well as the explicit traditions of the Natives, and even the reports of early settlers, prove that the Maori had a domesticated dog before the arrival of the white race.

A few dogs reported to be of this primitive breed were known within the last 20 years, and are said to have beeen remarkable for their docility and sagacity. Whether there was also a distinct breed of wild dog in New Zealand is not stated in any work I have been able to refer to, but it is

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* Compare Cook's account of the human sacrifice at Tahiti and those mentioned by Veytia, Torquemada, etc., among the Aztecs.

improbable that the same dogs were both highly prized domestic pets and also used for food. Among the Sandwich Islanders the dog, was up to late years, carefully fed and fattened for food, the best quality, called *iliopoli*, being fed on taro, and when young suckled by the women at the expense of their infants. But these dogs were not petted or treated as intelligent companions, or prized for their sagacity, as I understand the Maori dogs were.

Any information respecting this extinct breed of Maori dogs has therefore an ethnological value, and I have this evening to bring before the society an interesting contribution on the subject by Captain Rowan. Before describing his discovery, which relates to probably the earliest remains of the dog yet found in New Zealand, I will shortly refer to the only specimens, supposed to be genuine, of this breed which I have been able to examine, and which were probably among the last survivors of the race.

A bitch and full-grown pup were known for several years in the densely wooded country between Waikava and the Mataura plains, and did great damage among the flocks of sheep, but exhibited such cunning and daring that it was not till after hunting them for two years that they were shot by Mr. Anderson, who presented them to the Colonial Museum. Of the smaller specimen both skin and skeleton were taken to the British Museum by Sir George Grey, and the skin of the mother was preserved here, and has been recognized by many old Maoris as a genuine *kuri* or ancient Maori dog.

In general appearance it resembles a poodle, but it presents characters unlike any other of the many breeds of dogs with which we are familiar.

It is a large bodied dog with slender limbs, large ears, and a straight half-brushed tail, wide head, and small pointed nose. Its colour is white, with a black spot on the loins, and a brown spot on the crown of the head, and a few faint spots on the ears. Its nose is black and its claws are white.

The back is covered with hair about one and a quarter inch in length, laid smoothly, but the lower surface of the tail, rump, back, legs and ears, and the belly have long rough hair. The total length is three feet.

The height of the shoulder is seventeen inches, the height of the foreleg being ten inches, and the depth of the chest ten inches; the ears are four inches, and the tail is thirteen inches long.

The skull, which is the only part of the skeleton preserved, proves it to have been a very old individual, the canines being worn down to their stumps, and the processes and ridges of the cranium strongly developed. On this account it is perhaps all the more valuable for comparison with the skull found by Captain Rowan, which belonged to a young individual, as it discloses any points of similarity that are maintained at all periods of growth.

For further comparison I am enabled also to show two dog skulls found by Mr. Travers among the remains of a cannibal feast he discovered on the east side of Wellington Harbour, and of which he has already given an account to the Society. There is no evidence of these skulls, being of ancient date, but they are clearly of the same breed as the true Maori dog.

Captain Rowan's discovery I will give in his own words :—

" I send you some bones, which I think, from the teeth and the skull, are the remains of a dog. I have failed to suggest to myself any possible means by which they could have attained the position where found, except by the animal having crept in of itself and died there ; or by its having been washed in by the stream which appears to have at one time run on the gravel bed overlying the marlstone. It has been suggested that, as the spot is much frequented at times by Maoris for fishing, one of them may have killed a dog, and stuck its body into the hollow tree. Putting aside the improbability of a Native taking the trouble to bury a dog, with the sea close at hand to throw it into, and the absence of any Native account to corroborate this idea, I think the following facts worth attention :—

" The different strata above the marlstone are continually receding owing to the action of the weather ; consequently, a few years ago what is now the face of the cliff was then hidden, and it is only since the last slip took place that the portion of the trunk containing the bones became exposed.

" When found, the palate was tightly impacted with dead wood, which I had to remove with a knife, so as to be able to see clearly the number and shape of the upper jaw teeth. It therefore seems to me that the animal must have become a skeleton before the wood had decayed. Also, I think it would have been quite impossible for a human being to have choked up the orifice of the tree with river sand in the manner in which I found it: the sand had every appearance of being drifted in by running water.

" Supposing for an instant that the remains are those of a dog which lived at a time when stratum No. 6 in the accompanying section was the bed of a river ; would it not be natural for that dog to have had his lair in a hollow tree and near to water ? Would it not be natural for a dog, when feeling the approach of death, to crawl into his lair and to die there ? And if so, what more likely than that the tree, by a landslip, or a flood, should ultimately lie water-logged at the river bottom ? Or, the slip might have occurred while the dog was alive, but asleep, and unable to escape ;

in which case he would naturally be drowned. The flax fibre, too, would be a very natural substance for a dog to drag in to make a warm, comfortable bed of.

"I am only putting forward such suggestions as occur to me. Of course, if any reasonable means can be shown by which the bones might have been artificially deposited in the tree; or, if it is certain that, at the period when the tree was deposited in its present position, no *Phormium* existed, my suppositions would be unjustifiable.

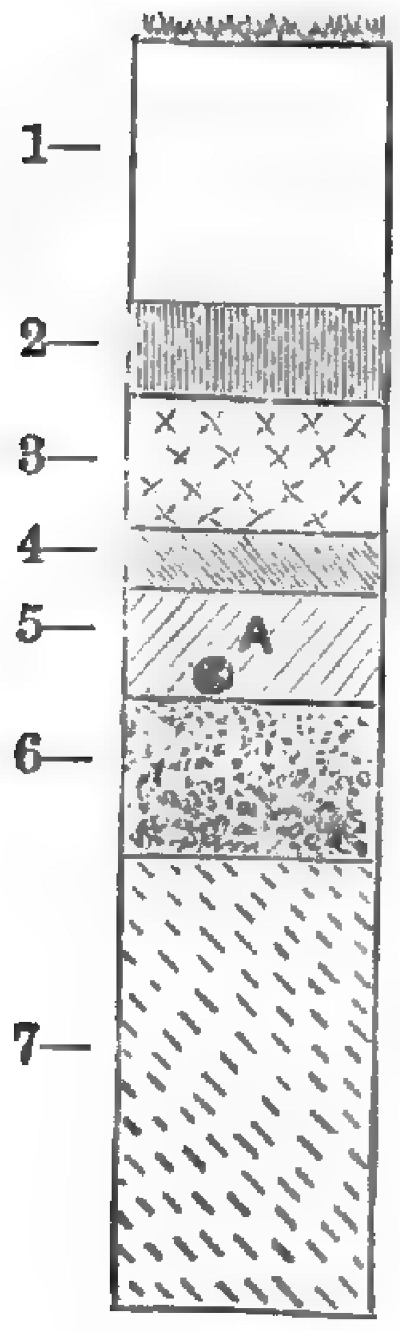
"It was during last winter that two of Captain Good's sons, having gone down, as they frequently did, to this place to fish, first noticed what seemed a bit of bone projecting from the sand. In all probability the winter rains had shortly before caused a slip, the remains of which are still visible, and so exposed this fragment. The boys, with a bit of stick, dug out the upper portion of the skull, and took it home as a curiosity, neither thinking of searching any further, nor noticing that the sand was only the core of a hollow tree. It was some six weeks or two months afterwards that I first saw the skull: and, after hearing how and where it had been found, took the first opportunity at my disposal of visiting the spot to make further search. No mention of the discovery had been made to any one, except myself, outside of Captain Good's own family, and no one had apparently, or as far as I could ascertain, visited the spot since the boys' discovery of the skull. Indeed, the one who accompanied me was in some little doubt as to the exact spot, when we first reached the ledge of blue marlstone known as the 'fishing rock.' In order that I might have the benefit of other judgment besides my own, Mrs. Good and Captain Messenger were kind enough to accompany me, and I had also an Armed Constabulary man, carrying some tools.

"The skull had been found—so the boys told me—lying teeth uppermost; and I could see traces of the slight excavation they had made in extracting it. As soon as we began to remove the sand, we found we were working into the hollow of a tree, and almost immediately found the two lower jaw bones; and slightly further in, the other bones, and the matted hair; further still, the flax-stick and fibre.

"We excavated as far as we safely could—about six feet in,—and cut the tree off, without finding any more animal remains. Although the orifice was becoming much smaller, the tree still continued hollow, and I shoved my arm and a flax-stick in, without resistance, for about nine feet further.

"I think I have now told you all the facts, and I shall be glad to hear what conclusion you come to as to the bones and their probable origin.

Section of the Cliff, showing the Position of the Tree which contained the Dog's Skeleton.



a Red friable loam with about 10 inches of black soil on top. 9 feet.

b Sandy clay with imbedded remains. 2 feet.

c Lignite and clay mixed. 4 feet 6 inches.

d Soft sandstone. 8 inches.

e Plastic blue clay. 3 feet.

f Sand and gravel. 5 feet.

g Blue marlstone, about 15 feet.

"This sketch is intended to show the stratification of the face of the cliff in which is imbedded the hollow tree (A), in which were found the remains herewith, at a depth of nineteen feet two inches from the surface.

"The situation is on Captain Good's farm, and about half a mile on the town side of the Urenui river. As may be seen, the tree lies in the surface of the sixth distinct stratum from the ground level. It is hollow and the bones, hair, etc., now exhibited, were found in the hollow and closely imbedded in sand, clay, and decayed wood. The flax stick and flax fibre were rather further in than the bones themselves, and the log continues hollow into the cliff for more than twelve feet."

From the evidence adduced in the foregoing remarks it is not very clear to my mind that the dog may not have been buried in the hole made by the hollow tree imbedded in the cliff; or may it not have crawled into it from the top of the landslip that has since come away, but which may formerly have been on a level with the tree as shown in the section. The lignite-bearing beds along the top of the cliff, north of Taranaki, though belonging to a very late geological period, are, nevertheless, of great antiquity, and the state of preservation of the bones, as compared with the thorough alteration that the vegetable matter of the lignite has undergone, inclines me to believe that the dog remains are of modern origin.

But even in that case, the circumstances under which they have been found, and the decayed state of the dentine layer of the teeth tend to refer them to a period further back than any previously obtained.

The comparison of the skull with the other specimens is, therefore, interesting, and shows that in all the specimens of the Maori dog now before us, there is evidence that they belong to one common breed, which has been even more specialized from the wild dog—such as the *dingo*—than any of our most intelligent and finest-bred domesticated dogs.

Measurements of Remains of the Dog found by Captain Rowan.

		Inches.
Skull—		
Total length		5·5
Zygomatic breadth		3·6
Palate, length		2·7
,,	post. nares to ant. palat. foramen	1·9
,,	width at the canines	0·75
,,	,, ant. edge of 3rd præ.-molar	1·0
,,	,, post. ,, 4th ,,	1·7
,,	of cranium at front parietal suture	1·7
,,	,, ,, post orbital process	1·7
,,	middle parietal	2·2
Mesial Sutures—		
Supra occipital		·8
Inter-parietal		·15
Parietal ,,		·75
Frontal ,,		1·6
Nasal ,,		1·8

Post orbital ridge very slightly elevated and continued back. No parietal crest. Supra-occipital crest, feeble.

	Inches.
Lower Jaw—	
Height	4·0
Greatest depth under first molar	·65
Length of condyle	·6
Height of coronoid process	1·2

Other bones—Altas and part of a humerus.

Comparative Measurements of Various Dog Skulls.

	Post Frontal Width. Inches.	Palatal Width. Inches.
Dingo	$4\frac{1}{3}$	2
Old Maori dog	3	$1\frac{2}{3}$
,, ,, ,,	$3\frac{1}{2}$	$1\frac{2}{3}$
,, ,, ,,	$3\frac{2}{3}$	$1\frac{2}{3}$
Young Maori dog (Capt. Rowan's)	$3\frac{1}{3}$	$1\frac{2}{3}$
Collie	4	2
Bull	4	1
Poodle	3	$1\frac{2}{3}$
Pug, old	$2\frac{2}{3}$	$1\frac{2}{3}$
,, young	$2\frac{1}{3}$	$1\frac{1}{3}$

ART. XXI.—*Savage and Barbaric "Survivals" in Marriage.*

By the Rev. JAMES WALLIS, D.D.

[Read before the Auckland Institute, October 2nd, 1876.]

1. The present is the outgrowth of the past. Modern civilization is the result of causes and influences which have been in operation from the very beginning of human history. The modern civilized man, with his customs and ideas and institutions, is the outcome or product of the whole past course of the world's history. Hence all we are—all the things of our civilization may be viewed as "survivals." It is, however, in a stricter and more scientific sense that I will employ the word survivals here. In the long progress of mankind, from the lowest savagery, through barbarism and up to our present civilization, there have been many stages or grades, the lower grade usually passing to the higher. Certain customs, beliefs, etc., proper to an old and lower grade, find their way into a newer and higher grade—the growths of one age. These customs and beliefs often continue, more or less changed, throughout succeeding ages; but they are inconsistent or incongruous with the more advanced state of things in those ages. Such relics of the past living on into the present are survivals. E. B. Tylor defines survivals to be "processes, customs, opinions, and so forth, which have been carried on by force of habit into a new state of society different from that in which they had their original home, and they thus remain as proofs and examples of an older condition of culture, out of which a newer has been evolved." Speaking only of one class or department at present, I will show you some curious survivals in marriage—some customs and opinions and laws, obviously originating in savagery or barbarism, which still prevail among ourselves.

2. Marriage is the foundation of civilized life. Marriage of the monogamus kind, or the union of one man and one woman for life, is the most important of all our social institutions. The monogamy now existing among the most civilized nations seems to have been preceded everywhere by polygamy, and polygamy by what has been termed communal marriage. It is almost certain that in the very remotest times, all over the world, the sexes lived together promiscuously. From this degraded state the first upward step was towards polygamy, or the exclusive appropriation by one man of several women. The first step from communal, in the direction of individual marriage, appears to have been brought about mainly by war and slavery. In war between primeval savage tribes the conquerors were likely to kill most of the males of the conquered tribe, but to capture such of the females as pleased them. The warrior savage according to his pleasure might either kill a female captive or save her alive. If her life was spared,

she naturally became his slave primarily and his wife secondarily. However many he chose to save, they became his slaves, his wives. They belonged to him and him only, and his brother braves had no right to them. The women of the conquering tribe were the tribal sisters of the men, and belonged to them all; but the captured women of other tribes were the property of their captors. At first and for long ages slave wives captured in war and specially appropriated would have occupied a lower position in the tribe than the tribal or communal women. The Hetairism of the ancient Greeks and Hindoos was a relic or survival from this state of things. Nice people are shocked when they read of Socrates visiting Aspasia, or of the divine Buddha accepting the hospitality of the mistress of the Courtezans; but among the Greeks and Hindoos women like Aspasia and the hostess of Buddha were higher and more honourable in the social scale than the slave-wives. In the course of time the communal system, though traces of it long remained as survival, was superseded by the superior system of polygamy, brought in by war and slavery. Polygamy being generally established, the obtaining of wives by capture would have continued long; and in truth it has continued, either as a fact or as a symbol, over a considerable portion of the world till the present day. In the progress of society the buying of women to be slaves and wives makes its appearance. The purchase system comes in, and in a considerable degree mitigates and supersedes the capture system. From the time when authentic or documentary history begins, and long after, purchase was customary among the Chinese, Hindoos, and Greeks. It was customary among the Jews, for Moses allowed Jewish fathers to sell their daughters for slaves or concubines. (Ex. xxi. 7.) It was customary among the Romans, who had two kinds of marriage—one by "co-emptio," and the other by "confarreatio." In co-emption marriage the forms were the same as those which were gone through in the purchase of a slave. Confarreation marriage was a survival of the capture system, and in it a show of force was always employed by the husband in taking his bride away from the arms of her mother. From the beginnings of history we can trace the capture and the purchase systems, either as stern realities or as important ceremonies, all over the world and down the ages.

3. It may be said that the state of things I speak of has passed away; that the slavery of former times has ceased; that neither law nor custom amongst us tolerates the carrying off of women by violence, or the making merchandize of them. True, so far. Among the most civilized peoples, monogamy has supplanted polygamy, and this has vastly improved the whole marriage relationship. Our modern customs, opinions, and laws are unquestionably better than those of the past. But the past has its conse-

quences, its inevitable effects, in the present. Our customs, opinions, and laws relative to marriage are found, when examined, to be the very things of the past, more or less modified or improved. Like pebbles, originally rough and angular, many of them have become rounded and smoothed in the stream of ages which has rolled them down to us. But there are still, here and there, some pebbles which retain much of their original roughness and angularity. There are some customs, opinions, and laws which have floated like drift-wood from the remote past, and which may now be picked up by us on the shores of the nineteenth century. Though women are no longer captured and purchased to be made slaves and wives of, there are still some curious relics and vestiges of this which have found their way into our advanced civilization. In connection with marriage, and the position of women in the marriage relation, there are some survivals from the savagery and barbarism of old. These survivals may be arranged into two classes: the first, comprehending certain customs and ceremonies; and the second, comprehending certain opinions, or beliefs, and laws, still associated with marriage amongst ourselves.

I.—Ceremonial Survivals.

1. Our savage ancestors obtained their slave-wives by capturing them in war. As civilization advanced, *wiving* came to be done in a more peaceable and mercantile way. But even after this better way was generally adopted, capture continued, not as a reality, but as a symbol. It still survives as a symbol among almost all peoples, but in many cases the symbol has dwindled into a ceremony nearly meaningless. Among the ancient Greeks and Romans the bridegroom carrying away the bride by seeming force was an indispensable part of their marriage ceremonial. Our learned Bibliopole, in his "Old Identities," told us lately that this style of wooing still exists among our Maori neighbours. Sir John Lubbock, in his "Origin of Civilization," gives us numerous examples of this survival, taken from every variety of the human race. Among many others, he mentions the following marriage ceremony, as customary, among the Welsh, last century:—

"On the morning of the wedding-day, the bridegroom, accompanied by his friends on horseback, demands the bride. Her friends, who are likewise on horseback, give a positive refusal; on which, a mock scuffle ensues; the bride, mounted behind her nearest kinsman, is carried off, and is pursued by the bridegroom and his friends, with loud shouts. It is not uncommon on such an occasion to see 200 or 300 sturdy Welsh riding at full speed, crossing and jostling, to the no small amusement of the spectators. When they have fatigued themselves and their horses, the bridegroom is suffered to overtake the bride; he leads her away in triumph, and the scene is concluded with feasting and festivity."

Similar survivals are to be found in different branches of the Teutonic race. Language, scientifically studied, is beginning to yield a rich harvest of pre-historic knowledge: I am told that the word for marriage is, in old German, *brût-laufti*, and in old Norse, *quan fang;* and that the meaning of these words is bride-lifting, bride-catching, bride-racing. The Scotch still speak of cattle-lifting, and cattle-lifter; and in some dialects of northern Europe the bridegroom is styled the bride-lifter; and the meaning in the two cases is, no doubt, the same—carrying off by violence. Even in the Britain of our day this mock imitation of marriage by capture still exists, but smoothed and attenuated into a piece of fun and frolic all but unintelligible. Amongst ourselves, the marriage ceremony and luncheon being over, the newly-married pair prepare to leave; and, as they are moving towards the door, a cannonade of slippers, old shoes, etc., opens upon them. There can be no doubt there is a survival of marriage by capture in the ceremony of the slippers thrown in mock anger after the bride and bridegroom.

2. The ring which is put on a woman's finger in the marriage ceremony has given rise to many poetic fancies. It has become associated with a multitude of fine thoughts and sentiments. It is put on the third finger of the left hand, because, it is said, from that finger, and that alone, there runs a nerve direct to the heart. The ring being round, and having no end, is regarded as an emblem of the love then pledged, a love fondly fancied at the time to be everlasting. Passing from the realm of Fancy to that of Fact, I must state that the marriage-ring, like the ear-ring, is a relic of the remote past, a survival from the times of capture and slavery. Among the ancient Jews, and other nations, the ears were bored of those who had become slaves, and rings were hung in them. This custom, belonging to the days of slavery, is perpetuated in the ear-rings of our times. And, painful as it is to disillusionize poetic minds, I must state the truth, that the wedding-ring is traceable to the same servile origin. "What," asks Max Müller, Vol. II., p. 285, "What is the meaning of the wedding-ring which the wife has to wear? There is no authority for it either in the Old or New Testament. It is simply a heathen custom, whether Roman or Teutonic we shall not attempt to decide, but originally expressive of the fetter by which the wife was tied to her husband."

3. There is a wide-spread prejudice against being married in May. This prejudice or superstition has been noted in most of the countries included in the Roman empire, and wherever Europeans have colonized. Now why should marriages be held objectionable in May more than in any other

month? The answer to this is to be found in the religious customs of the ancient Romans. From pre-historic times downwards the Romans celebrated in May the funeral rites of the Lemuralia. The Lemures were ghosts, spirits, hobgoblins; and the month of May was specially devoted to religious or superstitious services in connection with them and the dead. May, therefore, notwithstanding its beauty and its flowers, and its abounding life, became to the old Romans a month of gloom and terror. The poet Ovid, who lived 1900 years ago, says that in his time it was considered unlucky to marry in May, on account of the occurrence in that month of these funeral rites of the Lemuralia. This curious superstition seems to have spread as far as the Roman conquests extended, and even farther; and in this, I doubt not, we have the true origin of the idea so widely prevailing among ourselves and in the modern world that marriages made in May are unlucky.

4. The modern honeymoon, with its marriage jaunt or wedding tour, is another survival from ancient and barbarous times. Fighting for a girl to make a wife was naturally associated with stealing her. Capture by force and theft are closely allied. The relatives of the captured or stolen girl would endeavour to get her back, and would long be angry with the robber or thief. He would keep himself, and his fair charmer too, out of the way for a time till their wrath was somewhat abated. When, in the progress of civilization, the reality of capture passed into a symbol, this frequently concomitant part of the transaction was not likely to escape symbolization. It is still kept up in many semi-civilized communities. It is still kept up among ourselves, for some of our philosophers regard our honeymoon, with its going away from home and the keeping out of our friends' way, as the symbolized continuation of the primeval state of things. Against this barbarous survival the English press is beginning to lift up its protest. I mean against driving newly-married people away from their friends on a wedding tour of about a month's duration. Hiding themselves away from all the comforts of home, they cannot help making each other miserable. With great truth and feeling the " Saturday Review" the other day said:—" We condemn the unfortunate couple to a penance which would try the deepest affection and irritate the sweetest temper. When Hodge and his sweetheart crown their pastoral loves in the quiet old country church, they enjoy a walk in their finery and white cotton gloves, and then take possession of the cot beside the wood, and settle down at once to connubial comfort. But they have chances of happiness denied to their richer neighbours. It is a matter almost of moral duty, certainly of superstitious strictness, that when the squire marries the rector's daughter, or my lord marries my lady, the first month of married life must be passed (away from

friends) in the discomfort of foreign hotels, or the still less endurable desolation of English inns, as if to strain to the utmost the strength of their newly made bonds." In this month of homeless misery we have the barbarism of the past surviving in a symbol almost as disagreeable as the reality.

5. The marriage customs we have spoken of are mainly survivals of the capture system, which in the progress of civilization passed into the purchase system. We do not doubt that now-a-days some marry on principle and from pure love and affection; but the purchase system largely characterizes the present grade of civilization. Of this system there are two kinds, the one antique and homely, and the other modern and refined. The antique and homely way was to pay hard money to parents or guardians for the lady. This is still the custom in many parts of the world, and it was the custom both in France and in England at no very distant date. Our modern method of purchase is much more refined. Let a man who is marriageable have plenty of money, and almost any one of a score of girls round about is ready to accept his hand. In cases of this sort the man purchases the girl—the girl literally selling herself for money. If men still purchase wives, it is equally common for women to purchase husbands. Let a girl inherit a fortune, and however overlooked she may have been hitherto she now becomes the belle of the place. Marriageable men in hundreds are thinking about her; letters full of her praises burden the local letter-carrier, and crowds of prudent youths take a fancy to the kind of gospel preached in the church she attends.

"Be a lassie e'er sae black,
  Gin she ha'e the name o' siller;
Set her up on Tintock tap,
  The wind will blaw a man till her."

In such cases the girl purchases the husband—he literally selling himself for her money.

II. Survivals in Opinions and Laws.

1. I come now to consider the second and more important class of survivals, consisting of ideas and opinions and laws, which, originating in the rudest states of society, have lasted on into our times. The primitive slavery to which women were subject is not quite extinct. No doubt their legal and social position in civilized countries now-a-days is an improvement upon what it was in the old times. Not a few married women, exceptionally fortunate in their husbands, feel they could not be freer or better situated than they are at present. Such, however, should be reminded that they are what they are, not by law but by grace—by the grace of their lords, by the favour of their legal masters. The old slavery, modified and mitigated in some respects, still continues, but disguised under the name of the subordination of the one sex

to the other. In reference to married women, despotic slavery, it may be said, is dead, and constitutional subordination reigns in its place. The old state of things, it may be supposed, has quite passed away. We read that among the Romans the word *familia*, from which comes our *family*, meant a man's slaves, and that his wife and children, as part of his family, were literally slaves. Or, we are told that in China women have always been so ill-treated and oppressed that the poor creatures often spend their hours of leisure or rest in religious services and prayers that they may be born men and not women in the next state of being. Or, we learn that it is still the custom in Canada to place a strap, a kettle, and a faggot in an Indian bride's cabin. The strap to indicate that she must carry burdens; the kettle, that she must dress food; and the faggot, that she must procure wood for her husband. Or we learn that in some provinces of Russia the bride on her marriage presents her lord with a rod, which symbolizes the chastisement she expects for any misconduct. Or we learn that among our own chivalrous ancestors in the middle ages women in general were serfs or property. Shakspeare, the great delineator of life and manners in those ages, puts into Petruchio's mouth the popular opinion and the common law of the wife's relation to her husband. Alluding to his exquisite Catherine, Petruchio says :—

> "I will be master of what is mine own;
> She is my goods, my chattels; she is my house,
> My household stuff, my field, my barn,
> My horse, my ox, my ass, my anything."

Learning thus the savage and barbarous treatment of wives—of women generally—in former times, we should inquire if this state of slavery or servitude which so shocks us, has passed away, or if it still lives on under the disguised name of lawful subordination, in the midst of our boasted civilization. Mr. Mill, referring to the legal and social position of wives now-a-days, says: "The law of servitude in marriage is a monstrous contradiction to all the principles of the modern world. It is the sole case, now that negro slavery has been abolished, in which a human being in the plenitude of every faculty is delivered up to the tender mercies of another human being, in the hope, forsooth, that this other will use the power solely for the good of the person subjected to it. Marriage is the only actual bondage known to our law. There remain no legal slaves, except the mistress of every house." In confirmation of Mill's opinion, I will now give a few examples of the wrongs which wives and women suffered of old, still flourishing vigourously in our midst. In those old times there was one law for women and another for men in reference to chastity; and in those old times the children a woman bore belonged not to her but to her owner.

And in those old times women were largely disinherited, and were legally incapable of holding property. These old wrongs continue to a considerable extent unredressed. Though somewhat modified and white-washed, they still survive. Women, married women, are still wronged in reference to the marriage contract, and conjugal infidelity; and in reference to the upbringing and guardianship of their children; and in reference to property.

2. Marriage, which ought to be a fair and equal partnership, is, amongst us, a contract which gives undue advantage and power to one of the contracting parties over the other. Its injustice in punishing a woman for marrying, by spoiling her of her property, I will speak of by-and-by. At present I speak of some other respects in which the contract is grossly one-sided, or uni-lateral. Neither general opinion nor law requires a man to be as faithful to this contract as a woman. For unfaithfulness, both opinion and law inflict heavier penalties on the woman than on the man. All this seems to have resulted from the prevalent polygamy of former times. Amongst us polygamy has long ceased to be a lawful institution, except, perhaps, in the case of the males of royal houses. In Germany and in Britain, for instance, the law seems to tolerate, or to wink at, the disguised polygamy of left-handed marriages in high places. This polygamy has left its mark upon us;—upon our opinions, manners, and institutions: for, wherever it existed as a lawful institution, people could not help thinking that men were entitled to more liberty of a licentious kind than women. This idea still survives, contaminating public opinion. We observe it in the different degrees of reprobation with which we treat impurity in women and in men. To a woman, impurity brings disgrace, ruin, social damnation; but in a man it is only an excusable peccadillo, which scarcely affects his social position or fortunes. A parallel survival or out-come, of the polygamous epoch, we have in the fact that the female partner, in the marriage contract, is more severely punished for unfaithfulness than the male—not only by public opinion, but also by law. A husband can obtain a divorce from his wife by proving that she has been unfaithful to the marriage vow; but, in most civilized nations, a wife cannot obtain a divorce from her husband on the same ground. In France, a wife cannot obtain a divorce unless the adulterous husband keeps his concubine in the same house with her. In England, a wife can obtain a divorce only when her husband, besides being unfaithful, has treated her with cruelty, or beaten her, not in moderation. In the paper whence I gathered these curiosities it was stated that at present only in two European countries, Italy and Scotland, does an equal, or bi-lateral, law of divorce prevail. (Is the New Zealand law also bi-lateral?) We have now seen that legislation has stamped a uni-lateral character on conjugal infidelity, and inflicts severer

penalties on the female infidel than on the male. We have seen also that law and public opinion allow greater liberty to the male than to the female of being licentious with impunity. From this it obviously follows that we recognise one moral code for women, and another, and laxer, code for men; or that men are not bound by the same rule of moral purity as women. The things I have just now spoken of,—the injustice of the marriage partnership; the uni-lateral character of conjugal unfaithfulness; and the different moral codes imposed on men and women—seem to me to be survivals and outgrowths of slavery and polygamy. If you do not adopt my views of their genealogical descent, I am sure you will acknowledge it would be hard to find worse principles and practices among barbarians and savages; and that in the midst of our modern civilization it would be premature as yet to thank Heaven for our being much wiser or better than the generations which preceded us.

We have another barbarous survival in connection with the legal relation in which married women now-a-days stand to the guardianship of their children. In the view of common sense, father and mother have an equal right and interest in their children. But British law proceeds on the assumption that they are the father's children exclusively. "He alone," says Mill, "has any legal rights over them. No one act can she do towards or in relation to them, except by delegation from him. Even after he is dead she is not their legal guardian, unless he by will has made her so. He could even send them away from her, and deprive her of the means of seeing or corresponding with them, until this power was in some degree restricted by Sergeant Talfourd's Act." In treating this part of the subject I feel I am getting out of my depth. Help, however, is at hand, for last year there was published a work on the "Rights of Women," apparently by a very able lawyer. Amongst other matters this author details the laws bearing on the guardianship of children at present in force in England, Scotland, France, etc. The book is reviewed in the last April number of the "Westminster." "By the English law of guardianship," says the reviewer, "the father alone can dispose by will or deed of the custody and tuition of his children; that is, of the management of their property and the control of their persons. The mother, who until the year 1873 had no legal power whatever over her children after they were seven, can never appoint a guardian by deed or will, though in default of such appointment by her husband, and on condition of remaining unmarried, she becomes guardian herself. The Scotch law is very similar. The father has the custody of the children during his life, and may remove them where he likes. He can recover them from any one who detains them, and, after infancy, even from their mother. He alone can nominate tutors by his will; the mother cannot, even though a widow. She only has the custody of the child's person, if her husband has appointed no one else. But in no case does the tutorship, that is the direction of the child's education and property, devolve upon her, but on the next male agnate who is over twenty-five. In France the law is that the right of guardianship goes first and indefeasibly to either survivor of the marriage, and then, in default of his or her appointment, to their parents in turn. It is impossible for the father to defeat by his will his wife's right in this respect. The utmost he can do is to limit her power by nominating an adviser whom she must consult. As legal guardian a widow has full control over her children's education. She alone can oppose or consent to their marriage. She has the usufruct of their property, and can appoint a guardian by her will. Similarly the code published for the State of New York in 1866 has so far departed from the conditions of the common law that, though the father remains the legitimate guardian of his children, and entitled to their custody, service, and earnings, yet *he cannot transfer the guardianship to any person other than the mother, without her written consent*; and if he is dead, or unable or unwilling to act, the right devolves unconditionally upon her." From these remarks it is evident that, in relation to mothers and the guardianship of children, the barbaric survivals are fewer, or less outrageously unjust in France and New York than in Great Britain; and it is to be hoped that the after discussion of this subject will show that the New Zealand law is as civilized as that of the State of New York.

4. Another relic (and this is our last,) of barbarism and savagery, is the relation in which women, especially married women, still stand to property. In those old times when a woman's social position, especially a wife's, was quite undistinguishable from that of a slave, her not being allowed to own or hold property was consistent with the then existing state of things. Her position, however, improved, in certain respects, during the world's progress; but in respect of property, it is scarcely as good as it was, in heathen Rome, fifteen or seventeen centuries ago; and much worse than it was in Hindustan according to the laws of Manu. According to those laws, all property given to a wife by her own parents or kindred, or given by her husband, remained inalienably the wife's, even though it consisted of lands or houses, inalienably hers during the husband's life, and after his death. In strange contrast with this is English law. Hitherto the tendency both of English opinion and English law has leaned towards the disinheriting and stripping of women of whatever was righteously theirs. In the testamentary disposition, whether of property or money, they are seldom dealt with fairly or equitably. A late iron-master, of enormous wealth, and whose wealth was entirely at his own disposal, left all his

landed property to the males of his family; and in bequeathing his money, he gave to the females only units, and to the males hundreds of thousands. The English law punishes a woman for marrying, by depriving her of her property; though rich people, who are able to employ lawyers, can to a certain small extent baffle the law by marriage settlements, pin-money, etc. The principle of English law seems to be that whatever is the wife's is the husband's, but whatever is the husband's is not the wife's. But I feel again that I am getting beyond my depth; and that, though stating what is substantially correct, I am likely, as a layman, to blunder in the language I employ. In my difficulty, I will fall back upon the great philosopher and the able lawyer whom I have already quoted from. Two or three very short extracts will suffice:—

"The wife's position under the common law of England is worse than that of slaves under the laws of many countries: by the Roman law, for example, a slave might have his *peculium*, which, to a certain extent, the law guaranteed to him for his exclusive use." Again, "The English law deprives a married woman of any property in real estate, or of any power to dispose of it by deed or will, as against her husband, unless it has been expressly vested in trustees, or given to her for her separate use." And, with the exception of what comes to her as the heiress of an *intestate*, "at law her husband is entitled to the rents and profits of any other realty she may have, nor can she convey it without his concurrence. As to personality: till 1870 England was the only country in which a wife had no rights to personal property; in which she could neither bequeath it by will nor dispose of it by gift, and in which it was at the mercy of her husband, and subject to his debts." Again, "It is still possible, in England, for a man to leave all his property, and so much, also, of his wife's as does not fall within the scant provision of the Property Act of 1870, away from her and her children, so as to leave them absolute paupers."

I ask your pardon for alluding to matters of this sort, which I know I do not fully understand. You should remember I do not undertake to set before you all the intricate relations of married women to property. The statements made, and the quotations adduced are only samples, intended to prove that, in reference to property and other things, women are still treated much as if they were slaves, or poor creatures to whom less of legal justice and kindness is due than to man, their free and lordly brother. Like his male progenitors in the wild days of yore, man still continues woman's legal and social tyrant. He is like Shakespeare's fox—

"Who—ne'er so tamed, so cherished, and locked-up—
Still has a wild trick of his ancestors."

I doubt if you will find, amid all the injustices and anomalies of our complicated and unequal civilization, any vestiges, or survivals, more unquestionably unjust than those which I have been speaking of. The kitchen refuse-heaps of Denmark, and the stone hatchets of the Valley of the Somme, are no more indicative of barbarous times and men, than are many of the present opinions and laws which affect women in relation to property and other matters. In this respect, the said opinions and laws are as genuine relics of old savagery, and as veritable fossils of barbarism, as any flint implements, or pithecoid skulls, dug out of Kent's Hole, or the Enghis, or Neanderthal Caves.

Art. XXII.—*Draining of Towns: Results of having Outfall Drains within Sydney Harbour.*

Communicated by W. R. E. Brown, Registrar-General.

[Read before the Wellington Philosophical Society, December 7th, 1876.]

When the subject of the drainage of towns was lately brought before this Society, the discussion assumed somewhat of a local aspect. In view of the conflicting theories held and of a possible large expenditure on drainage works, I requested Mr. Von Dadelszen, of my department, who was about to visit Sydney, to endeavour to obtain some information as to the practical results of allowing the harbour to be a receptacle for the drainage of the city; more especially with regard to the effect on the health of the inhabitants. The latter data are not obtainable on account of reasons given, but their absence is, however, far from being evidence that the health of the population is not, in parts of the town, seriously affected by the cause stated. On the contrary, the evidence given before a Board constituted to inquire into the subject of "the sewerage of the city, and on the best means of protecting the inhabitants thereof," points unmistakeably in the other direction. From the length of the letter, addressed to me by Mr. Von. Dadelszen as the result of his enquiries, an abstract only can be given, and I cannot do more than refer any gentleman who may desire fuller particulars, to this and the reports of the Board, and the evidence taken before it. The evidence taken before the Board contains much that is well worthy of attention.

I trust that the experience gained may not be thrown away upon us, but that the evils, proved to exist, may serve as beacons to prevent us wasting health and material resources by adopting systems that have been found insufficient or injurious:—

"According to request, while on my late visit to Sydney, I called on

Mr. Ward, the Registrar-General, and inquired if any information as to the influences of the drainage discharges was shown by the health statistics. He informed me that owing to the situation of the wards from which the mortality tables are compiled, no comparison in the way enquired about could be established.

"Mr. Ward, however, introduced me to Professor Pell, of the Sydney University, who is chairman of a Board appointed in 1875 to enquire into and report upon the best means of disposing of the sewage of the city of Sydney and its suburbs, as well as of protecting the health of the inhabitants thereof; and such information as I have obtained from the reports of the Board now before me I will endeavour to review under the following different principal heads.

"*Effects of Discharge of Sewage into Harbour.*

"The evils occasioned are two.

"1. The contamination of the shores and harbour.

"2. The silting up of the harbour.

"The substances it is desired to dispose of otherwise are as follows:—

(1.) The light contaminating matters, partly in suspension and partly in solution, which create the nuisance.

"(2.) The fine sand, comminuted clay, and other purely divided earthy matters, which are at all times brought down by the sewage water, and in large quantities during heavy rains. This matter is carried over every part of the harbour, and even far out into the ocean, and slowly settles to the bottom.

"(3.) The coarser sand brought down in times of flood, a part of which is deposited at the bottoms of the sewers, generally near their mouths, and a portion at or about the outfalls, forming in some cases sand-banks which become polluted by the offensive organic matter.

"The committee reports show how great the evil is of discharging it either on a foreshore or spreading it abroad on the surface of the water.

"An extract from the report of the committee for the investigation of crowded areas and dwellings, shews, that the committee found the odour at the bottom of Liverpool street at midnight was so offensive, at low tide, that they could not have credited it, without personal experience of it, and that no description yet published equalled the foul reality.

"Mr. Moriarty, Engineer-in-chief for Harbours and Rivers, in his evidence before the Board, states that the nuisance from the sewage floating on the surface of the salt water is frightful, and that offensive mud-banks are formed, and as a matter of fact we hear that the outlets of the sewers are invariably offensive, and that the reason, why the harbours and rivers become polluted with animal and organic matter, is that this matter is discharged with a lot of sand and mineral matter, which entangles it and causes it to sink to the bottom and putrify. That there is no sewage matter which of itself would not float, and could not form a deposit were it not entangled and kept down by some heavier substance. The main sewers collect both the house sewage and also the street washings, and when mixed together form putrid mud at the outlets, which is very offensive.

"In a report, attached, 'of the Committee appointed by the Sydney City and Suburban Sewage and Health Board, 16th July, 1875, to examine and report upon the outlets, of the city sewers, discharging into the Harbour,' it is stated, that silt-pits are used to intercept heavy particles before discharge at the outlet; that one constructed at the Market Wharf outfall has stopped the silting up of the outlet. It contains, when full, 100 tons, and fills up about every six months. The area drained by it being about eleven and three-quarter acres.

"The evidence of Dr. Alleyne, taken after the reading of the above-mentioned report, shows clearly how offensive is the matter discharged in spite of these silt pits. At Fort Macquarrie the rocky bottom is covered with a film some inches thick, which has rendered reclaimation necessary.

"A letter from Captain Nares is appended, dated 19th November, 1874, giving a bad account of the state of the anchorage in Farm Cove, and stating that the moorings there have already had to be moved in consequence of the unhealthiness of the previous position, due to the discharge from the sewers.

"I myself found on arrival at Sydney, that the smell was so abominable as to render it impossible to remain in the berth-room of the Newcastle steamer, while the port-hole was open; and I was forced to leave the vessel's cabin and walk about in the town until the hotels opened.

"*Method by which the Pollution of the Shores can be lessened.*

"Iron pipes are to be laid down from the mouths of certain sewers to convey the ordinary dry weather flow into deeper water, at a distance of about 120 feet in one case from the present outlet. The description by Mr. Moriarty of his plan for this work is appended, in which he condemns the sewage being allowed to flow into the Harbour at all.

"*Decision of the Board in Sydney to Divert the Sewage from the Harbour.*

"The sewage is to be discharged for the most part by gravitation through a tunnel to the ocean, or by tunnel, pipes, and conduits, to some tract of land suitable for sewage farming.

"In addition to the subject you directed my attention to more particularly, I append remarks on the pollution of the water supply, owing to water-closets being directly connected with the mains. This is a great source of sickness. An investigation of this subject was instituted, and

Dr. MacLawrie gave strong evidence on the evils due to this cause,* and the result of it was a recommendation that an Act be passed (which is now law,) requiring that every water-closet should be connected with mains only with the intervention of a cistern, approved by the City Engineer as being of such construction as to prevent the pollution of the water.

"Remarks are also appended upon cesspits, which are still necessary in some parts of Sydney. It has been recommended that, to lessen the evil effects of cesspits, full powers should be given to the local authorities to regulate the construction of cesspits as to their size and situation; and to insist on their being made water-tight; and also that the duty of cleansing them be transferred to the town authorities, and owners of houses relieved of all responsibility in the matter, except as regards payment for the work done on their behalf; and 300 acres be authorized by an Act to serve for the deposit of the night soil.

"The earth-closet system is discussed in the Fifth Report of a Committee of the British Association on the treatment and utilization of sewage, in which this system is condemned. And in the Third Progress Report of the Sydney Board it is considered practically impossible to secure proper management, and a supply of suitable earth; that they would not diminish the contamination of the sewers; and that the manure is of little value.

"*Crowded Dwellings and Areas.*

"A portion of the work devolving upon the Board in Sydney was the investigation of crowded areas and dwellings, and the results of the examination show the effect of allowing land to be divided according to the will of the proprietor, uncontrolled by thorough legislation for the protection of the health of a town population.

"I have endeavoured in the above, to compress, into a short space, from the reports under my notice, an account of the principal matters being dealt with in Sydney. There are no less than eleven progress reports of the Sydney Board, all supported by minute and carefully-taken evidence; from them much more might be gathered if necessary. The contents are only briefly alluded to in this letter. The work of the Board is most thorough in its character, and done at a very great expense to the Government."

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* Dr. MacLawrie, in his evidence attached to First Progress Report, stated that, in the Harbour of Wellington, N.Z., the crew of H.M.S. "*Challenger*," having had occasion to use the water from a former town supply, now superseded, an outbreak of diarrhœa occurred, and continued for about three weeks, and it ceased on the supply being stopped. The water was found to have been contaminated with fœcal matter from cesspits in the town during the heavy rains. The water had a disagreeable smell, and the suspended particles gave it a milky consistency.

Reports and Acts referred to in Mr. Brown's Paper.

An Act for preventing the pollution of the water supplied to the city of Sydney and its suburbs. Assented to, 22nd July, 1875.

Report to the Sewage and Health Committees upon the Sydney city and suburban water supply, by A. Liversidge, F.C.S., F.G.S., Prof. of Geology and Mineralogy, Sydney University. Printed, 24th July, 1875.

Report from City and Suburban Sewage and Health Board, respecting disposal of night soil in Melbourne. Printed 20th July, 1875.

Report of the Committee appointed by the Sydney City and Suburban Sewage and Health Board, on 11th July, 1875, to examine and report upon the outlets of the city sewers discharging into the harbour. Prof. A. Alleyne, chairman. Adopted, 15th September, 1875.

An Act for preventing certain nuisances in the city of Sydney and other municipalities, 11th August, 1875.

Third report to the Sydney City and Suburban Sewage and Health Boards upon the quality of the Sydney city and suburban water supply, by A. Leversidge. Dated 11th May, 1876.

Progress reports of the Sydney City and Suburban Sewage and Health Board, appointed 12th April, 1875, to enquire into and report as to the best means of disposing of the sewage of the city of Sydney and its suburbs, as well as protecting the health of the inhabitants.

First	Report	... ...	Printed,	6th May, 1875.
Second	,,	... ...	,,	25th June, ,,
Third	,,	... ...	,,	19th July, ,,
Fourth	,,	... ...	Adopted,	25th Aug., ,,
Fifth	,,	... ...	Printed,	16th Nov., ,,
Sixth	,,	... ...	,,	23rd Nov. ,,
Seventh	,,	... ...	,,	3rd March, 1876.
Eighth	,,	... ...	,,	,, ,,
Ninth	,,	... ...	,,	26th May, ,,
Tenth	,,	... ...	,,	4th July ,,
Eleventh	,,	... ...	,,	16th Aug., ,,

ART. XXIII.—*On Skew Arches.* By W. ARTHUR, C.E.

Plate.

[*Read before the Otago Institute, 3rd October, 1876.*]

IN introducing to your notice such a dry subject as that of this paper, my excuse must be, that in these days of great public works in the colony, its consideration may prove useful, more particularly as the best authorities, such as "Buck, on Oblique Bridges," cannot be got at all here; and another thing is that, being confessedly a difficult subject, it may be found all the more deserving of some attention, at any rate from engineers. But before describing particularly the details of the design of a skew arch, it may not be altogether uninteresting to look for a little at what is known of arches in general, built during past ages of the world, and also at the position of bridges in Otago at the present day.

History of Arches.

Arches of masonry—that is, ordinary arches—are of very ancient origin. The earliest known remains are to be found in the ruins of Nineveh; they occur next among the oldest buildings of ancient Egypt. The caves of Adjunta and Ellora in British India reveal to this day circular and pointed arches in their subterranean temples, shewing the skill and handicraft of a race of men who lived probably three thousand years ago. Dr. Robinson, the American traveller, discovered at Jerusalem, part of a very old arch, which appears to have connected Soloman's Temple with a portion of the city, from which it was separated by a small valley or gorge. He found only a few stones still in position at the springing of the arch next the temple, or what is now the mosque, but these were of very great dimensions. From measurements made across the valley, the span of this arch was found to be about 350 feet. I have calculated the weight of one of these arch stones from such dimensions as are given, assuming the material to be limestone, and it turns out to be twenty tons! The Romans next appear to have availed themselves of the principle of the arch, as may be seen in their domes, bridges, vaults, and sewers. And lastly, in the explorations which were made forty years ago in Mexico, together with pyramids and ancient cities, several specimens of arches also came to light, which are believed to be at least two thousand years old. It thus appears that the principle of the arch was known and appreciated from the earliest ages. In modern times the construction of arches has received greater attention, but we have no knowledge of the existence in ancient or modern times of a skew arch, until 1530, when one was built in Italy. In our own country, no attempt was made to erect such a structure, until the introduction of railways compelled engineers to avail themselves of the principle, and now skew arches are to be met with on nearly every line of railway in Great Britain.

Bridges in Otago.

In a colony like this, bridges as a rule have hitherto been constructed of timber. This is owing to the rapidity and cheapness with which such works can be carried out, and the circumstances of a young colony seem to justify such economy. But I question whether there is in this any real economy in the long run. For even where the workmanship is of the best and the quality of the material unexceptionable, timber bridges require constant repairing, and cannot at most be expected to last more than fifteen or twenty years. Iron bridges are no doubt very convenient in railway works and for great spans, but even they are not equal in durability to good stone arches. This fact has caused the Parisians to substitute arches of masonry in their main thoroughfares, for the iron bridges previously erected there. English engineers are coming round also to admit, that stone after all, has many advantages over iron in permanent structures. Most of the bridges recently built in Otago by the Provincial Government are a great improvement on timber pile bridges, as the piers and abutments have been built in masonry, the superstructures only being in timber. The only stone arches however, of any importance, which Otago at present possesses, are those on the Main North Road from Dunedin to Oamaru, five in number, and two or three on the road from Palmerston to the interior; the greatest span of any one of these being sixty feet. There are no skew arches in Otago and I am not aware of the existence of one in any part of New Zealand at present.

On bridges in Otago there was spent by the Provincial Government, during last year alone, no less than £34,751, so the kind of material which is best for their construction is a consideration worthy of the attention of all good colonists.

Skew Arches.

I will now proceed to describe the principles and construction of skew arches in masonry, illustrated by drawings, and a small model of an actual segmental arch, built seven years ago. These drawings are No. 1, and No. 2, appended to this paper: No. 1 shewing half elevation, plan and section; and No. 2, the development, on a flat surface, of the intrados and extrados, which is the more important and necessary drawing for the guidance of the builder.

Definition.

A skew arch in masonry may be defined as being an arch whose abutments are equal, parallel, but not directly opposite each other, and whose courses, from face to face, are not parallel but inclined to abutments, and are spiral surfaces. The angle of skew, θ on Drawing No. 1, is the angle

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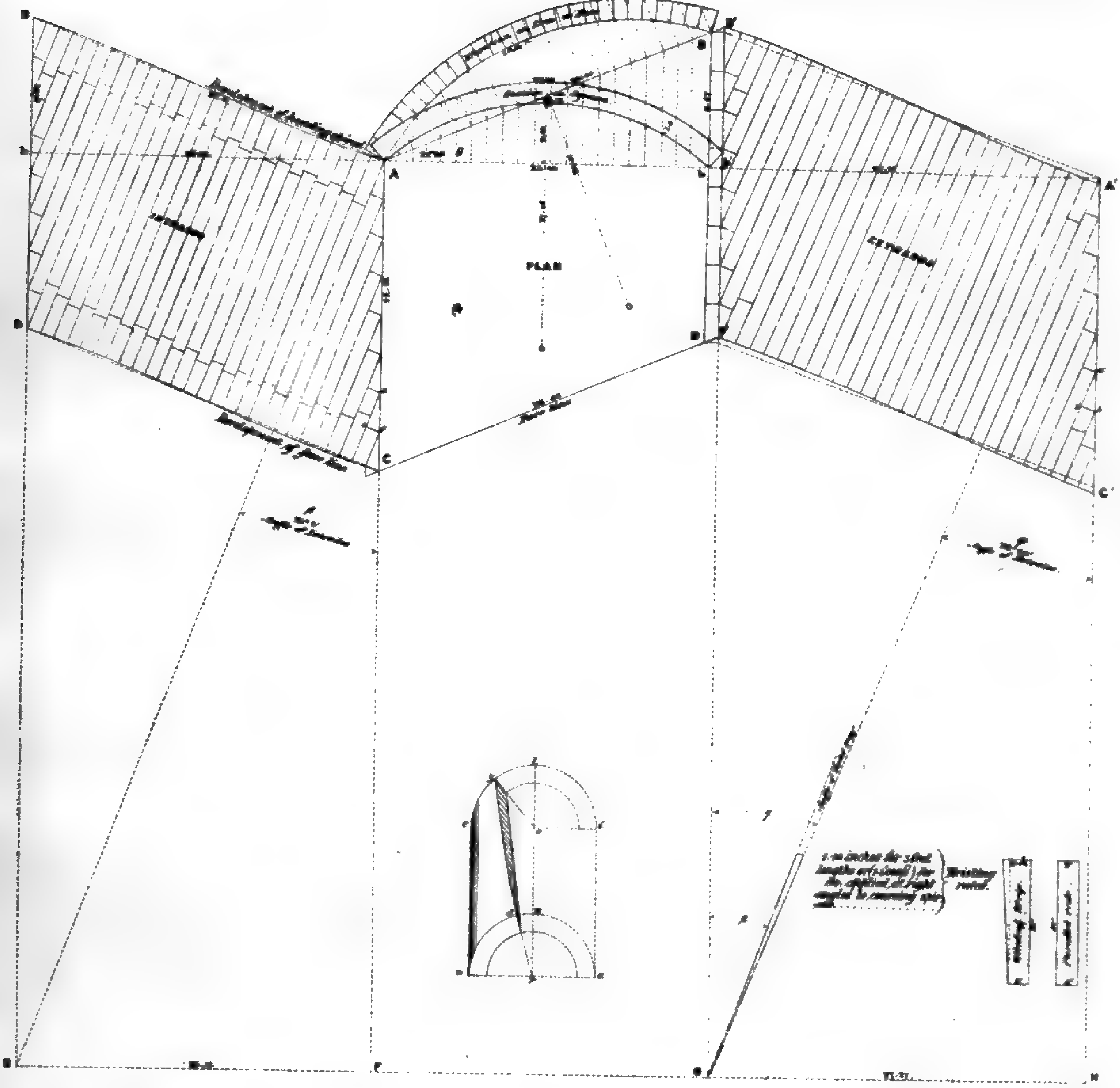

SKEW BRIDGE – [illegible]

Development of Intrados and Extrados

Scale

contained between the face line and its position, if drawn at right angles to the abutment. Most writers give the complement of this, or *B A D*, as the angle of skew, but this does not appear appropriate; and Professor Rankine, I find, gives an angle of equal value to the one I have adopted. The spiral surfaces are the beds formed by the continuous courses of arch stones, or "*voussoirs*," which run from one face of the arch to the other. One such surface is shewn in Drawing No. 2, where *c i n e* is half of a hollow cylinder, and *d y* (as shaded) represents a spiral course, or a "coursing spiral," as it is called. It may be regarded as described by the revolution of radius *y o* through angle (*y o l*—*d r p*), simultaneously with its progression from the position *d r* to *y o* along the axis of the cylinder *r o*. The peculiar direction of the coursing spirals is necessary to bring these courses as nearly as possible at right angles to line of pressures. Beds running at right angles to these are heading spirals, and in the actual arch are the end surfaces of arch stones, where these abut on one another. The best guide to show the curious lines, angles, and surfaces which result from a bridge being built on the skew principle, is a model; this simplifies many difficulties.

Stability.

It is not properly within the scope of this paper to go into the equilibrium of arches. But besides what I have unavoidably stated, that the coursing spirals should be at right angles to the line of pressures, I may add that the general principles of stability are the same as in ordinary arches, the chief one of which I shall only mention. Taking half the arch—the half-arch ring must carry its own weight, that of the spandril wall above it, with its load, acting vertically through the centre of gravity of the mass, and be supported by two pressures, one upward and inclined from the abutment (see Fig. 1) and the other horizontal, passing through the keystone; these pressures should intersect each other in the line of gravity of the mass. It is not usual, unless arches are of great span, to investigate by actual calculation the line of pressures; the ordinary formulæ in use are sufficient for determining the thickness of abutments and arch ring.

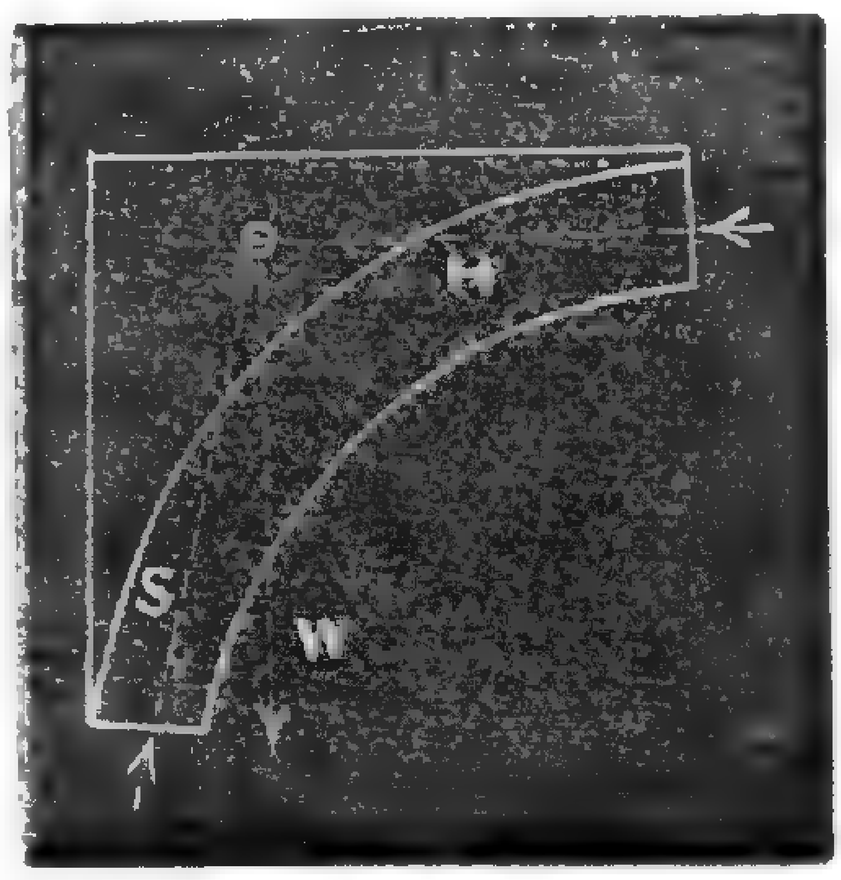

Fig. 1.

Design.

In designing a skew arch a ground plan *A B C D*, as shown in drawing No. 2, is prepared provisionally from measurements made at the site of the bridge. Afterwards, as will appear, it may have to be slightly altered before finally fixing its dimensions.

Section on Square and Skews.

A section on the square, of the arch with given rise and span, is then described as segment $A\,B$. A series of ordinates are drawn parallel to abutments from the chord $A\,b$ on plan, to the solid face line $A\,B$, and continued where necessary to the extrados of section on square. From the points where these lines meet $A\,B$, ordinates are then drawn at right angles to $A\,B$, and on these heights are carefully marked corresponding to the heights measured between the chord $A\,b$ and the two surfaces of section on square, or its intrados and extrados. By this means, the elevation on skew or of face, can be accurately drawn; the curved lines of this elevation are portions of ellipses.

Intrados.

The development of the intrados, or soffit of the arch, must next be designed. $A\ B\ C\ D$ on left of plan, represents the hollow surface or under side of arch, turned backwards round the impost line $A\ C$ and spread out as a flat surface. It is drawn in this way:—Through A produce chord $A\,b$, making its length equal length of segment. Draw $b\,B$ at right angles to segmental length $A\,b$ from b and equal to $b\,B$ on plan, and join $A\,B$ as shewn by dotted lines; that line is the development of a heading spiral. Complete the figure by drawing $B\,D$, $D\,C$, parallel and equal to the sides opposite to them. Draw $A\,E$ from A at right angles to heading spirals $A\,B$ or $C\,D$, and produce $B\,D$ to meet it in E, and complete figure $A\,b\,E\,F$, making $A\,F\,E$ a right angle. The length $b\,E$ or $A\,F$ is readily calculated thus:—$b\,E = \frac{bA^2}{bB}$. Angle $E\,A\,F$ or β is the angle of intrados, which in this arch is 21° 3′; and tan. $\beta = \frac{bB}{bA}$. The number of courses of arch stones, always an odd number (in this case 27), is decided on and laid off along the heading spiral $C\,D$. If $A\,E$ does not coincide at its intersection with $C\,D$ with one of these divisions, it must be made to do so—in other words, the development requires adjustment. This is effected in several ways; such as altering the number of divisions of face line, altering span, radius, or length of impost. In Bathlin Bridge, it was done by ruling the line $A\,E$ through the nearest face joint, and altering impost line $A\,C$ to correspond; thus avoiding any disturbance of angles or number of courses. On $A\,C$, mark off as many skewbacks as there are courses between C and $A\,E$, and through these points draw lines parallel to $A\,E$; these lines will intersect the courses marked on the heading spiral between C and $A\,E$, and will represent coursing spirals. Complete drawing of courses through remaining divisions on $C\,D$, and draw development of face line $A\,B$ by ordinates laid down at right angles to $A\ b$ at distances equal to those between the ordinates along the segment or section on square, and of lengths equal to those of the corresponding ordinates between the chord $A\ b$ and face line

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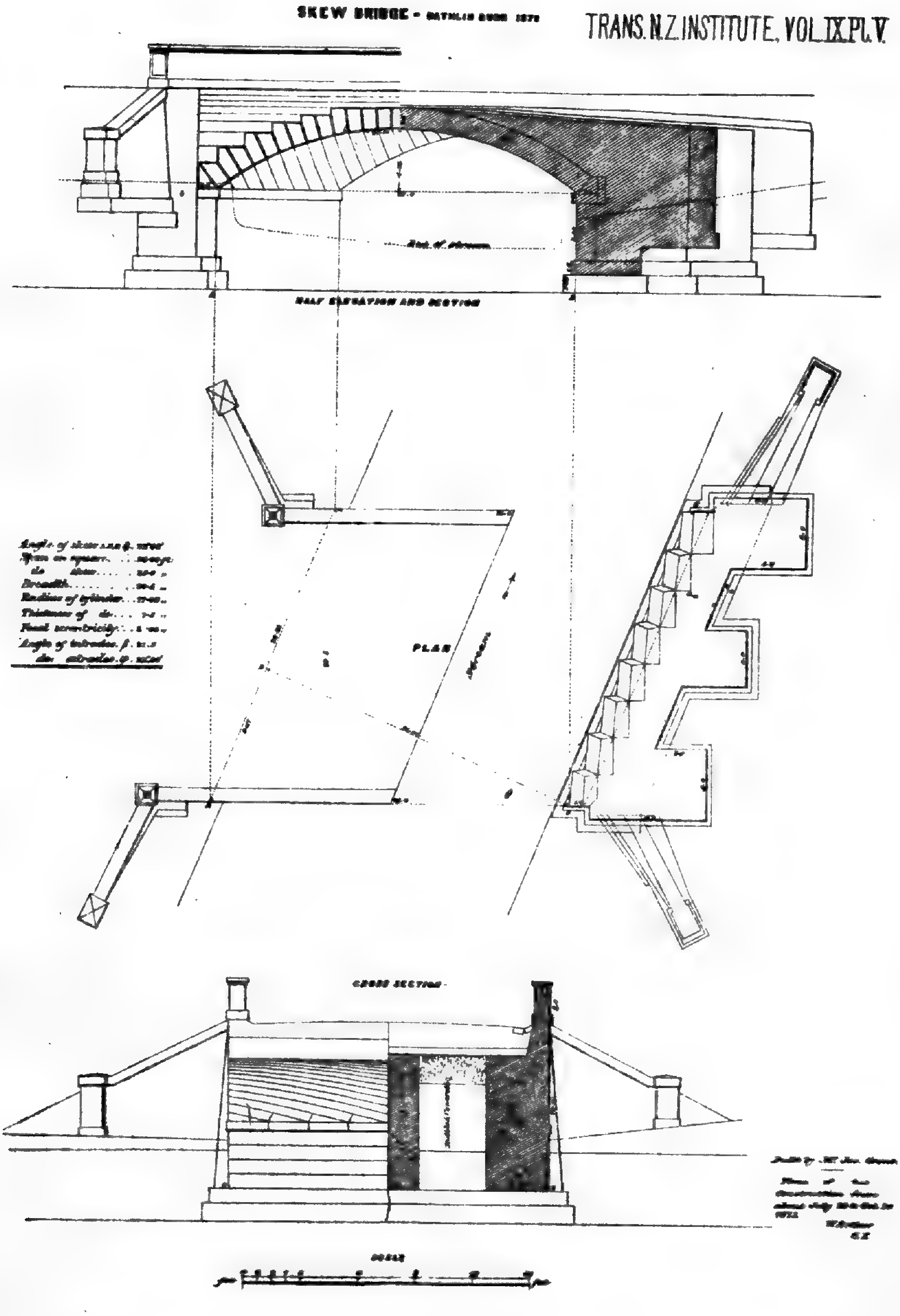


A B. In the same way draw face line *CD*, and then the heading joints of skewbacks, and face quoins at right angles to coursing joints. The other heading joints of soffit may be left to the builder to arrange, care being taken that a good bond is maintained throughout. This is the usual method of designing the development of the intrados, and, taken in connection with plan and development of extrados on same drawing, it is very convenient, so far as showing the relation of the different parts. But it is reversed from its normal position, or turned upside down: this will be referred to again.

Face Joints.

The elevation on skew or elevation of face, must have the face joints, or rather their chords, drawn from a centre lower than the axis of the cylinder and from which point they radiate. This property in skew arches was discovered by Mr. Buck, and is known as the focal eccentricity, or the difference between centre of cylinder and centre from which chords of face-joints radiate. The formula for calculating this is $60 = \text{Rad.} \times \tan. \theta \times \tan. \phi$; and a geometrical method is given by diagram in "Masonry and Stone-cutting," by Dobson.

Extrados.

The development of the extrados should next be drawn. This is done similarly to that of the intrados, but with this difference, that the coursing spirals are not at right angles to the heading spirals. The reason of this is that the length of the coursing spirals, measured or projected on the axis of the cylinder is the same for intrados and extrados, but the length of the heading spirals is greater in the extrados than the intrados. Another consequence is that the angle of extrados *G A′ H* or ϕ, is greater than the angle of intrados β. The figure *A′ B′ C′ D′*, Drawing No. 2, represents a development of the extrados.

Elevation, etc.

The more essential designs having now been completed, from these the elevation, plan and cross section, shewn in Drawing No. 1, are drawn. In the elevation, the only matters further to be noted are that the back of the arch-stones should be stopped, and the courses of spandril walls built to correspond, thus securing greater stability than if these precautions were neglected. The plan shews the peculiar serrated appearance which the springers or skewbacks present, owing to the obliquity of the courses; and it will also be perceived that the boss stones at the obtuse and acute angles, are greater and less respectively than the other skewbacks, for the same reason.

Bathlin Burn Bridge.

The remaining peculiarities of skew arches, and the rules which are necessary to be observed in construction, may perhaps be more conveniently laid before you if, during the rest of this paper, I adhere as nearly as possible to a description of the methods actually adopted in the Bathlin Bridge. Drawing No. 1 shows the ordinary designs that were used, and the principles above explained and represented by Drawing No. 2, were carried out in a modified form.

Skewbacks or Springers.

First, the skewbacks were cut to sizes, and templets taken from impost line $A\ C$ (as $d\ e\ f$ templet for soffit), and built into position, the face of quoins being cut to lie in perpendicular plane; the stones dressed to thickness of arch-ring, and the extrados left rough and quarry-faced—templet, $\acute{a}\ g\ h$, not being used. When skewbacks were fixed, centreing and laggings were erected carefully. The intrados was drawn on paper on a scale of two feet to an inch, but instead of being turned upside down, as in drawing No. 2, it was designed in its normal position; an elevation on skew and section on square, on same scale, and a full-sized drawing of twisting rules, as sketched in No. 2, were made; but no development of extrados was drawn, it was found sufficient to calculate angle of extrados ϕ. In using the normal development of intrados for this arch, it was found to secure much convenience to the builder, who was thus saved the awkwardness of always treating the arch-stones as inverted. A large wooden platform was constructed adjoining site of bridge, and on it a full-size drawing was made of development of intrados in its natural position, and the sizes and joints of all the stones arranged on it. On the laggings the coursing spirals were laid down or marked off from the development on the platform.

Angle of Twist.

The angle of twist (ϕ—β) having been found by calculation, the winding strip and parallel rule were drawn full size, and from these the actual rules were cut, which the builder used in dressing the beds of the arch-stones to the proper twist. The divergent portion of winding strip shown is that applicable to stones of three feet in length, applied at right angles to coursing spirals. These twisting rules may be used either as rules or templets.

Face angle of Quoins.

The next thing in importance, requiring great care, was the working the faces of the quoins to the proper angle with the soffit. From the springing to the keystone the faces of quoins make different angles with the coursing joints. On the side next the acute angle these angles are acute, and on the side next the obtuse angle they are obtuse; and the angles equi-distant from keystone are complements of one another. The angle in each case was measured on the laggings between a perpendicular plane in line of face and the coursing spiral at the particular point. A convenient method to find this angle is with a board, one edge of which is dressed to the curve of the soffit in the direction of spiral courses, applied at a point marked at the centre, or any convenient point, of this curved edge to the face-line on laggings, and resting on laggings in the true position of a coursing spiral. A plumb-line run then carefully along the upper edge of board till the weight points exactly on the face line, will give a point on that edge, which joined by a pencil line with centre-point on curved edge below, will represent the actual angle and its complement at the particular course where the measurement is taken. From this board the templets may be made.

Fig. 2.

The obliquity of the arch causes a curious result in the length of the top and bottom of quoins. That is, on the acute side of arch the soffit of the quoins is longer than the top or extrados, while on the obtuse side the soffit of the quoins is shorter than the extrados.

Working of Arch Stones.

In the operation of dressing or working the arch stones, such as the quoins, a plain surface is first prepared approximating in size and direction a coursing joint or bed, and on this the curve of the arch soffit, in the same direction, is drafted. The twisting rules are next applied, and the plane surface is worked off to the proper twist, right handed or left, as the case may be. Then the soffit is worked to the arch square—(a rule made by joining a straight-edge at right angles to a rule having the curve of the arch)—the heading joint is dressed at right angles to soffit, and the face to a rule or templet forming the correct angle of the face. There are also the necessary dimensions of quoins to be taken from diagram on platform and from drawings as required.

Though not all mathematically accurate, these rules as I have now given them, for the building of a skew arch, are those commonly followed in practice, and give sufficiently good results to justify their use.

Skew Arches of other forms.

In the above description of the design and construction of a skew arch, it will be observed that a segmental arch only has been treated of. There are other forms of skew arches rendered sometimes unavoidable by the peculiar circumstances of the case, such as an elliptical skew arch, and a skew arch the plan of which is on a curve.

As to elliptical skew arches, the principles involved in designing these are the very same as for segmental arches; therefore, in applying these, the ellipse may be divided into two or more portions, which may be taken as continuous segments of circles, or an approximate segment of a circle in position and length may be assumed as the actual one, and developed accordingly.

And as to skew arches on curves, these may be designed as if the faces were straight, in the same manner as given in this paper, and the correction in the lengths of courses applied afterwards to the development of the intrados, lengthening those on the convex side and shortening those on the concave side. But it is evident that the principle can only be applied safely within certain limits, and in so doing, it must always be borne in mind that the properties of the lines and sections of a cylinder lie at the basis of the design of any skew arch.

Art. XXIV.—*On the Simplest Continuous Manifoldness of two Dimensions and of Finite Extent.* By F. W. Frankland.

[Read before the Wellington Philosophical Society, 11th November, 1876.]

Among the most remarkable speculations of the present century is the speculation that the axioms of geometry may be only approximately true, and that the actual properties of space may be somewhat different from those which we are in the habit of ascribing to it. It was Lobatchewsky who first worked out the conception of a space in which some of the ordinary laws of geometry should no longer hold good. Among the axioms which lie at the foundation of the Euclidian scheme he assumed all to be true except the one which relates to parallel straight lines. An equivalent form of this axiom, and the one now generally employed in works on geometry, is the statement that it is impossible to draw more than one straight line parallel to a given straight line through a given point outside it. In other words, if we take a fixed straight line A B, prolonged infinitely in both directions, and a fixed point P outside it; then, if a second straight line, also infinitely prolonged in both directions, be made to rotate about P, there is *only one* position in which it will not intersect A B. Now Lobatchewsky made the supposition that this axiom should be untrue, and that there should be a finite angle through which the rotating line might be turned, without ever intersecting the fixed straight line A B. And in following out the consequences of this assumption, he was never brought into collision with any of the other axioms, but was able

Fig. 1.

to construct a perfectly self-consistent scheme of propositions, all of them valid as analytical conceptions, but all of them perfectly incapable of being realized in thought.

Many of the results he arrived at were very curious; such as for instance that the three angles of a triangle would not be together equal to two right angles, but would be together less than two right angles by a quantity proportional to the area of the triangle. If we were to increase the sides of such a triangle, keeping them always in the same proportion, the angles would become continually smaller and smaller, until at last the three sides would cease to form a triangle, because they would never meet at all.

There are many other assumptions, at variance with the axioms of Euclid, which may be made respecting distance-relations, and which yield self-consistent schemes of propositions differing widely from the propositions of geometry. We see therefore, that geometry is only a particular branch of a more general science, and that the conception of space is a particular variety of a wider and more general conception. This wider conception, of which time and space are particular varieties, it has been proposed to denote by the term *manifoldness*. Whenever a general notion is susceptible of a variety of specializations, the aggregate of all such specializations is called a manifoldness. Thus space is the aggregate of all *points*, and each point is a specialization of the general notion of *position*. In the same way, time is the aggregate of all *instants*, and each instant is a specialization of the general notion of *position in time*. Space and time are, in fact, of all manifoldnesses the ones with which we are by far the most frequently concerned. Now there is an important feature in which these two manifoldnesses agree. They are both of them of such a nature that no limit can be conceived to their divisibility. However near together two points in space may be, we can always conceive the existence of intermediate points, and the same thing holds in regard to time. Mathematicians express this fact by saying that space and time are *continuous* manifoldnesses. But there is another feature, equally important with the foregoing, in regard to which space and time are strikingly contrasted. If we wish to travel away from any particular instant in time, there are only two directions in which we can set out. We must either ascend or descend the stream. But from a point in space we can set out in an infinite number of directions. This difference is expressed by saying that time is a manifoldness of *one dimension*, and that space is a manifoldness of *more than one dimension*. An aggregate of points in which we could only travel backwards or forwards, would be, *not* solid space, but a *line*. A line therefore is a manifoldness of one dimension. A *surface*, again, may be regarded as an aggregate of lines; and it is an aggregate of such a nature that if we wish to travel away from a particular line there are only two directions in which we can set out. It is therefore a line-aggregate of one dimension. Considered as a point-aggregate it has two dimensions, and accordingly it is a manifoldness of two dimensions. In the same way it will be seen that solid space is a manifoldness of three dimensions.

I have endeavoured by these preliminary remarks to explain what is meant when we speak of a continuous manifoldness of two dimensions. It is the object of this paper to communicate some results I have arrived at respecting the properties of the simplest of such manifoldnesses which has a finite extent. The existence of the particular manifoldness I shall endeavour to describe has been referred to in a remarkable lecture by Professor Clifford on the Postulates of the Science of Space, but I am not aware that its properties have not hitherto been worked out in detail.

The simplest of all doubly extended continuous manifoldnesses is the *plane*, but it is not a manifoldness of finite extent. It reaches to infinity in every direction, and its area is greater than any assignable area. It is therefore not the manifoldness of which we are in search. Now the circumstance in which the plane differs from those doubly extended manifoldnesses, which are next to it in order of simplicity, is the possibility that figures constructed in it may be magnified or diminished to any extent without alteration of shape; in other words, that figures which can be constructed in it at all can be constructed to any scale. That this property is not possessed by curved surfaces may be seen by considering the case of a spherical triangle. If the sides of a triangle constructed on a given sphere be all of them increased or diminished in the same proportion, the shape of the triangle will not remain the same. Now it has been found by Professor Riemann that this property of the plane is equivalent to the following two axioms:—(1.) That two geodesic lines which diverge from a point will never intersect again; or, as Euclid puts it, that two straight lines cannot enclose a space; and (2.) that two geodesic lines which do not intersect will make equal angles with every other geodesic line. This second is precisely equivalent to Euclid's twelfth axiom. Deny the first of these axioms and you have a manifoldness of uniform positive curvature; deny the second, and you have one of uniform negative curvature. The plane lies midway between the two, and its curvature is zero at every point.

Let us consider, then, the case of a doubly-extended manifoldness, of which the curvature is uniform and positive. The first of the before-mentioned two axioms is no longer true. Geodesic lines, diverging from a point, do not continue to diverge for ever. They meet again, and enclose a space. The first question which presents itself, is with reference to the situation of the point towards which they ultimately converge. In the case of a spherical surface, they will converge towards a point which is separated from the starting-point by half the length of a geodesic line. And this is the only case we are able to conceive. The surface of a sphere is the only doubly-extended manifoldness of uniform positive curvature which geometry recognizes, and it is the only one which we can figure to ourselves in thought. It is not, however, the *simplest* of such manifoldnesses. To obtain the simplest case, we must suppose that the point towards which two geodesic lines converge is separated from their starting-point, not by *half*, but by the *entire* length of a geodesic line; or, what amounts to the same thing, that it *coincides* with the starting-point. It is true that we are utterly unable to figure to ourselves a surface in which two geodesic lines shall have only one point of intersection, and shall yet enclose a space. But we are perfectly at liberty to reason about such a surface, because there is nothing self-contradictory in the definition of it, and because therefore the analytical conception of it is perfectly valid. It is the simplest continuous manifoldness of two dimensions, and of finite extent, and those few properties of it, which I have worked out, appear to me to be very beautiful. In order to make my observations more intelligible, I shall for the future speak of it as a surface, and its geodesic lines I shall speak of as straight lines. I have the highest authority for using this nomenclature; and, though it will impart to my theorems a very paradoxical sound, it is calculated, I think, to give a juster idea of their meaning than if I were to use the more accurate, but less familiar terms.

Assuming, then, as the fundamental properties of our surface, that every straight line is of finite extent (in other words, that a point moving along it, will arrive at the position from which it started after travelling a finite distance), and that two straight lines cannot have two points in common, the first corollary I propose to establish is, that all straight lines in the surface are of equal extent.

Let A B be two straight lines in the given surface. If possible, let A be greater than B. From A cut off a portion equal to B. Let P Q be the extreme points of this segment, and let R be any point in B. Apply the line A to the line B in such a manner that the point P falls on the point R. Then, since, in a surface of uniform curvature, equal lengths of geodesic lines may be made to coincide, the segment PQ will coincide with the entire straight line B. Hence Q will fall upon R. But P coincides with R, and P and Q do not coincide with one another, since P Q is less than the entire straight line A; therefore, Q cannot coincide with R. Hence A cannot be greater than B.

The straight lines here spoken of are of course not *terminated* straight lines. What the proposition asserts is, that the *entire* length of all straight lines in the given surface is the same. The corresponding proposition in spherical geometry is, that all great circles of a given sphere are equal.

There are a great many other analogies between the imaginary surface here treated of and the surface of a sphere. Its straight lines, though they are like the straight lines of a plane, in the circumstance that any two of them have only one point of intersection, are in many other respects analogous to great circles. In any of its straight lines, for instance, each point has a corresponding point which is *opposite* to it and farther from it than any other point in the line. For, if by setting out from a point and travelling a finite distance in a particular direction we get back to the starting-point, there must be a point half-way on our journey which is farther from the starting-point than any other point in the line, and which may very appropriately be called its *opposite* point. It is an obvious corollary, that the distance between any two points will be the same as the distance between their opposite points.

Let us now consider the case of a number of straight lines radiating from a centre. In each of them there will be a point which is opposite to that centre. And it will be a separate point for every separate straight line. For no two straight lines can have two points in common; and, since these radiating lines have a common centre of radiation, they can have no other point in common. Hence, if we suppose one of these lines to rotate about the centre, the point opposite to the centre will describe a continuous line, and one which finally returns into itself. It is the locus of all points in the surface opposite to the centre of radiation. What, now, is the character of this locus? In the first place, it is a line which is of the same shape all along, and of which all equal segments, therefore, can be made to coincide. For any two positions of the rotating line which contain a given angle, may be placed upon any other two positions which contain an equal angle. Then, since the length of all straight lines in the surface is the same, the opposite points will coincide, and, by parity of reasoning, all intermediate points of the locus. But, in the second place, the locus is also of the same shape on both sides. For each point in it may be approached from the centre of radiation in two different ways, and it is at the same distance from that centre, whether it be approached in the one way or the other. Any particular segment, in fact, of the locus, has its extreme points joined to the centre of radiation by lines which are of equal length, and which include an equal angle—lines, therefore, which may be made to coincide. Since this is the case for any segment whatever, and for every subdivision of a segment, all the points of a segment will still remain on it if the segment be turned round and applied to itself. Hence the locus is of the same shape, whether viewed from the one side or the other. But, since it is also of the same shape all along, it satisfies Leibnitz's definition of a straight line; and it is, in fact, a geodesic line of the surface.

Hence we have this second proposition, that all points in the surface opposite to a given point lie in a straight line.

From the method of its construction, this straight line is further from the given point than any other line in the surface. Travelling from the given point as a centre, in whatever direction we might set out, we should, after completing half our journey, arrive at this furthest straight line, we should cross it at right angles, and we should then keep getting nearer and nearer to our starting point, until we finally reached it from the opposite side.

Each separate point in the surface, moreover, has a separate furthest line. For if any two points be taken, the points opposite to them on the straight line which joins them will be distinct. Hence their furthest lines will cut this joining line in two separate points. They must, therefore, be two *separate* lines, for the same straight line cannot cut another straight line in two separate points. In a similar manner it may be shown that each straight line in the surface has a separate furthest point. Hence there exists a reciprocal relation between the points and straight lines of the surface,—a relation which we may express by saying that every point in the surface has a *polar*, and that every straight line in the surface has a *pole*. It is then easy to show that when a point is made to move along a straight line, its polar will turn about a point, and that when a straight line is made to turn about a point, its pole will move along a straight line.

It is interesting to compare these propositions with the corresponding ones in spherical geometry. There, too, each point has a furthest geodesic line, that is to say, a geodesic line which is further from it than any other geodesic line on the sphere, but each geodesic line has *two* furthest points, or poles, instead of having only one. Hence there is not that perfect reciprocity of relationship between points and geodesic lines which exists in the surface we have been examining; and this is one of the many ways in which the sphere shows itself to be inferior to that surface in simplicity.

The most astounding fact I have elicited in connection with this surface is one which comes out in the theory of the circle. Defining a circle as the locus of points equi-distant from a given point, we shall find that it assumes a very extraordinary shape when its radius is at all nearly equal to half the entire length of a straight line. For, let us again figure to ourselves a number of straight lines radiating from a point. Let l be the total length of each straight line. Then, the supposition that we have to make is, that the radius of our circle shall be nearly equal to $\frac{l}{2}$. Let us suppose it equal to $\frac{l}{2} - m$, where m is small as compared with l. Each of the radiating lines will cut the circle in two points, and each of these points will be at a distance from O equal to $\frac{l}{2}-m$, or $\frac{l}{2}+m$, according as the distance is measured in the one direction or the other. And their distance from each other will be equal to $2m$, that is to say, it will be comparatively small. But each point on the polar of O will be at a distance from O equal to $\frac{l}{2}$. Hence each point on the circle will be at a distance from this polar equal to m. Moreover, every point at a distance of m from the polar will be a point on the circle, because it will be at a distance of $\frac{l}{2}-m$ from O. But the locus of points at a distance of m from the straight line A, B, will consist of two branches, C, D, and E, F, one on either side of A, B, and at the same distance from it, along their whole length. It is true that these branches form in reality a single continuous line. A point travelling along from C to D, and further in the same direction, would ultimately appear at E, travel along to F, and then, after a further journey, reappear at the point C. But this does not alter the fact that when a small portion only of this line is contemplated, it presents the appearance of two straight lines, each of them parallel to, and equi-distant from A, B.

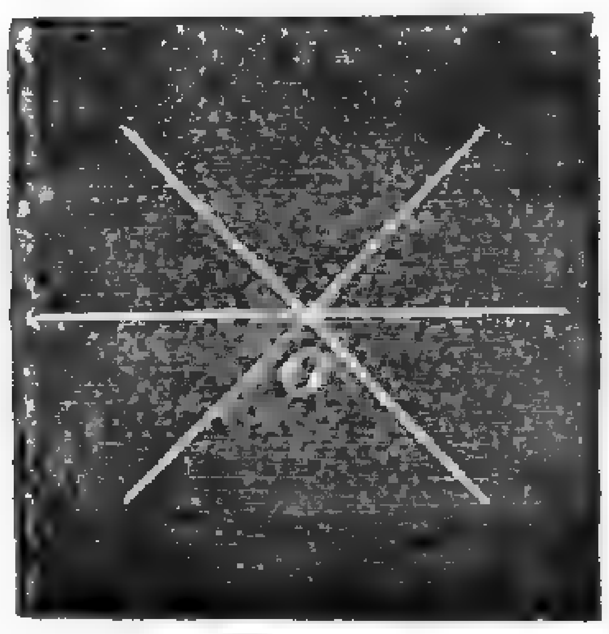


Fig. 2.

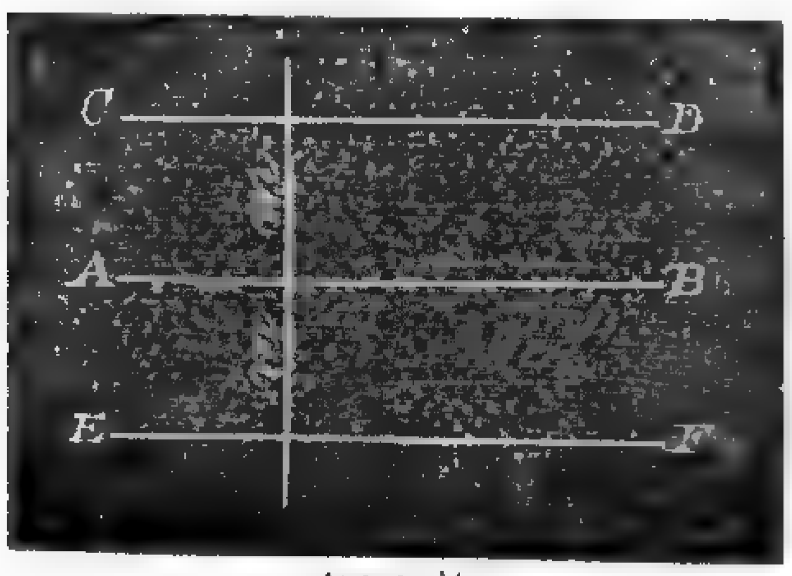


Fig. 3.

In the limiting case, where the radius becomes equal to $\frac{l}{2}$, C, D, and E, F, both of them coincide with A, B. The circle merges into a straight line, and becomes, in fact, the polar of its own centre. It is not, indeed, quite accurate to say that it merges into a straight line, for it reduces itself, rather to two coincident straight lines, and its equation in co-ordinate geometry would be one of the second degree.

In regard to the surface here treated of, it is easy to see that, as with the sphere, the smaller the portion of it we bring under our consideration, the more nearly its properties approach to those of the plane. Indeed, if we consider an area that is very small as compared with the total area of the surface, its properties will not differ sensibly from those of the plane. And on this ground it has been argued that the universe may in reality be of finite extent, and that each of its geodesic lines may return into itself, provided only that its total magnitude be very great as compared with any magnitude which we can bring under our observation.

In conclusion, I cannot do better than quote to you the passage in which Professor Clifford explains what must be the constitution of space, if this hypothesis should be true:—"In this case," he says, "the universe, as known, is again a valid conception; for the extent of space is a finite number of cubic miles. And this comes about in a curious way. If you were to start in any direction whatever, and move in that direction in a perfect straight line according to the definition of Leibnitz; after travelling a most prodigious distance, to which the parallactic unit—200,000 times the diameter of the earth's orbit—would be only a few steps, you would arrive at—this place. Only, if you had started upwards, you would appear from below. Now, one of two things would be true: either, when you had got half way on your journey, you came to a place that is opposite to this, and which you must have gone through, whatever direction you started in; or else, all paths you could have taken diverge entirely from each other till they meet again at this place. In the former case, every two straight lines in a plane meet in two points; in the latter, they meet only in one. Upon this supposition of a positive curvature, the whole of geometry is far more complete and interesting; the principle of duality, instead of half breaking down over metric relations, applies to all propositions, without exception. In fact, I do not mind confessing that I, personally, have often found relief from the dreary infinities of homaloidal space in the consoling hope that, after all, this other may be the true state of things."

Art. XXV.—*Further Notes on Moa Remains.* By C. H. Robson. With Plates.

[*Read before the Wellington Philosophical Institute, 24th February, 1877.*]

A great deal has been said and written to prove that the Moa was hunted and eaten by the present race of Maoris, and the reverse. Some of the papers, however, read before this Society during the last year, quite settle that question; proving beyond a doubt that the Moa-hunters were Maoris, such as we see about us at the present time. There is another point of some interest as yet unsettled, namely, what tribes hunted the Moa, and how they hunted him. I hope to be able to show who were the Moa-hunters in the vicinity of Cape Campbell. In a paper * read before this Society, about a year ago, on some Moa remains found near and on the Cape, I stated that up to that time I had not discovered any traces of Moa-hunters. I was afterwards fortunate enough to come upon some of their old ovens, so near the sea that it is probable that others have been washed away. Those which remain are situated on the sand-bar between Lake Grassmere and the sea, near some ponds, and only a few yards from high-water mark. All the Moa bones found in these ovens were very much broken, and were chiefly leg bones of various kinds. I did not meet with a single head or sternum, and only a few vertebræ and parts of pelves. There were,

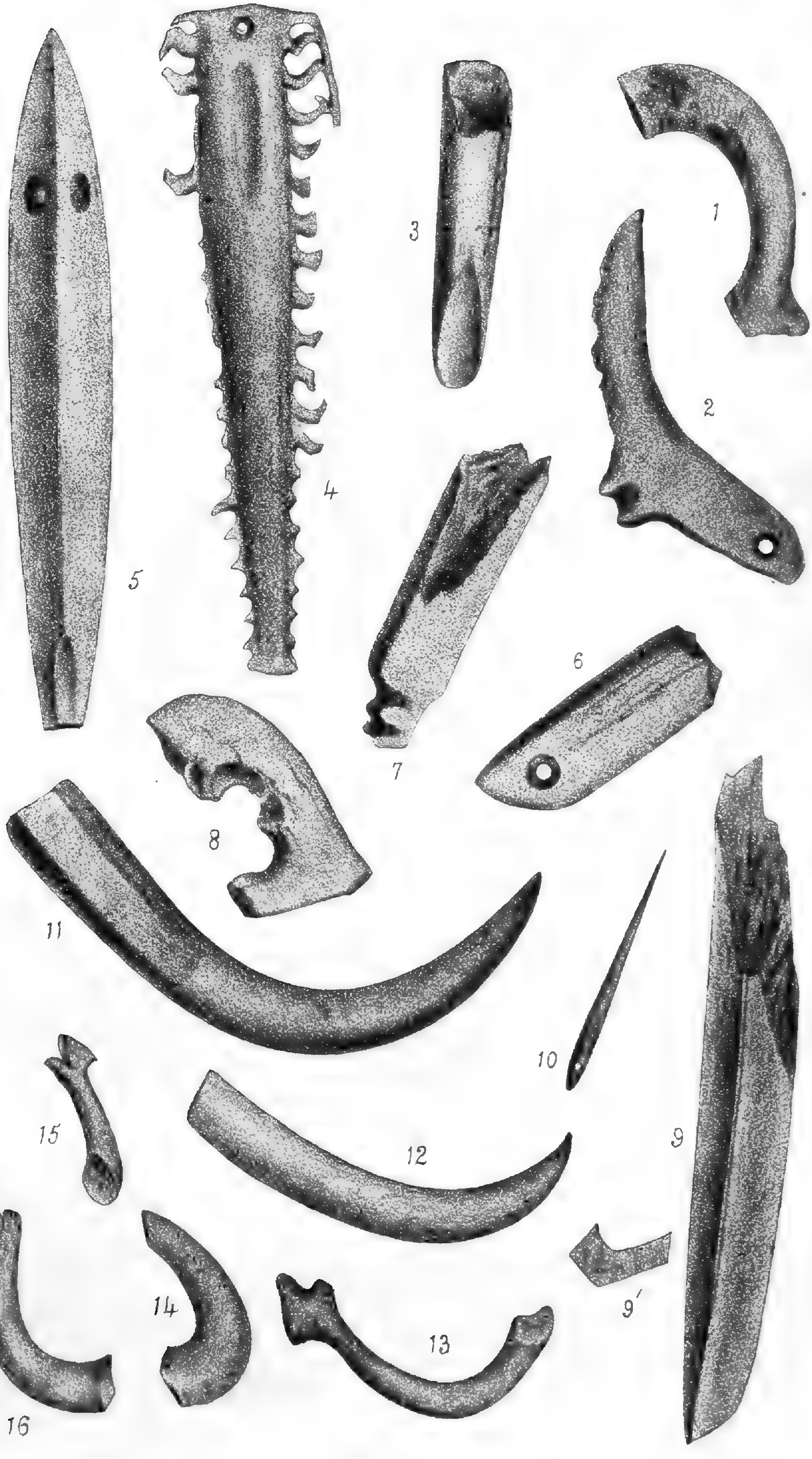
* "Trans., N.Z. Inst.," Vol. VIII., p. 95.

however, a considerable number of pieces of burned bone, and a quantity of bone earth, or ashes, so that it is probable that bones were often used for fuel. Mixed with the Moa bones were bones of the seal and dog, as well as a large quantity of fish bones, with *pipi* and other shells, and a few human bones; and, lying about in all directions, but near the ovens, were parts of bone fish-hooks, stone net-sinkers, needles of bone and stone, flakes of obsidian and flint, and stone adzes of various kinds. Examples of all of these are shown in the drawings, by Mr. Hamilton, which illustrate this paper; and it is to be observed that amongst them there is not a single bit of greenstone. From this omission I am led to believe that the Natives who here hunted the Moa were not acquainted with it. They were, no doubt, the first human inhabitants of the place, and were a *hapu* of the Ngatimamoe, who had worked their way down the coast from the Pelorus Sound, where, I am told, they first landed. After a time, they were either driven off or succeeded by the Ngatikahungunu, who were not Moa-hunters, and were in turn expelled by the Ngatitoa, under Te Rauparaha and other chiefs. These latter tribes had settlements all along the beach, from Lake Grassmere to Cape Campbell; and must at one time have lived there in considerable numbers. They also fought many battles along this part of the coast. Upon making an examination of their old cooking and camping places, I found a good number of stone tools of various kinds; many of them being of greenstone, and intended for a variety of purposes; and all of them are, as a rule, of much higher finish than those found with the remains of the Moa. Several of them were used for carving in wood; and an old Maori, named Kelly, living at Port Gore, near the Pelorus Sound, explained the uses of most of them to one of my sons a few months ago. Some of them are now, I believe, exceedingly rare, the Natives having ceased to make any since they became acqainted with the use of steel tools, and all are interesting, as serving to illustrate a chapter in New Zealand history now fast drawing to its conclusion.

Art. XXVI.—*Notes on the system of Survey proposed by Mr. Thomson to be adopted for New Zealand, from a Legal point of View.* By W. T. L. Travers, Esq., F.L.S., Barrister Supreme Court.

[*Read before the Wellington Philosophical Society, 24th February, 1877.*]

The paper read by Mr. Thomson before this society in September last, in which he seeks to justify his adoption of the "Meridian Circuit system of Minor Triangulation," used by him in Otago, as the system best adapted for use in the survey of the waste lands of the Colony at large, is one which requires close criticism, not only at the hands of those who are more imme-



To illustrate Paper by C. H. Robson.

J.B. del. et lith.

diately connected with the surveys of the waste lands, but also at the hands of those who are engaged in the business of conveyancing; and, as I differ from the views of the Surveyor-General on the expediency of adopting the system in question, I propose—premising that my own knowledge of the practice of surveying is limited,—to offer a few remarks upon his paper, with the view of eliciting further discussion.

It is unnecessary that I should dwell upon the necessity of accuracy in the description of the "parcels" in conveyances of land. For, not merely lawyers, but almost every intelligent person who has had any practical acquaintance with our system of dealing with land as a marketable property, is more or less aware of the difficulties which result from errors on this point. Indeed our law books are full of cases arising out of such errors, and no warning is more strongly held out to the student of the art of conveyancing, than that of taking the greatest possible care in regard to the description of the property to be conveyed. The importance of this point is fully recognized in connection with the system of dealing with land under the Land Transfer Acts in force in this Colony; in which mere verbal descriptions are, as much as possible avoided, in favour of reference to plans prepared by duly qualified and certificated surveyors. And the certainty that before many years have passed, all the land in the Colony belonging to private individuals will be brought within the provisions of these Acts, renders it imperative that the most reliable system of surveying known to science should be used in connection with alienations by the Crown, as well as with subsequent subdivisions of the land so alienated.

Now, it will be remembered that, in 1874, Major Palmer, a surveyor of great eminence, and who happened at the time to be in the Colony in connection with the observations of the transit of Venus, was requested by the General Government to examine and report upon the existing surveys of the Colony, and as to the best means of getting rid of the serious difficulties which were then known to exist in connection with them. Major Palmer undertook the duty, and, in April 1875, presented to the Government a most valuable report on the subject referred to him; in which he pointed out the causes and extent of error which had been committed,—involving, as he showed, the waste of enormous sums of money,—and recommended a course for the future, which would, in his opinion, not only remedy the errors already existing, but also provide, at a very moderate cost, for the completion of such trigonometrical surveys as would ensure the proper degree of accuracy in the ordinary sectional surveys. In dealing with the subject referred to him, he first gave a sketch of the history of each of the surveys then being carried on in the Colony, and an opinion of its worth; and then proceeded to point out the best means of remedying the existing difficulties, and of setting on foot a sound general system. First in order, he referred to the surveys which had been made for the General Government, and which were then under the direction of Mr. T. Heale, Inspector of Surveys, comprising surveys for the use of the Native Lands Court, surveys of Confiscated lands for sale, and surveys of blocks of land to be purchased from the Natives; and, after a most careful examination of all these surveys, which then extended over more than seven millions of acres of land, he came to the following conclusions:—

1. That, as regards lands surveyed for the purposes of the Native Lands Court, the area of which was,—

In Auckland	2,330,760	acres,
,, Hawke Bay	1,124,000	,,
,, Wellington	1,235,027	,,
,, Canterbury	21,769	,,
Making a total of ...	4,711,556	,,

but little, if any, had been done with such accuracy and detail as would enable it to form part of a general cadastral survey.

2. That, as regards the surveys of confiscated lands (the area of which was about 1,916,000 acres), none were good; and that those in the Waikato were as bad as bad could be,—done mostly by contract, years ago; plotted to all kinds of compass meridians; unchecked and unconnected. But, nevertheless, the greater part of those lands had been granted by the Crown on the basis of those worthless surveys.

3. That, with regard to the surveys of blocks of land acquired from the Natives, the survey consisted simply of a periphery traverse of the boundaries of any block about to be purchased.

It is due to Mr. Heale to state, that he was in no degree responsible for the mass of error referred to by Major Palmer, and was then engaged in rectifying the matter as far as possible, and Major Palmer points out that if a sound system be introduced, and made the basis of land transfers, possession and documentary titles might gradually be brought into harmony, as required, without any special active provision for the purpose. He then proceeds to consider the various Provincial surveys, commencing with those on the North Island, and, first, with those of Auckland. The area supposed to have been surveyed under the direction of the Provincial Government was about 2,400,000 acres; and he tells us that the history of these surveys is one of lamentable confusion and neglect, and want of system and accuracy. He says,—

"A block having been thrown open, selectors were allowed to take up sections, usually rectangular, anywhere within it, not less than eighty acres in extent, and to have them surveyed by men of their own choosing. The section surveys were most of them made by contract, with compass and chain; and they were seldom inspected or tested. As a single section might be taken up anywhere in a block, and as there was no obligation on the surveyor to connect his work with previous surveys, or with boundary lines, or with any fixed points whatever, it often happened that the whereabouts of a section could only be guessed at, until in course of time the intervening areas became filled up, and a sort of connection formed. The results of this miserable system may be easily imagined—constant errors of survey in the first instance, leading, in the way I have already described, to overlaps and discrepancies between the maps and the ground, to a fair prospect of having to do much of the work over again, and to the certainty of a rich future crop of trouble, expense, and litigation. It is almost incredible that such a reckless mode of dealing with the lands should have been allowed to prevail for a single week, yet it did prevail for two years without any attempt at improvement, and under it large areas were sold and granted."

He next deals with the Hawke Bay surveys, extending over some 3,050,000 acres of land; and of these he says, that the work, though a little better than that in Auckland, had very many inaccuracies and shortcomings. And he points out that, although, for reasons which he gives, no great legal difficulties had yet arisen, yet the errors were sufficiently large and many to create a good deal of trouble, inconvenience and public distrust: and to prejudice the working of the Transfer Acts in a manner which had already caused bitter complaint.

He then passes to Wellington, and commences by stating that there was no occasion for him to enter at any length into the history of the early surveys in that Province, because the old mistakes had been, to a great extent reduced within the last ten years, by a more enlightened process of survey. He adds that the inheritance of blunders and chaos to which Mr. Jackson, the then Chief Surveyor of the Province had succeeded, on taking office in 1865, had been gradually swept away under a system of trigonometrical survey; and was then so far reduced that more than two-thirds of the sold and granted lands in the Province had been laid out and mapped within small limits of error, and might be brought, at any time, under the operation of the Land Transfer Acts without further trouble. In view of this opinion, it is unnecessary for me to call attention to the causes and extent of error which existed in the surveys of this Province before the department came under the charge of Mr. Jackson; but a perusal of Major Palmer's report will convince any one of the importance and value of the system adopted by Mr. Jackson, and of the excellence of the work done by him.

Of Taranaki, Major Palmer says, "The old work is valueless for further use; many of the field-books are missing, and for miles together no original survey marks can be found." And it appears that, of a total of 2,137,000 acres, 10,000 only are correctly section-surveyed; 130,000 are section-surveyed, but need revision; and 1,997,000 acres are practically unsurveyed.

Passing to the South Island, we find the same confusion to exist in the surveys of Nelson and Marlborough; and Major Palmer says, after pointing out the wretched condition of things in the former Province, that "most fortunately, whether from indifference, or despair, or fear of expense on the part of landowners, no serious legal difficulties had yet resulted." Major Palmer was doubtless unaware that several expensive lawsuits had already taken place in that Province with reference to disputed boundaries, and that nothing short of the impossibility of procuring any proper definition of boundaries had prevented further litigation; landowners preferring, in many cases, to submit to considerable encroachments rather than plunge into litigation the issues of which were doubtful. Of Canterbury, Major Palmer says:—

"While in Auckland and some other Provinces one chief cause of the difficulties which beset the early land sales under the principle of selection before section survey was that they often had absolutely no topographical map with any pretension to accuracy as a basis to work upon; in Canterbury, on the other hand, we have the case of large areas having been triangulated and topographically mapped for purposes of land selection, with a certain show of accuracy, yet so carelessly, in reality, that but little good was gained; error and confusion of the usual types were introduced at the very outset, in spite of a large expenditure of money, and have never since been thoroughly eradicated."

After pointing out the nature and extent of the errors he refers to, and the evils which necessarily flow from original bad surveys, and other causes affecting the accuracy of Crown grants, he adds that "puzzling questions of disputed or defective title, and of overlaps and surplusage are for ever cropping up for decision by the Crown Commissioners, or the Registrar-General of land, and that Government incurs the risk of having to pay large sums of money as compensation for erroneous grants."

Coming to Otago Major Palmer remarks that fortunately for that Province its chief surveyor had not been cramped in means for carrying on the work under his control, and he tells us that Mr. Thomson established, in 1861, a uniform system of surveying, which, if not highly scientific or scrupulously exact, was simple and practical, and not likely to introduce inordinate errors or distortions. He then proceeds to give a sketch of this system, to which I need not refer, inasmuch as it forms the subject of the elaborate paper * read by Mr. Thomson before this society. Major Palmer remarks of the work done by Mr. Thomson, that it might be considered fairly accurate, showing that *as an expedient* for promoting rapid and correct land sales and preventing waste it had answered well; but Major Palmer does not recommend the adoption of this system as a general one throughout the colony, and, indeed, whilst giving credit for the skill and care with which it was carried on, he treats it only as an expedient for promoting rapid settlement in a country exibiting the natural features and resources of Otago.

On the contrary Major Palmer distinctly points to a different system as being necessary in order to remedy the serious mischiefs which have already resulted and must continue to result from the defects in the existing surveys over a large tract of the Colony, and to make careful provision for the future.

"On this point," he says, "it is in my opinion perfectly clear that, whatever be the means introduced for systematizing and carrying on future detail surveys and revising old ones, the basis of all such reform must be a general triangulation of the Colony. In support of this view there could, perhaps, be no more convincing proof than this—that nearly all of the really good work hitherto done is that which has been founded on triangulation. That nothing short of trigonometrical survey will produce accurate estate maps of extensive areas is an axiom familiar to every educated surveyor; and in New Zealand accuracy is of special importance, from the responsibilities incurred in granting land, from the preponderance of undefined section boundaries, and from the scattered nature of the surveys. Triangulation, moreover, is cheap, because it insures the desired accuracy and saves the cutting of lines; the country is favourable for it; the old difficulties of native interference and want of roads are fast disappearing; it has been urged by the conference of Chief Surveyors, and by successive Secretaries and Registrars-General of Crown lands. Lastly, Government have already signified their assent to the principle, by taking a preliminary vote for this very purpose."

It is important, moreover, to bear in mind, in connection with observations contained in Mr. Thomson's paper as to the relative cost of money and time required for completing the surveys of the Colony under his system, and that recommended by Major Palmer, that the latter estimates the total cost at £100,000, and the time at ten years only—figures which differ materially from those suggested by Mr. Thomson, and which, so far as I am able to judge, are much more reasonable.

It will have been observed that in the foregoing remarks I have relied

* "Trans. N. Z. Inst.," *ante*, p. 96.

largely on the report of Major Palmer as an authority in connection with the system of survey to be used throughout the Colony, and I have had no hesitation in doing so, not merely because that report has emanated from a gentleman whose knowledge upon the subject under discussion is admittedly profound, but also because his views coincide with those of several surveyors in this Colony, whose opinions on the matter are entitled to the highest respect. I now propose, with some diffidence, however, to offer a few remarks on the adaptability of Mr. Thomson's system to the Colony as a whole, and to discuss it in comparison with that suggested by Major Palmer.

It is necessary to premise that where a country practically admits of the bearings of all its sectional lines being run by the theodolite in the open, and also of nearly all those lines being chained, a method of survey may be adopted which would not be applicable where neither of these operations can be performed, and therefore that a system might fairly be used as an expedient for the rapid settlement of an open and moderately hilly country which would in no degree answer for a country of a different aspect.

Now those portions of Otago which have been surveyed under Mr. Thomson's system consist chiefly of open and undulating or moderately hilly lands, the process of surveying which is easy as compared to that of surveying the densely wooded and broken tracts which, for the most part, prevail in other parts of the Colony, and especially in the North Island. Otago, therefore, does not furnish for the purposes of a system of survey, either as regards cost or accuracy, a fair example of what can be accomplished for New Zealand as a whole.

Let me call attention, in the first place, to the probable ratio of error between the meridian circuit system of minor triangulation of three-mile sides executed with five-inch theodolites divided to minutes of arc, and a major triangulation of twelve to fifteen-mile sides, with eight or ten-inch theodolites divided to ten seconds of arc. This ratio is quoted by Mr. Thomson as two links to one link per mile only in favour of the better class of instrument and higher standard of execution.

Now I apprehend that the limit of the measuring power of a theodolite may be said to be represented by the degree of accuracy with which an observation can be read with it. Thus all measures of an angle taken between two objects with a five-inch theodolite divided to minutes of arc only, might result in giving the same whole minute of reading. The accordance of such observations is, therefore, not conclusive as infallible evidence of their accuracy. On the other hand a similar number of observations with an eight or ten-inch theodolite between the same objects would result in actually showing discrepancies of ten seconds between the single observations, because in this latter case we have approached more closely the limits of our measuring powers, and have therefore become sensible of the discrepancies of the observations. Here, however, the discrepancies themselves are *prima faciæ* evidence of the angle observed being subject to an error of ten seconds only, whereas in that taken with the five-inch theodolite the amount of error could not be relied upon as being within one minute. In both instances they may be called errors produced from *constant* causes.

The inference from these remarks is that the ratio of error of work performed by the two classes of instruments is as six links to one link per mile. I am informed, that remarkably enough, in practice the errors disclosed by the two class of triangulations bear out this theory. That taking, for example, the partial check afforded by the sides of triangles which combine into polygonal figures and comparing common sides, it is found that the computations derived from the eight or ten inch theodolite give consistent results with an average accuracy of a half link per mile, while those due to five-inch theodolites average three links.

The above figures cannot, however, be taken as representing the *actual* errors committed by each class of instrument. They serve only to show that the *ratio* of error is in the proportion of six links to one link per mile. The *actual* error of triangulation with eight or ten-inch theodolites, as exhibited by closing its sides on *measured* verification bases at intervals of 60 miles or so, amounts, I am told, to one foot per mile, and this large increase may easily be accounted for from various causes, such as errors arising from tremors of the telescope produced by wind, from anomalous changes in the atmosphere, from anomalous contraction and expansion of the parts of the instrument used, and from an accumulating tendency to error in the triangulation itself. Indeed, an accumulating tendency to error is obvious, and must proceed in arithmetical progression according to the number of triangles extended from the measured base line. It therefore follows that the risk of an accumulating tendency to error increases as the extent of country to be triangulated over without check. It was in order to avoid this that the engineers who conducted the great trigonometrical operations of Great Britain and India inaugurated the now received principles of primary, secondary, and minor triangulations, the superior order serving as a check upon the inferior. Thus by carrying each principal series of triangles in a direct course from one measured base line to another in as small a number of stations as possible, the accumulating tendency to error becomes reduced to a minimum.

Thus both theory and practice agree in allotting to triangulated sides of twelve to fifteen miles, with eight or ten inch theodolites, a minimum error of four inches per mile, progressing to a maximum of one foot per mile, when extended for sixty miles or so; and to triangulated sides of three miles, with five-inch theodolites, a minimum error of two feet per mile, progressing to a maximum of six feet per mile, when similarly extended. In this latter case, however, it should be remarked that, on the theory of accumulating errors increasing in proportion to the number of stations triangulated, the maximum error becomes reached by minor triangulation when it has passed over fifteen miles or so. The average error may, therefore, be quoted at four feet per mile or six links, and as this may take either a positive or negative direction, a double error of twelve links per mile might become exhibited by crucial tests. Practical instances might be instanced bearing this out, either when triangulation of this class has been carried on from one measured base line to another about fifteen miles apart, or when the test of secondary triangulation has been applied to it.

Instances have, I am told, occurred, where closing meridian circuits in Otago have exhibited no greater errors than two links per mile; such an accordance, however, cannot be received as conclusive evidence of the consistent accuracy of the measures throughout the circuit, on the ground before stated with regard to five-inch theodolites, namely, the want of sufficient measuring power in its operations. It is only when a higher order of triangulation is placed over it that we should become sensible that the stations of a meridian circuit are more or less dislocated from their assumed positions, by the larger amount of error above quoted.

The practical question to discuss, therefore, resolves itself into this, what limit of error is it desirable not to exceed in the triangulation necessary for checking sectional surveys, the errors of these latter being admitted to far exceed any assigned limit to the triangulation? From the foregoing statements, if the assigned limit of error is to be four feet per mile, with a possible double error of eight feet per mile attached to it, minor triangulation meets the case; if it is to be one foot per mile, involving a double error of two feet per mile, secondary triangulation should be had recourse to in addition; but if greater accuracy is desired, then we must revert to primary triangulation. With regard to the adaptability of minor triangulation with measured bases at intervals twelve miles apart for New Zealand generally, it may be asked how are such operations to be carried on in vast wooded tracts, such as those which occur in many parts of the North Island, such, for example, as the Forty-mile Bush and the Manawatu districts in the Provincial district of Wellington, and others of still greater extent in that of Taranaki? It is clear that in these localities a larger system of triangulation becomes a matter of necessity, from which minor points may become fixed as opportunities present themselves, in order to obtain an accurate system of rectangular co-ordinate distances for the traversed points. I have already shortly alluded to the question of the relative cost of a major triangulation and meridian circuit minor triangulation systems: which, on reference to Mr. Thomson's figures, I find is stated as eight to one in favour of the latter. But it may fairly be asked, even if this were established, whether—inasmuch as the cost of the survey of lands into one hundred acre sections or thereabouts in this Colony varies, as I am told, from 1s. to 3s. per acre before the Crown Grant can safely be issued—the fraction of a penny per acre more or less, which would be spent in securing efficient checks, would materially affect the total cost? Or whether the practice of such economy would possibly compensate for the obvious advantages to be derived from securing the superior check system?

However, in a return furnished to the Conference of Chief Surveyors, in 1873, shewing the total cost of the triangulations executed in the several Provinces of New Zealand up to that date, I find it stated that 6,739,920 acres cost £40,618 to triangulate in Otago; whereas, in Wellington, 2,496,000 acres, of major and minor triangulations combined, cost only £9,800: thus shewing the relative cost to be two to one in favour of Wellington. I give these figures, as furnished in the return, merely as matter of information, and with no desire to disparage, in this aspect of the question, the system pursued in either Province.

It might, moreover, be asked whether astronomically determined latitudes, at intervals of 60 miles, with portable instruments, furnish a sufficient check on the accuracy or otherwise of triangulation. I have made inquiries on this point, and am informed that even the most skilful observers with such instruments will scarcely venture to assert that a latitude could be determined within a probable error of two seconds of arc, or nearly 200 feet of linear measurement; and as this error may take either a positive or negative direction, it may be concluded that, under the most favourable circumstances, there would be a possible error of 400 feet in a distance of 60 miles, or nearly seven feet per mile. A reliable check could only be expected by this method under similar conditions when the two stations are at very large distances apart, for the probable error would not thereby be increased, whilst the error per mile would be reduced in proportion to the greater distance of the stations; so that, for the reasons above given, this method could only be relied upon for checking triangulated distances when the stations are very far apart. Electric differences of longitude, measured with the portable transit instrument, are asserted by competent authorities to be liable to an error of one second of time, or equivalent to 1,150 feet in this latitude.

It will probably have appeared to my hearers, at the first blush, that the objections I have already urged against the adoption of Mr. Thomson's system, are objections rather from a surveyor's point of view than from a lawyer's; but a more careful consideration of the matter will, I think, lead them to the inference, that, in the main, objections taken from the one must apply with equal force to the other. In a former part of this paper I pointed out the importance which lawyers, engaged in conveyancing, attach to accuracy in the description of the property to be dealt with, and I now propose shortly to sketch the origin of our system of conveyancing with the view of shewing the tendency of improvement in this particular direction, and the special necessity for such improvement if the system, established under the Land Transfer Acts, is to become a satisfactory reality.

I have always personally advocated the adoption of cheap and simple modes of dealing with landed property, but I have also deprecated interference with these questions on the part of untrained men. Changes of law and system in matters of such moment ought not lightly to be made, and, when made, ought to be attended with all the safeguards against error which the widest experience can bring to bear upon them. Now, although I am quite alive to the advantages which the community may reap from the adoption of the principle involved in the Land Transfer Acts, I cannot shut my eyes to the fact—and I do not hesitate in saying that all the officers engaged in administering those Acts will concur with me in opinion—that, as now in operation in this Colony, they are ill-constructed and embarrassing, and are sure to produce an abundant crop of litigation. If my watch is out of order, I do not take it to a tinker for repairs; and I see little difference between this case and that of a layman attempting to make amendments in a highly technical branch of law, with which he has no acquaintance whatever, beyond the possible accident of having purchased a few acres of land. Our system of dealing with land is one of very long growth, but although, in the remarks I am about to make, I shall have to go back many centuries in time, I do not propose to make them very wearisome.

Our Anglo-Saxon ancestors, who were ignorant of the art of writing, conveyed their property from one to another in open *folkmoot*, by means of visible signs and symbols, which awakened attention, and ensured that the memory of the transaction should remain with the *Witan*, who were called together by the "*Mot-bel*" to witness and record it. Many curious instances of alienation by symbol are to be found, collected by Selden, Palgrave, and others, but the symbols themselves appear to have varied with the whim of the donor, and not to have been reduced to any particular system. In like manner, we find that, amongst the Jews, when a purchase was effected, the party "plucked off his shoe, and gave it to his neighbour, as a testimony in Israel." But the delivery of the symbol was always accompanied by another ceremony, that of naming and recording the bounds of the property alienated, for its position and boundaries were as much matters for proof by oral evidence as the fact of alienation itself. It will be remembered by those who have read Mr. John White's instructive lectures on the manners and customs of the New Zealanders, that the boundaries of tribal lands were carefully handed down from father to son. And we find even amongst the deeds of cession to the Europeans, that the boundaries of the lands conveyed are described by reference to such ancient land-marks.

Antiquarians have found it impossible to ascertain, with any degree of precision, when the Anglo-Saxons began to use written forms of conveyance. It has been stated that the first written conveyance was one made by Withredus, King of Kent, in 694; and, as declared by the charter itself, was appointed to be kept at Canterbury, as a form for posterity to imitate. But, at whatever time these charters were first employed, they did not displace the use of symbols, which were continued long after the Norman Conquest, and have been partially used even to this day.

When land was conveyed by a written instrument it was called *boc-land*, and the instrument itself corresponded to the "*libellus de terra*" of the Continental conveyancers, and the "possession-boke" of the ancient Jews. Sometimes the general body of the charter is in Latin, and the description of the land in Saxon, and sometimes the whole is in Latin.

"The Saxon conveyances," says Turner, "consisted principally of these things: The grantor's name and title are stated. Next, a recital of title, or of some circumstances leading to the gift. Then the conveying words, and the name of the donee. Next, the consideration for the gift. Then the premises are mentioned, which are usually very shortly described by their measured or estimated quantity of land, and the name of the place where they are situated. The nature of the tenure, and the services from which the land is liberated, and those to which it is to continue subject, are then stated; after which follow the date, signature, and attestation."

It will be seen how closely this resembles the forms still in use; but, to whatever age in the history of conveyancying we look, we find that the greatest care was taken that the property dealt with should be capable of strict definition.

In former days, however, alienations were not frequent, and private sub-divisions of land still less so; and, indeed, it is only of late years that the practice of dealing with land has attained the enormous extent to which it now prevails. In this colony, the sub-division and ownership of land already obtain to a very great extent; and daily experience shows the importance of accuracy in the definition of boundaries. I have no hesitation in saying, that but for the exercise of the greatest forbearance, and that natural unwillingness which exists to embark in litigation with a neighbour, the Courts of this Colony might be fully employed from one year's end to another in cases of disputed boundaries. In the larger towns, the settlement of such questions is daily assuming a more difficult aspect, owing chiefly to the extraordinary increase in the value of property; and I have already known instances in which a claim for a couple of feet of ground, originally valued at a few shillings, has caused an expenditure of hundreds of pounds, when the value had increased from £20 to £50 a foot. It is familiar knowledge, moreover, to those who are acquainted with the state of the surveys in the rural districts of this Provincial district, for example, that in numberless instances, the boundaries of adjoining properties, for which grants had been issued, over-lapped to the extent of a chain and upwards, the later occupant being usually the loser in such cases, and being advised to submit to his loss rather than attempt to remedy it by the expensive and uncertain course of a lawsuit. In the course of my own practice I have had occasion to advise in dozens of such cases, and I cannot therefore but look with concern upon the probable introduction of a system of surveys which is calculated, as I conceive, to maintain the continuance of evils, which were being rapidly and satisfactorily got rid of, under the more accurate and enlightened system which it is intended to displace. But the public are even more concerned than the lawyers in such a matter, and if it be desired that the "Land Transfer" system shall produce its best fruits they ought to insist upon the adoption of the most effectual and scientific system of surveys, as that alone which is likely to produce such fruits. Under that system, as I have before observed, written descriptions are as much avoided as possible, reference to an accurate plan having already proved itself to be of very great value in simplifying and cheapening dealings. This fact alone justifies me in offering objections to any system of survey which is not founded on a sound scientific basis, and which is opposed to the practice and recommendations of writers of authority on such matters. It is a rule in societies such as that which I am now addressing not to discuss political questions, but the complete enforcement of such a rule would necessarily exclude even such a paper as this, which was, of course, never intended. It is not even, as I conceive, a violation of that rule on my part to observe that those who are engaged in the work of administering the Government of the Colony, ought not to permit experiments to be made in matters of vital importance to the community; and that when they are in possession of, and have in effect adopted, the well-considered views of an eminent man upon any matter under their control, more especially when those views are in accordance with systems used in countries of advanced civilization, they are bound to give effect to those views, in preference to any mere expedient, however practical, unless circumstances of a very exceptional character happen to justify its temporary adoption.

ART. XXVII.—*On Anemometry.* By CHARLES ROUS MARTEN, F.R.G.S., F.M.S., M.Sc.M.S.

[Read before the Wellington Philosophical Society, February 24th, 1877.]

1. ANEMOMETRY—the science of measuring wind-force—is a branch of Meteorology which always has attracted much attention, and engaged much inventive ingenuity. The practical advantage, as well as the scientific interest attaching to a knowledge, first, of the actual dynamical force of the wind in severe gales, as experienced in the past, and therefore likely to be sustained in the future; and, second, of the comparative wind-force in different localities, have produced various methods of estimating and comparing that force.

2. Hence we observe a two-fold aim in Anemometry: first, to gauge the actual pressure of the wind on a given vertical plane area; second, to compare its average force as felt in various places. Thus, it is obvious that both accuracy and uniformity are essential.

3. Unfortunately the result of all the efforts in this direction up to the present time is so unsatisfactory that Anemometry would appear to be wholly indefinite and untrustworthy so far as any approach to scientific exactness is concerned. I regret to say that after many years' careful study and comparison of anemometrical observations, I have been unable to arrive at any other conclusion, than that the instruments and formulæ, now in use, not only fail to give an accurate register either of the pressure or the velocity of the wind, but also utterly lack the essential qualification of comparability.

4. The strength of the wind is measured chiefly by three methods: first, by estimating its relative force, either in words, such as "light," "fresh,"

"strong," "a gale," or in figures, as by the scale introduced in 1805, by the late Admiral Sir Frederick Beaufort, and still known by his name—other scales of relative force have been tried, but none have maintained so permanent a hold and extensive a use as the Beaufort scale of 0–12–; secondly, by gauging the pressure in pounds on a plate one foot square, which, acting on a spring, enables the actual apparent pressure to be registered by a simple mechanical contrivance (this is the principle of Osler's anemometer); thirdly, by measuring the velocity of the wind in miles per hour, with an instrument known as Dr. Robinson's anemometer—to be described later.

5. All attempts to reconcile the results of these three methods, so as to institute any trustworthy comparison, have proved futile. And here I would observe that it is necessary to bear in mind the distinction between force, pressure, and velocity, in the following comparisons. The primary object is to ascertain the wind's *force*, but (excepting the rough guess-work *relative* force, estimated by the Beaufort scale,) this is obtained from deductions from the recorded pressure, or velocity, or both. In fact, the modern practice is to observe the velocity by instrument; thence to calculate the pressure, and from that to deduce the relative dynamical force exerted. The Osler anemometer, on the whole, is so unsatisfactory, both from the difficulty of estimating the mean pressure registered by it, and from the liability of its machinery to get out of order, that I fully agree with the Director of the English Meteorological Office, Mr. R. H. Scott, who says in his paper on the subject, "I am convinced that meteorologists on the whole have acted rightly in preferring velocity to pressure as a mode of registering the action of the wind." Taking, then, velocity, as our standard of comparison, we find that 49 miles per hour is described by Denham as a "great storm;" while, in the Beaufort scale, as translated into velocities by the Meteorological Office, that velocity only represents force 8, or what is called a "fresh gale;" and the maximum force, 12, is stated to represent a "furious hurricane," which is estimated as having a velocity of 85 miles per hour. The result has been rather absurd, for, as anemometers have recorded a velocity of over 100 miles per hour, it has been found necessary in describing the wind's force by the Beaufort scale to add extra numbers, up to 14, or two degrees beyond the wind's greatest possible force! This obvious absurdity caused a re-arrangement of the tables, and the force 12 was made to represent a velocity of 100 miles per hour by anemometer. Even this, however, did not meet the difficulty, for I myself, have registered velocities of 107 and 109 miles per hour: 120 miles has been registered at Holyhead and Liverpool; and in the recent storm at Sydney the observer there recorded the hitherto unprecedented speed of 153 miles per hour

6. Thus, practically, we may dismiss the estimated-relative-force system as a very rough-and-ready and a thoroughly unscientific and non-comparable mode of anemometry. It remains to be seen whether the scientific systems be more accurate.

7. It has been stated already that the most generally received method is by measuring velocity, and that the instrument used for that purpose is Dr. Robinson's anemometer. To make comprehensible what is to follow, a brief description of this instrument is necessary.

8. It consists of four hemispherical equi-distant cups, forming the terminations of as many arms, disposed horizontally, in the shape of a cross, and revolving on an axis, the cups being so placed that the concavity of one and the convexity of another are always exposed to the full force of the wind, simultaneously acting on their diametrical planes. The revolutions are numbered and recorded by a simple and ingenious mechanism, which it is unnecessary to explain.

9. The circumference of the circle described by the cups in each revolution, and the number of revolutions made in a given time, being known, it is easy to calculate the distance travelled by the cups in such given time. Dr. Robinson calculated that from the resistance offered by the convex cup on the one side, the force of the wind on the concave one on the other side, would be only sufficient to propel it at one-third of the wind's velocity, and that this rule was irrespective of the diameter of the cups, or the length of the arms. His calculations are given in Vol. XXII. of the "Transactions of the Royal Irish Academy." His mode of testing his original anemometer was by fixing it on a pole eleven feet in length, attached to a locomotive engine, which was driven a measured distance, in calm weather, on the Dublin and Kingston Railway, at various speeds, ranging up to nearly 70 miles per hour, the anemometer thus being pressed against the wind, instead of the wind pressing against the anemometer. The distance run by the engine being known, it was only necessary to compare it with the number of revolutions made by the cups, and the consequent comparative distance they had travelled. The result was that they were found always to have travelled one-third of the distance run by the engine; and this "irrespective of their diameter or of the length of the arms." This went to confirm the theory Dr. Robinson had formed on the subject; but it is noteworthy that he apparently regarded that coincidence as somewhat fortuitous. Nevertheless, its correctness has been sustained by many subsequent experiments, including those made in Greenwich Park by Mr. Glaisher, who, testing the instruments at various velocities and under differing conditions, always found the result to corroborate the inventor's theory.

10. I may state here that I entirely accept that result *so far as it goes*, viz., as establishing the rule that, the cups once fairly under way, the centres will travel at about one-third the wind's velocity, *so long as a steady rate of speed is maintained*, but no longer.

11. It will be perceived that this last qualification implies a most serious possibility of error, inasmuch as the wind's velocity varies almost every moment; however, I am inclined to believe that a really good anemometer will give a very fair *mean* velocity for a lengthened period, such as 12 or 24 hours, or in other words that it will indicate with tolerable faithfulness the total horizontal movement of the air during such periods. This, although not fulfilling the first of our two postulated anemometrical desiderata, as will be shown shortly, would suffice for the second, viz., comparison of the average wind-force experienced in various localities, provided the anemometrical records be themselves intercomparable. Let us now examine whether this be the case.

12. In the year 1871, I made a series of experiments at the Southland Observatory, with the view of ascertaining whether three of Dr. Robinson's anemometers gave approximately identical results, in order that, should this prove to be the case, I might place them in as many different localities to obtain comparative records of wind-force. Of these instruments two were the ordinary double-indexed single-dial anemometers by Casella, with cups three inches in diameter, and registering to 505 miles, and the third was an improved five-dial instrument by Negretti and Zambra, with cups four inches in diameter, and registering to 1,000 miles. A single week's trial sufficed to prove all comparison hopeless. The three instruments were exposed in a precisely similar way, and their individual positions were interchanged. Nevertheless, their records varied so widely as to be simply ridiculous and unworthy of preservation; accordingly, I relinquished my plan of comparing the respective local wind-forces, and adopted the Negretti anemometer, being apparently the most trustworthy, as my standard. As an instance of the variety in the records of these three instruments, I may mention that in one of my 24 hours' observations, when the Negretti anemometer indicated 517 miles, one of the Casella instruments indicated 370, and the other 283 miles. So much for my own personal experience.

13. About the same time, similar but more elaborate experiments were being carried on in England, on behalf of the Meteorological Society, by Mr. Fenwick Stowe, and by Mr. Robert Scott, the Director of the Meteorological Office. Both have published the results. Mr. Stowe's were the most extended observations, and I extract the main conclusions at which he arrived. No fewer than ten anemometers were thus tested, Nos. 1, 2, and 3 being the same as in my experiment; No. 4, one by Adie, with four-inch brass

cups and moderately short arms; No. 5, ditto, with arms only two inches in length; No. 6, ditto, with nine-inch arms; No. 7, ditto, but with eighteen inch arms and large elliptical cups; No. 8, ditto, but with very light *tin* cups and arms; No 9, ditto, but the cups conical instead of hemispherical; and No. 10, a large standard anemometer, with copper cups nine inches in diameter, as recommended by Dr. Robinson. Omitting the intermediate results, which progress by tolerably uniform degrees from minimum to maximum difference, the respective results at the highest and lowest velocities observed were as follows :—

No.	—	At Lowest velocity. Miles.	At Highest Velocity. Miles.	Range of Velocities at which tested. In Miles per Hour.
1	Casella's	833	762	3—35
2 & 3	Negretti's	1,041	748	3—38
4	Adie's	1,120	750	4—30
5	" Short arms	810	619	11—35
6	" Long arms	856	822	7—40
7	" Longer arms and elliptical cups	915	850	9—18
8	" Light tin cups, 2½in. deep	840	568	5—30
9	" " " conical cups, 4in. deep ..	none	661	—41
10	Kew standard, 9in. cups	1,000	1,000	—

On this discouraging result Mr. Stowe remarks,—

"It will at once be seen that the results of these experiments are, in the case of every instrument tried, utterly irreconcilable with Dr. Robinson's dictum, that the centre of each cup travels at one-third of the rate at which the wind moves, and that *this law is irrespective of the size of the cups or the length of the arms.* Anemometers with short arms do *not* agree even approximately with the standard, excepting at low velocities; but there is this peculiarity, that, while those which have the smallest cups relatively to the length of arm, maintain at all velocities a tolerably even percentage of the motion of the standard, those on the contrary which have large cups and arms move at a high relative speed in very light airs, but fall actually below the others when the wind is high. If the standard be assumed correct, the cups of most of the small instruments move through a space scarcely more than one-fourth of that passed over by the wind. Of course it may be asked—which is correct? I do not know with what instruments Dr. Robinson's experiments were made; but I assume that, as he adopted and recommended the adoption of large anemometers, they ought to be taken as a standard, at least till they are proved incorrect, about the probability of which even I have no means of forming an opinion. Only as our confidence has been rather rudely shaken in one respect, we, perhaps, need re-assuring that the relation between the wind and the cups is not equally mythical."

14. The results of these experiments, which are corroborated by those of Mr. Robert Scott, Mr. Glaisher, and Mr. Charles Cator, appear almost conclusively to dispose of the question—whether our present anemometrical returns be intercomparable for the purposes of climatology, by answering that question most decidedly in the negative. I may add that the observations taken at the various New Zealand observatories during the past ten years exhibit such striking and inexplicable discrepancies as strongly to support this unfavourable view.

15. We now arrive at the second point on which anemometry is supposed to furnish us with information, namely, the force of the wind in heavy gales. We seek to ascertain the dynamical force exerted by the horizontal movement of the air on a vertical plane surface, such force to be expressed in pounds of pressure on each square foot of the said surface. It is accepted as an axiom in meteorology that the velocity and pressure of the wind are correlative, and this correlation has been variously formulated. The formula now most generally accepted is that given by Sir Henry James, which is that the pressure in pounds on the square foot equals the square of the velocity in miles per hour multiplied by ·005; or, expressed algebraically, if a be the velocity and x the required pressure, then $\frac{a^2}{200} = x$.

16. From this formula it will be perceived that the relation of velocity to pressure proceeds with increasing velocities by a peculiar mode of progression. The theory when investigated gives some rather remarkable results. For instance, at a velocity of 20 miles per hour, or what is considered a "fresh" breeze, the pressure is 2 pounds per square foot, but at a velocity of 40 miles the pressure is 8 pounds. So at 50 miles the pressure is 12·5 pounds; at 100 miles 50 pounds; at 150 miles, 112·5 pounds. At 200 miles, could such a velocity be attained, the pressure would be 200 pounds; at 400 miles, 800 pounds; and at 1,000 miles, 5,000 pounds. Thus by this formula when the velocity is doubled the pressure is quadrupled. Such at least is the accepted theory.

17. It is true that other tables of relation between anemometric velocity and pressure have been constructed, but apparently they are founded merely on the concurrent records of Robinson's and Osler's anemometers, and not on any definite mathematical theory or investigation of the principle involved. For example, one author represents a force of 9 pounds as equal to a velocity of 49 miles, which he describes as "a great storm." Another describes similarly a velocity of 74 miles, which he gives as equivalent to a pressure of 21 pounds. In a third work a "most violent hurricane" is represented by a velocity of 107 miles, and a pressure of 46 pounds. A fourth describes a pressure and velocity of respectively 49 pounds and 110 miles, as "a hurricane, tearing up trees and throwing down buildings"; while a fifth

gives a much higher force even than this apparent maximum, viz., 58 pounds and 120 miles.

18. It will be necessary to bear in mind these records of wind-force for the purpose of the comparison now about to be made; but as they are obviously deduced from no distinct formulæ, it is needless to analyze the mode of their construction or the theories on which they are based.

19. Let us see now how these estimates of wind-force agree with others made during various severe storms. During the Madras cyclone of 2nd May, 1872, the maximum velocity recorded at the Madras Observatory was 53 miles per hour (14 pounds on the square foot). It happened that Captain Donkin, of the ship "*Inverness*," who was in this cyclone, was caught, six months later, in the English Channel, in the sudden and violent storm of 22nd November. On learning this, the Director of the Meteorological Office wrote to Captain Donkin, asking him whether the force of the Channel gale had been at all equal to that felt during the Madras cyclone. Captain Donkin replied:—"It is my opinion that for two hours only, at Madras, did it blow harder." In each case the force of the wind was recorded as 12 in the ship's log; and the velocity of the Channel gale at the nearest observatory to the ship's position—Falmouth, was 57 miles per hour (16 pounds), or much about the same as at Madras; but, as 70 miles an hour often had been recorded at Falmouth, it was plain that a serious discrepancy existed somewhere. As already mentioned, 36 pounds once was deemed the maximum pressure attainable; and anemometers frequently succumb at even less pressure, as in the great storm of 15th October, 1868, in Southland, when my anemometer yielded to a force of 35 pounds. It began to be found that a 40-pounds pressure often was recorded in hard gales, as at Glasgow, on 24th January, 1868, when 42 pounds was indicated. At the Liverpool and Holyhead observatories pressures of 50 to 60 pounds gradually began to be accepted, and then 70 or even 80 pounds; while at the Bidston observatory, on 9th March, 1871, a pressure of 90 pounds was recorded. In Mr. Blandford's paper on the climate of Bengal, published in the "Proceedings of the Asiatic Society," it is stated that the highest pressure ever registered in Calcutta was 50 pounds; but that was in a storm of no remarkable violence, and one which did but little injury. In the far more severe storms of 2nd November, 1867 and 5th October, 1864, the anemometer was blown way at 36 pounds. The greatest force I ever recorded was in Southland, on 23rd December, 1871, when, in one gust, the Negretti anememeter registered a velocity of 160 feet per second; equal to 109 miles per hour, or nearly 60 pounds on the square foot, and in another gust, 107 miles, or 57 pounds.

20. All these records, however, are completely eclipsed by the results

given by the anemometer at Sydney, during the recent great storm, when the amazing velocity of 153 miles per hour, equivalent to a pressure of 117 pounds on the square foot was registered; being the highest ever yet recorded in any country; while several times during that storm a pressure of 112 pounds was indicated.

21. To appreciate the real meaning of such a tremendous pressure, the following illustration of its practical effect may be given:—A plate-glass window three feet square, a very common size, would receive a blow of 1,053 pounds, or nearly half a ton. A sheet of plate-glass such as those of several shop windows in this city, viz., ten feet by five, would have to sustain a *blow* (not a steady pressure, be it remembered,) of nearly 6,000 pounds, or almost three tons; while the side of a building 50 feet long and 40 feet high—no extraordinary dimensions—would receive a lateral blow of 234,000 pounds, or more than 100 tons.

22. Such would have been the dynamical power of the wind, if (1) its velocity were really that indicated by the anemometer on the occasion referred to; and (2) if that velocity actually represented the pressure deduced by the accepted formula.

23. This latter point I do not purpose to investigate in the present paper, but I shall endeavour on a future occasion to show that there is good reason to doubt the correctness of the accepted ratio of wind-velocity to pressure.

24. I now proceed to explain why I do not believe that the actual velocity of the wind, on the occasions of these extraordinary records being obtained, was that apparently indicated by the anemometer.

25. In the first place, let it be clearly understood that the only point actually recordable by the anemometer is the number of revolutions made by its cups. From this datum simple multiplication gives the distance travelled by the cups. The accepted formula is, that a second multiplication by 3 gives the distance travelled by the wind. Hence, in the Sydney storm, when the apparent velocity of the wind was 153 miles, the actual self-recorded speed of the cups was 51 miles, and the triple velocity was deduced on the adopted ratio of 3–1. But is this ratio applicable to all conditions of the wind, to steady or unsteady breezes, to zephyrs or gales, to increasing or decreasing forces, or to sudden gusts or lulls? If a dead calm were followed by a gust, would the cups at once revolve at full speed in spite of their *vis inertiæ?* Or again, if a gale were suddenly succeeded by a calm, would the cups, at one instant revolving so rapidly, in the next moment become motionless? The reply is obvious: they would not. In the latter hypothetical case, the cups would continue to revolve by momentum at least for several seconds. Proceeding further, suppose the cups

to be revolving at a speed of 20 miles, being propelled by a 60-mile breeze, and that, in a sudden gust, the actual velocity of the wind was increased to 90 miles: would the speed of the cups be augmented only by one-third of the added velocity,—*i.e.*, 10 miles per hour? Clearly, if the cups moved at the same rate as the wind, no possible increase of wind-velocity, superadded to any degree of initial velocity and momentum, could drive them faster than the propelling power. But, as they only move at one-third the speed of the latter, is it not conceivable that successive augmentations of the propelling power, superadded successively to the initial velocity and its attendant momentum, may raise the actual speed of the cups at least to a rate considerably more than one-third of that of the wind?

26. My theory may be illustrated thus: Suppose the wind to be travelling at the rate of 60 miles per hour, and suddenly to fall calm, or, which would amount to the same thing, to be shut off suddenly from the anemometer. In such a case, it would be found that, notwithstanding (1) the resistance of the atmosphere, which at first would be equal to an opposing wind of nearly 20 miles an hour force, (2) the resistance of friction, and (3) the absence of any propelling power, the cups would revolve by momentum at a gradually decreasing velocity for upwards of a minute, in which period they would have travelled perhaps half a mile without the aid of any propelling power but momentum. On the other hand, although, if a dead calm were followed suddenly by a 60 miles-an-hour gust, the cups would not start instantly into full velocity, being retarded by *vis inertiæ*, yet this retardation would be almost inappreciable. Repeated experiments proved to me that a well made anemometer will take considerably less than a second to attain its full velocity, and in fact the cups catch the wind's force so quickly that I found it impossible to arrive at any definite appreciable allowance to be made for *vis inertiæ*. As, too, the best made instrument is that in which the resistance of friction is reduced to the minimum, it follows that the anemometer which is the quickest in attaining full velocity will be the slowest in parting with that velocity. Thus a 9-inch Kew standard instrument or a 4-inch Negretti and Zambra, owing to their delicate construction and admirable balance, will be found—once set in motion—to retain that motion for a much longer period of time than would be imagined by any one who had not actually tried the experiment.

27. Now let us take another case. Suppose the wind to be strong but squally and unsteady—blowing generally at a speed of 30 miles per hour, and consequently propelling the cups at the rate of ten miles per hour. Next suppose a sudden gust of five seconds' duration to blow at exactly double that strength, or 60 miles per hour, what velocity would be indicated by the anemometer? The theory hitherto has been that the increase in

velocity being merely relative to the previous speed, the motion of the cups would be accelerated only by one-third of that additional wind-velocity, and that their rate of travelling would be $\frac{30}{3} + \frac{30}{3} = \frac{60}{3} = 20$.

28. But from careful observation and experiment I am convinced that this formula is not strictly accurate; that, inasmuch as the cups already are travelling at a speed of ten miles per hour, instead of being at rest, their real velocity in a sudden gust of double strength would be $\frac{60}{3}$, *plus* momentum, *minus* some indefinite amount to be deducted for the resistance of *vis inertiæ*—which would be exceedingly small in such a case—and for the gradual loss of momentum velocity, which also would be very trifling in so brief a space of time. Hence if my theory be correct, the cups in this hypothetical case would travel at a velocity of nearly 30 miles an hour for those few seconds, or almost half the actual speed of the wind, and I can conceive of cases where several successive and rapidly following augmentations of wind-velocity might cause the cups to travel at very nearly the same velocity as the wind. This of course could only be for a few seconds, and under a most exceptional continuation of contributing causes, for after those first few seconds the cups soon would settle down to their ordinary relative velocity. The occurrence, however, of a modified form of the above-mentioned hypothetical case would suffice to account for some of the marvellous statements of the force supposed to have been exerted by sudden gusts, that force being deduced on the ratio of $\frac{a2}{200} = x$, x representing the required force, and a the velocity, as ascertained by multiplying the speed of the cups by 3.

29. Take, for instance, the great Sydney storm, already quoted in this paper. When the anemometer cups were travelling at the rate of 51 miles per hour, the accepted formula bade the observer record the wind's velocity as 153 miles an hour; but if my hypothesis be correct, the wind's velocity on that occasion may not have been more than 100 miles an hour, or perhaps even less. And supposing that the precise case suggested had occurred, of a suddenly doubled velocity, the theoretical speed of the wind, when the cups were travelling at 51 miles per hour, would be about 102 miles—probably somewhat less, which would represent a pressure of 52 pounds on the square foot instead of 117 pounds as calculated—a most material difference.

30. Now let us see what light Mr. Fenwick Stowe's experiments throw on the problem. Under my theory the heavier and larger the cups the greater the velocity they should indicate at the higher speed, as compared with lighter ones, for the simple reason that the greater weight necessarily would imply greater momentum. Reference to the table already quoted answers this question in a most decided and unmistakeable manner. It

will be seen that the lighter the cups the smaller their comparative velocities at higher speeds, the lightest of all—that with very thin cups of tin—indicating little more than half the velocity registered by the large Kew instrument at the highest speed compared. It is curious that Mr. Fenwick Stowe did not see the conclusion to which this result of his experiments pointed, but it must be remembered that his object was not that of the present paper, but simply a comparison between large and small anemometers, with the view of ascertaining which were the more trustworthy instruments at different velocities, and in these tests the large Kew anemometer always was adopted as the standard of comparison, without any attempt to ascertain whether it might not be, under certain conditions, the less trustworthy of the two. The probability of an excessive amount of atmospheric horizontal movement being registered (by momentum) in case of calms succeeding gusts is noted, but not the other aspect of the case—the possibility of this occurring also with sudden increases of wind force.

31. One explanation has been suggested of the extraordinary pressure exerted by sudden gusts, as indicated by an Osler (pressure) anemometer, but not by the continuous self-registering Robinson (velocity) instrument. It is that such abnormal force may be exerted only in narrow columns of air—in gusts perpaps only a few yards, feet, or even inches in breadth, as is seen sometimes in the case of tropical hurricanes. That such non-uniformity in the wind pressure does exist is unquestionable. Evidence of this may be seen in every gale that blows across our harbour, whose waters frequently are "streaked," as it were, with narrow gusts of excessive violence, which seem actually to tear up the water as they rush over it, yet are often only a few feet in breadth, or even less. Such gusts possibly might strike the concave cups of the anemometer, while the convex cups, less than two feet distant, might be in a comparative calm. Such an occurrence would account for unduly high anemometrical readings, but the probability is rather a remote one.

32. This non-uniformity of pressure—this "streakiness," if I may use the expression—of the wind it is important to consider from another point of view, the one only alluded to in passing in an earlier part of this paper, viz., the possibility of the accepted ratio between anemometric velocity and pressure not being so strictly accurate as is generally supposed to be the case. Of course were the atmosphere a solid body of uniform density, moving with uniform velocity, the dynamical force exerted by its impact on a vertical plane surface of given area always must be in proportion to that velocity. But this is not the case; indeed, the reality is almost the reverse of this supposition. The wind rushes forward in a number of irregular darts or tongues, often curling about in curves and eddies, seldom if ever

striking any plane surface at a fair right angle, but exhibiting infinitely more irregularity in its course than even a body of water; how easily that may be deflected it is needless to state, the fact is obvious to any one who has watched the current of a tide or river. This attribute of water is, *à fortiori*, that of the more elastic fluid—air—and hence it is that I think it open to grave doubt whether, even if we grant that the wind may move at the immense velocity asserted, it really exerts that dynamical pressure, on a given plane area, which, *cæteris paribus*, we should be led from such velocity to predicate.

This paper already has exceeded due limit as to length, and I must defer the further investigation of the subject to a second paper.

Art. XXVIII.—*Elements of Mathematics.* By James Adams, B.A.

[*Read before the Auckland Institute, 4th September, 1876.*]

When Peter the Great determined to rouse his subjects to the active life and business habits of the people of England and Prussia, he began by removing impediments. He wished his people to become skilful workmen and mechanics; and it was evident that the Russian of his time, with his long flowing robe and his pendulous beard, could not work at the forge or the bench. To remedy this, Peter stationed men at the city gates, each armed with a pair of shears, who cut off the long skirts and sacred beard of all those who passed through the gates.

This was the first step in giving them a mechanical education, and the effect he produced, in raising his people to the level of other European nations, has always been a subject of admiration.

A similar course was adopted, in the matter of education, after the French Revolution; when the School Commissioners dismissed, in a summary manner, the teachers of the schools and colleges, and flung after them, so to speak, the golden legends, controversial treatises, Aristotle's Ethics, and Euclid's Elements; not that they felt no reverence for these books, but because a new era had arrived, when practical knowledge had taken the place of speculative, and when it was of paramount inportance that the students should reach, by the shortest and plainest route, the wide range of learning that was now for the first time opened to the human mind.

The object of education to their mind was to study the nature of things, with the view of adding to the comfort and happiness of man, and not to learn to dispute in the argumentative manner of ancient philosophers.

They confessed their inability to comprehend how that acumen of intellect could lead to the *summum bonum*—

> "Which could distinguish and divide
> A hair 'twixt south and south-west side."

It was fully believed by the supporters of the old system, that such a change would banish learning from the earth, and that, like Orpheus, it would be torn to pieces by the Bacchanalians. But as no such consummation took place—but, on the contrary, that literature, and science, and art flourished with renewed vigour—the denunciations ceased, and similar changes in the school system were adopted in other countries. England, since that time, has been slowly making changes. Greek and Latin verses are not now composed with the same assiduity as formerly. The rules of the Latin Grammar are written in English; the *as in presenti* is not so commonly learned, and many other changes have been grudgingly made with the view of cutting off the non-essential, and thus affording more time for the pupils to study physical science and mathematics.

The English have not followed the example of the French in discarding Euclid's Elements, but, on the contrary, they have made it a standard text-book for those who intend to study the higher mathematics. And an admirable book it is, as it contains the summary of what was known of mathematics during that brilliant period of history, when Ptolemy Soter ruled Egypt; and not only so, but geometry cannot be known without the proof of Euclid's propositions. But, that it should be absolutely necessary to use Euclid's own words in the proofs, now that the range of mathematics is so much wider and the aim so different, is open to grave doubt.

The difficulty a pupil experiences in entering on the study of geometry is great enough, by his having for the first time to form conceptions of quantities of two dimensions without adding any unnecessary obstacle. The actual work he ought to accomplish is quite enough without leading him to it by a most circuitous route. This work may be thus arranged:—

First, to calculate areas from line measurements.

Second, to calculate areas and distances by means of measured lines and angles.

The third step takes in the additional element of force, but the object is still to determine some point or points in space. This embraces the usual mathematical course for secondary schools, namely—mensuration, trigonometry, and mixed mathematics.

It is evident that, in order to learn the first, mathematically, the pupil must solve a great many geometrical problems, understand the principles on which constructions are obtained, and acquire the method of calculation. But as all this leads to a definite object, he learns only what he shall absolutely require, and of which he must constantly make use.

Now, it is thought necessary for a boy to know, at least, two books of Euclid before he can properly commence to survey with the chain alone, and as Euclid, like an ancient philosopher, is speculative rather than practical in his propositions, the abstract relations of magnitudes are alone regarded, and none of the particular or general terms used in calculation are at all mentioned. The result is that, after a pupil has mastered the two books, he cannot, of himself, discover anything in them relating to calculation of areas. And besides, his attention has been directed to the demonstration alone, and the essential part of construction is left to his own invention. Euclid's long proofs and admirable chains of reasoning are not put to practice after the books are read, for, in actual questions, the proofs are written in the algebraic form.

Again, it is found that some of Euclid's propositions are made unnecessarily difficult, some of them are self-evident, and none of them expressed in modern mathematical language.

Take, as an example, the fifth in the first book, called the *pons asinorum*, which is a real barrier to many learners, and was at one time the limit to geometrical studies for the generality at the universities. Now this proposition can be proved like the fourth by super-position, so that the dullest can at once comprehend it; but, as teachers must conform to Euclid and Euclid alone, two weeks of school life, allowing two hours a-week for geometry, must be spent before the *most intelligent* boys can comprehend it.

The name that this fifth proposition has obtained shows the vast number who have failed to pursue the study of mathematics owing to their inability to see the proof veiled, as it is, in Euclid's drapery of words.

The eighth proposition is another stumbling-block, owing to the indirect method, although the theorem can be far more easily proved directly, and at the same time render the seventh proposition unnecessary. The thirteenth proposition really needs no proof, and for this very reason boys find great difficulty in writing down or saying Euclid's proof for it; and such instances can be multiplied.

It is nothing new to be aware of the faults in Euclid's Elements, but the range of mathematics and physical science was so limited until the eighteenth century, that the time might be spared for Euclid's proofs, as there was little more to learn.

We know what took place when Euclid undertook to teach Ptolemy Soter. After that the latter had learned the definitions, many of which are more difficult than the things defined—had passed safely through the postulates and axioms, and arrived, as we may suppose, at the *pons asinorum*—the King asked him if there was no easier method. Euclid gave the reply so often repeated, "There is no royal road to geometry." I think I may venture to say that there are excellent navigators, surveyors, and engineers, who could not prove this proposition in Euclid's manner; and if there was no shorter method we should not have attained to our present knowledge of mathematics.

For the second step in geometry, namely, to commence the study of trigonometry, it is usual to learn six books of Euclid. This means four years at least of careful teaching in a secondary school; for, as our primary schools are, as a rule, of a most inferior description, nearly all the elementary work must be done in the secondary schools. Four years are spent before the pupil enters on the study of mathematics in such a form as to induce him to pursue the study after leaving school. Now, after these books are mastered, the pupil finds that he has not learned the language of trigonometry, nor the method of the proofs.

It is as if he had learned Latin in order to speak French. He will have acquired such terms as *invertendo*, *convertendo*, *ex æquali*, and *ex æquo*, duplicate and triplicate ratios; but not a word of *sines* and *cosines*, nor even the relative values, in general terms, of the sides of a triangle to each other, nor of the side of a regular figure inscribed in a circle to the diameter. The abstract proofs of Euclid confuse rather than clear his understanding, when he has to calculate areas and distances by general or by concrete values. The natural order of instruction is the concrete first, then the general, and last of all the abstract; but in teaching mathematics we reverse the order. Let anyone who knows Euclid's Elements, as now read commence Plane Trigonometry, and I feel sure he will be astounded at the little preparation he has made. He will find that the work of the modern mathematician is with definite values, and with every variety of new problems, of which the construction must be found, and moreover that the proof is in the algebraic form, quite regardless of Euclid's language.

When it is considered that every branch of mathematics has its own language or terminology—and this is the real difficulty in trigonometry, conic sections, mechanics, hydrostatics, and every other subject—what is more reasonable than to dispense with Euclid's language, which does not apply to our modern methods of calculation? If we had a text book, with the single definite object of preparing pupils to enter on the study of trigonometry, there would be a great deal of valuable time saved. Nor is there any fear of speculative geometry dying out, as those with only a taste for mathematics are too prone to it, but in the greater mathematicians it amounts almost to a disease. Mathematical proofs cannot be otherwise than rigid, whether we use the modern or the ancient method. But to solve a problem by the analytic method, and then write out the proof in the synthetic is exactly what Macaulay charges Samuel Johnson with doing, namely, first writing in English and then translating into Johnsonese.

The object of mathematics is calculation, and they become extended just in proportion as the method of calculation is improved.

Now it is worth while to consider the facilities that existed for calculation in Euclid's time, and for many hundred years afterwards. Arithmetic, as we now know it, was then in its infancy. In fact, the seventh, eighth, and ninth books of Euclid's Elements are devoted to this important subject; but Euclid has written with such obscurity that his most devoted worshippers do not insist upon our reading these books. The clumsy symbols that were employed effectually hindered progress, and no one but a philosopher could multiply fractions. It would repay the trouble to work out a few sums in the Greek method, which continued to be employed until the so-called Arabic symbols and method were introduced from the east. Fractions, that enter so largely into our arithmetical calculations, have not been long properly understood. Killand and Tait, in their preface to Quaternious, give a curious instance of the conceptions entertained of them in the sixteenth century. At the present time we can solve all questions by them, and thus dispense with the so-called rules of arithmetic. In fact arithmetic cannot be taught as a branch of mathematics, unless by the aid of fractions, which enable us to keep the whole question before the mind at the same time. But Euclid had no such method of expressing the ideas in his learned head, and so he expressed them in the best manner he could. Where he speaks of multiples we use fractions, and his equality of ratios are with us equality of fractions. Duplicate, compound, and triplicate ratios lose their learned and formidable appearance when we employ fractions.

It is scarcely credible that Euclid would have devoted so many words to prove propositions if he had our concise method of recording results. If, for instance, we know that the area of a triangle is half the product of the base by the perpendicular, we must see that, when the perpendicular is constant, the areas of triangles vary as the length of the bases. Yet we know what scaffolding Euclid has erected in order to prove this self-evident proposition, and his proof is most difficult for learners to fully comprehend. As an example of the contrast between the modern mode of proof and Euclid's, the nineteenth proposition of the sixth book may be taken. It is required to prove that "similar triangles are to each other in the duplicate ratio of their homologous sides." Most of us, in thinking over the proof in the Elements, will remember the number of anxious students who could not understand the proof, but a little progress in algebra makes them reason thus:—Since the triangles $a\ b\ c$ and $a'\ b'\ c'$ are similar, the perpendiculars (p and p') on the sides b and b' from the vertical angles will divide the triangles into others which are respectively similar. Then $\frac{a}{b} = \frac{a'}{b'}$ and also $\frac{a}{p} = \frac{a'}{p'}$. Multiply these equal fractions and $\frac{a^2}{bp} = \frac{a'^2}{b'p'}$ or $\frac{a^2}{a'^2} = \frac{\frac{1}{2}bp}{\frac{1}{2}b'p'}$.

Thus the areas of similar triangles vary as the squares of the sides opposite the equal angles.

The books of Euclid are read by pupils, as commanded, but as soon as they read the chapter on ratio in the algebra they adopt the algebraic method, because the mind always takes the shortest route to a conclusion, and this appears to be the reason that self-evident propositions present so much difficulty to beginners.

The great fault in Euclid is that the pupil is not allowed to know as much about the proposition as the instructor.

The process by which Euclid arrived at his proof had been known to philosophers at least from the time of Plato. It is called the analytic method in geometrical researches, for by this method the problem is supposed to be solved, and then by comparing the magnitudes under this new aspect, and observing the relation between those given and those sought, a way to solve the problem is discovered. This is algebra as applied to mathematics, and it is the grand method of invention. All the progress made in mathematics during the eighteenth century is owing to it.

Pascal and Roberval made use of it; but when they had solved the problem they wrote out the demonstration in Euclid's synthetic method, and designedly concealed their method of invention.

Sir Isaac Newton did the same thing, not that he desired to hide the method by which he arrived at the solution, for even with this aid mathematics are not very easy, but he considered a proof was unfit for publication unless given after the manner of Euclid, and clothed as far as possible in his language. The following is a quotation from his work on *Fluxions* :—

"*Postquam area alicujus curvæ ita* (analytically) *reperta est et constructa, induganda est demonstratio constructionis ut omisso quatenus fieri potest calculo algebraico theorema fiat concinnum et elegans ac lumen publicum sustinere valeat.*

It appears from this that in such a question as the following taken from Todhunter's Mechanics—"Find the centre of equal like parallel forces acting at seven of the angular points of a cube"—that it is not sufficient to determine the point, which is easily done by supposing the forces to act at all the angular points; but Newton considered such a method unfit to see the light, and that the position of the point must be shown by geometrical construction; and this is often so difficult that the exercise may well commend itself to the great mathematicians as a kind of mental gymnastics. But for a teacher who is anxious to conduct a pupil in the study of mathematics to appoint from whence he can see their value and their beauty, it is most injudicious to perplex the learner's mind with intricate questions which properly belong to the speculative philosopher, and very often also of such a nature that the solution, synthetically, is easily discovered by a more extended knowledge of mathematics.

In spite of the opinion of such a genius as Newton, the algebraic method is adopted of necessity in all mathematical books of a practical nature; and scientific men adopt the same method. But discarded as Euclid's method and language are, for all practical purposes, there still lingers a conviction of their all-sufficiency for school-boys just as Mavor's spelling-book is the *sine quâ non* of primary instruction. Our own University, that should take into account the drawbacks that boys here experience in acquiring details, as they are deprived of the advantages of morning and evening study, which boys at home possess, insists on the very words of Euclid. On the top of the paper on Geometry is printed, "No symbols used to denote algebraic operations are to be employed in this paper." Which appears to mean, "Do not employ the signs used in practical mathematics, but the blessed, blessed words of the great Euclid." There is a great waste of time, as I have already shown, in learning to clothe a geometrical proof in Euclid's cumbrous drapery of words, which is a hindrance in entering on the actual study of mathematics. In fact, boys cannot compete creditably in the mathematical examination fixed by the same University for senior scholarships—if they must first go through so much to learn so little. If it is really intended that boys shall learn mathematics, we ought to have a text book of the *elements of modern* mathematics, and not the elements of the mathematics known 2,200 years ago; or at least the public examiners should require no other propositions than those bearing directly on trigonometry, and the proofs to be expressed in the usual mathematical symbols.

Anyone acquainted with trigonometry will perceive that this change would no more do away with the study of geometry than that the Russians all died from having their coat-tails cut off; but, on the contrary, there would be five mathematicians to one at present.

Euclid's elements properly belong to the department of logic, and to that department the study of them should be confined in our public examinations.

Art. XXIX.—*On some points connected with the Construction of the Bridge over the Grey River at the Brunner Gorge.* By C. H. H. Cook, M.A.; Fell. St. John's Coll., Cam.; Prof. Math., Cant. Coll.

[*Read before the Philosophical Institute of Canterbury, 5th October, 1876.*]

It is not my intention to examine into the cause of the disaster which overtook the suspension bridge at the Brunner Gorge on the morning of the 28th

July last, but to call attention to the most noticeable peculiarity in its construction, and to investigate mathematically the tension on the wire ropes which supported the bridge. In order, however, to make the calculations and other remarks intelligible, it will be desirable to give a short description of the principal points connected with the structure. And here it will be well to state that this information has been derived partly from the Report, recently submitted to the General Assembly, of the Commissioners appointed to inquire into the cause of the accident; partly from direct communications from J. E. FitzGerald, Esq., who was a member of the Commission.

The floor of the bridge was eight feet wide, and on each of its sides it was connected by means of suspending rods with a strong wire rope, or chain, which passed over two piers, each 25 feet high, one on each side of the river; each end of the chain was connected with an anchor-plate of cast iron attached to solid masonry, and intended to be built up with a mass of concrete. I may remark, in passing, that delay in executing this intention was, in the opinion of the Commission, the principal cause of the accident. The distance between the two piers over which the same chain passed was 300 feet; the distance between the two piers on the same side of the river was 30 feet. This width being much greater than the width of the floor of the bridge, 8 feet, it will be seen at once that the chains did not hang in a vertical plane. The lowest points of each chain may, it would seem, be taken to have touched the floor. None of the suspending rods on each side of that central point were vertical; the nearer the rods were to the banks of the river, the more and more did they slope outwards, till the the pair next the piers must have had their upper extremities nearly as far apart as the piers themselves, viz., 30 feet, whilst their lower ones were only eight feet apart. It is this peculiarity of construction which it is my purpose to examine mathematically, with a view of comparing the tension on the chain in this case with what it would have been had the usual method of construction been adopted, viz., that in which each chain as well as the suspending rods connected with it lie in a vertical plane, passing through a pair of piers. The object of this construction was, I believe, to stiffen the bridge.

The bridge was intended to carry, at any one time, only a single truck loaded with coals, and never to have a locomotive upon it. It was estimated, therefore, that the load, in addition to that caused by the weight of the bridge itself, would not exceed ten tons. The weight of the bridge and suspending rods appears to have been 82 tons; the weight of each chain, seven tons; so that the total weight under which the bridge gave way was only 96 tons, no extra load being on it at the time.

The above description is all that is necessary for my purpose. As regards the investigation that ensues, I may remark that it is of the same degree of exactness as that given in treatises on civil engineering as applicable to the more ordinary method of structure. In the first place, I have been compelled to neglect the weight of the chain, because, though it is easy to form the equations of equlibrium when that weight is taken into account, yet they are unintegrable, or, at any rate, I believe so. This is to be the more regretted in this particular instance, because the weight of the chains formed a very appreciable part, rather more than one-seventh, of the total weight; in ordinary cases, of course the weight of the chains is insignificant, compared with that of the bridge, and no sensible error is made, therefore, in leaving their weight out of account. In the next place, I have treated the chains as forming a continuous curve, which is a departure, though a very slight one, from the case which actually occurs. I repeat that these suppositions are those usually made.

For considering the equilibrium of either of the chains, take its lowest point as origin of co-ordinates, the vertical line through that as axis of z; the horizontal line through the same point, and parallel to the length of the bridge as axis of x; a line at right angles to both of them, that is to say, transverse to the bridge, as axis of y. Let w be the weight of a unit of the length of the bridge, T the tension of the rope at any point $(x\ y\ z)$ in it; s the length of the rope measured from the lowest point up to the point $(x\ y\ z)$; $X\ Y\ Z$, the resolved parts, parallel to the axes of co-ordinates, of the forces acting on the element ds in the neighbourhood of $(x\ y\ z)$; then the ordinary equations for equilibrium are:—

$$X - ds \frac{d}{ds}\left(T \frac{dx}{ds}\right) = 0 \quad \ldots \quad (1)$$

$$Y - ds \frac{d}{ds}\left(T \frac{dy}{ds}\right) = 0 \quad \ldots \quad (2)$$

$$Z - ds \frac{d}{ds}\left(T \frac{dz}{ds}\right) = 0 \quad \ldots \quad (3)$$

Since $X = 0$, there being no force in the direction of the axis of x, the first equation gives us at once $T \frac{dx}{ds} = \text{constant} = c$ suppose (4)

If T' be the tension along the suspending rod connected with the point $(x\ y\ z)$ and θ the inclination of that rod to the vertical; then

$$Z = T' \cos\theta;\ Y = T' \sin\theta.$$

But, since there are two rods, one on each side of the bridge, which between them support a length dx of the bridge, therefore resolving vertically,—

$$2\,T' \cos\theta = w dx$$

$$\therefore T' = \frac{w}{2} \sec\theta\, dx$$

$$\therefore Z = \frac{w dx}{2} \qquad Y = \frac{w}{2} \tan\theta\, dx$$

Equations (2) and (3), therefore, become,

$$\frac{d}{ds}\left(T\frac{dy}{ds}\right) - \frac{w}{2}\tan\theta\,\frac{dx}{ds} = 0 \qquad \ldots \qquad (5)$$

$$\frac{d}{ds}\left(T\frac{dz}{ds}\right) - \frac{w}{2}\,\frac{dx}{ds} = 0 \qquad \ldots \qquad (6)$$

The latter of these equations integrates at once, and gives us,—

$$T\frac{dz}{ds} - \frac{wx}{2} = k$$

but, when $x = 0$ we have $\frac{dz}{ds} = 0$, therefore $k = 0$

hence $\quad T\frac{dz}{ds} = \frac{wx}{2}$

But from (4) $\quad T\frac{dx}{ds} = c$

Dividing one equation by the other,—

$$\frac{dz}{dx} = \frac{w}{2c}\cdot x$$

Integrating, and observing that x and z vanish together, we get,—

$$z = \frac{w}{4c}x^2 \qquad \ldots \qquad (7)$$

or, $$x^2 = 4\frac{c}{w}z \qquad \ldots \qquad (8)$$

This is the equation to a parabola, and gives the parabola in which it is well known the chain would hang if everything were in a vertical plane.

To integrate (5), we observe that $\tan\theta = \frac{y}{z}$, substituting this value we obtain,—

$$\frac{d}{ds}\left(T\frac{dy}{ds}\right) - \frac{w}{2}\,\frac{dx}{ds}\cdot\frac{y}{z} = 0$$

But $\quad T\frac{dy}{ds} = T\frac{dy}{dx}\cdot\frac{dx}{ds} = c\frac{dy}{dx}$

and from (7) $\quad \frac{y}{z} = \frac{4cy}{wx^2}$

hence we obtain $\quad c\frac{d}{ds}\left(\frac{dy}{dx}\right) - 2c\frac{y}{x^2}\frac{dx}{ds} = 0$

or $\quad x^2\frac{d^2y}{dx^2} - 2y = 0$

This can be reduced to a linear equation by the well-known substitution of putting $x = e^{\phi}$, and changing the independent variable to ϕ. In this way the complete integral will be if a and b are the constants of integration,

$$y = ax^2 + \frac{b}{x}$$

And since x and y vanish together, b must be zero, hence the last equation reduces to

$$y = ax^2 \qquad \ldots \qquad (9)$$

This equation together with (8) determines the form of the curve in which the chain hangs. The constants a and c, which enter into them, are easily determined from the condition that the chain passes through the top of the pier, whose co-ordinates are, adopting a foot as our unit of length,

$$x = 150,\ y = 11,\ z = 25;\ \text{and } w = \frac{82}{300} = \frac{41}{150}\text{ tons}$$

$$\therefore a = \frac{11}{(150)^2} \cdot c = \frac{1}{4} \times \frac{41}{150} \times \frac{(150)^2}{25} = \frac{123}{2} = \text{tension}$$

at lowest point in tons.

From equations (8) and (9) we deduce

$$\frac{y}{a} - \frac{4c}{w} z = 0 \qquad \ldots \qquad (10)$$

the equation to a plane passing through the axis of x, that is, the straight line joining the feet of the suspending rods. Considering the curve in which the chain hangs, as determined by equation (10) combined with either (8) or (9), we see that the curve is that made by the intersection of the plane (10), with either of the parabolic cylinders (8) or (9), and hence is not only a plane curve, but is a common parabola.

Next to calculate the tension at any point. We have already shown that

$$T \frac{dx}{dx} = c \quad \therefore \quad T = c \frac{ds}{dx}$$

$$\left(\frac{ds}{dx}\right)^2 = 1 + \left(\frac{dy}{dx}\right)^2 + \left(\frac{dz}{dx}\right)^2$$

and

$$\frac{dy}{dx} = 2\,ax = \frac{22x}{(150)^2}$$

$$\frac{dz}{dx} = \frac{w}{2c}\,x = \frac{x}{3 \times 150}$$

By making the necessary substitution it is then easy to find the tension at any point of the chain. At the point where the chain passes over the top of the pier $x = 150$, hence then $\frac{dy}{dx} = \frac{11}{75}$ $\frac{dz}{dx} = \frac{1}{3}$

Therefore the tension at that point is

$$c\sqrt{1 + \frac{1}{9} + \frac{121}{75 \times 75}} = \frac{123}{2}\,\frac{\sqrt{75^2 + 25^2 + 121}}{75} = \frac{41}{50}\sqrt{6371} = 65{\cdot}45 \text{ tons nearly.}$$

The portion of the chain between the top of the pier and the anchor-plate will hang by its weight in a catenary, and the tension at the anchor-plate would be less than that at the top of the pier, by the weight of a piece of the chain equal in length to the vertical height between the two points. But, as we have neglected the weight of the chain all along, we must consider the tension on the anchor-plate to be equal to that at the top of the pier, viz., 65·45 tons.

If the chain and suspending rods had all lain in a vertical plane, equations (1) and (3) of our fundamental equations would have applied, and the chain would have then hung in the parabola whose equation is (8), and the c, which is a constant introduced by integration, would be the same as in the other case. It can be proved, as in the previous case, that the tension on the rope at the top of the pier would be

$$c\sqrt{1 + \frac{1}{9}} = \frac{123}{2} \times \sqrt{\frac{10}{3}} = \frac{41}{2}\sqrt{10}$$

The ratio of the tension in the construction actually adapted to the tension which would have existed had the whole been in a vertical plane, is $\sqrt{\frac{6371}{6250}}$, a fraction whose value will be found, on calculation, to be somewhat less than 1·01. It follows, therefore, that by adopting the construction explained in the foregoing part of this paper, the tension of the chain at the anchor-plate was not increased by more than one per cent.

It might, perhaps, have been legitimate to assume that the chain would lie in a plane curve; and then, by reasoning similar to that used in the more usual case of a suspension bridge, it might easily be proved that the curve would be a parabola. But the method above given is perfectly general, and can readily be applied to the case in which the middle point of the chain is not attached to the floor of the bridge, but is a given height vertically above it, and in which the suspending rods are not in the same plane. Upon examination, the equations of equilibrium will be found to be integrable in this case also.

I now wish to call attention to what appear to me to be serious defects in this bridge.

1. If there should have been any swaying of the bridge from side to side, inasmuch as the supporting chains did not hang in a vertical plane, there would have been a tendency to throw a great deal more than its due share of the burden on one chain. Mr. O'Conor, the District Engineer, says in the memorandum to the Commissioners, which forms Appendix A, attached to this Report:—" On the 24th of the month (three days before the accident) there was a heavy gale blowing down the gorge, which caused the bridge to sway to the extent of about six inches from side to side." In such a case the windward of the two ropes would be unduly tightened, whilst the leeward one would have its tension suddenly diminished. The windward rope therefore would be in a very abnormal state of tension, and if the wind came in sudden and violent gusts, as I believe constantly happens in mountain gorges, the increase in tension of one rope and decrease in the other would be sudden, and might, I conceive, be disastrous to the bridge.

I must mention, however, that it was contemplated to fix cross-braces, which it was expected would counteract the swaying completely, but these had not been fixed on the 24th when the swaying above alluded to was observed, nor do they appear to have been fixed at the time of the accident.

2. Each rope was made up of two sorts of material. The Commissioners' Report says:—" Each chain was to be composed of seven twisted wire ropes four and a half inches in circumference, laid side by side, and above these six other ropes, each made of thirty telegraph wires spliced together but not twisted, placed side by side, the whole united every ten feet by clips, forming a flat chain twelve inches in width, by two inches in depth." Each rope therefore consisted of two portions entirely different from each

other in structure, and doubtless also different in stretching capacity. Change in temperature or the application of sudden strain, such as might be caused by any swaying in the bridge, would tend to throw the whole tension of either of these ropes on to only certain strands of it, and thus the effective strength of the rope might be most seriously reduced.

II.—ZOOLOGY.

Art. XXX.—*Notes on the Tuatara Lizard* (Sphenodon punctatum), *with a description of a supposed new species.*

By Walter L. Buller, C.M.G., Sc.D., President.

[*Read before the Wellington Philosophical Society, 29th July, 1876.*]

The earliest mention of the Tuatara occurs in "Polack's New Zealand" (1838), where it is stated that a gigantic lizard or guana is found in the isles of the Bay of Plenty, and that "the natives relate ogre-killing stories of this reptile.* It was not, however, till five years later that any authentic account was obtained respecting it. This was furnished by Dr. Dieffenbach, the naturalist sent out by the New Zealand Company, who in his "Travels in New Zealand," Vol II. (1843), p. 205, thus announced its discovery :—"I had been apprized of the existence of a large lizard, which the natives called Tuatara or Ngarara, as a general name, and of which they were much afraid. But although looking for it at the places where it was said to be found, and offering great rewards for a specimen, it was only a few days before my departure from New Zealand that I obtained one, which had been caught at a small rocky islet called Karewa, which is about two miles from the coast in the Bay of Plenty. From all that I could gather about this Tuatara, it appears that it was formerly common in the islands ; lived in holes, often in sand-hills near the sea shore, and the natives killed it for food. Owing to this latter cause, and no doubt also to the introduction of pigs, it is now very scarce, and many even of the older residents of the islands have never seen it. The specimen from which the description is taken I had alive, and kept for some time in captivity. It was extremely sluggish, and could be handled without any attempt at resistance or biting." This specimen was presented by the discoverer to the British Museum, where it still is (as Dr. Günther informs us) in the most perfect state of preservation. It was described and figured by Dr. Gray, who recognized it as the type of a distinct genus, referring it to the family of *Agamidæ* and

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* The "monstrous animal of the lizard kind" mentioned in the diary of Mr. Anderson, the companion of Captain Cook, on the authority of the Maori boys who joined the expedition at Queen Charlotte Sound, was no doubt the fabled monster, or Taniwha of the Natives. ("Cook's Third Voyage," 2nd edit., 1785, Vol. I., p. 153.) Native tradition has always ascribed to this mythical dragon the form of a lizard.

naming it *Hatteria punctata*, by which name this lizard has since become generally known. It was lately discovered, however, that a skull of this reptile (whence obtained it is not stated) existed in the museum of the Royal College of Surgeons, to which the generic term *Sphenodon* had previously been applied. The familiar name of *Hatteria punctata* had accordingly to give place to the less barbarous one of *Sphenodon punctatum.*

The anatomy of the Tuatara has been made the subject of a very able and exhaustive memoir by Dr. Günther, published in the "Philosophical Transactions of the Royal Society" (1867). The learned author claims for this New Zealand form, which differs in some important structural characters from every other known Saurian, and in its osteology is the most *bird-like* of existing reptiles, a higher rank than that of a family, and proposes to make it the type of a distinct order of Reptilia, equal in systematic value to the ophidians and crocodilians. He points out that the crocodiles are removed from the lizards into a distinct order or section, on the ground of osteological characters as well as on account of the higher organization of their soft parts; that in *Sphenodon* the modifications of the lacertian skeleton extend to the same parts as in the crocodiles, although they are frequently of a different nature; and that the repetition of lacertian characters in its soft organs is in some measure counterbalanced by the absence of copulatory organs. The presence of a double bar across the temporal region, the intimate and firm connexion of the os quadratum with the skull and pterygoids, the erect ilium, and the uncinate processes of the ribs, are characters by which a tendency towards the crocodilians is manifested; while the affinities of *Sphenodon* with the true lizards are far more numerous and of greater importance, as shewn by the structure of the heart, of the organs of respiration and digestion, the absence of a diaphragm and of peritoneal canals, the transverse anal cleft, the absence of an external ear, the free tongue, etc. Yet to associate it with the lizards would entirely destroy the unity of this natural group; and Dr. Günther, therefore, proposes a modification of Stannius' division of recent Reptilia, adding the characters which distinguish *Sphenodon* from all other known Saurians, and assigning it the position of a third order in the first division *(Squamata)*, under the name of *Rhyncocephalia.*

In his concluding observations, he remarks that the skeleton of the Tuatara—"with its amphicælian vertebræ and abdominal sternum on the one hand, and its highly-developed osseous skull and uncinate apophyses of the ribs on the other—presents a strange combination of elements of high and low organization; and this is the more significant as this peculiar animal occurs in a part of the globe remarkable for the low and scanty development of reptilian life."

For many years after the discovery of the *Sphenodon*, by Dr. Dieffenbach, it was almost unknown in European Museums, although a few more specimens were forwarded to the National Collection by Dr. Knox and Captain Drury; and even as late as 1867, Dr. Günther writes :—" Evidently restricted in its distribution, exposed to easy capture by its sluggish habits, esteemed as food by the natives, pursued by pigs, it is one of the rarest objects in zoological and anatomical collections, and may one day be enumerated among the forms of animal life which had become extinct within the memory of man."

In December, 1851, Dr. Thomson, of the 58th Regiment, and a party of officers, visited the Island of Karewa, in the Bay of Plenty, and, in the course of an hour, collected nearly forty of these lizards of all sizes, the largest being about two feet in length. The island was swarming with the little scaly lizard called Mokomoko *(Tiliqua zealandica)*, and a number of these also were collected. An interesting account of this expedition appeared in the *New Zealander* newspaper at the time, and it was stated therein that, at the end of the return voyage, on opening the box containing the captives, it was found that they had eaten up all the Mokomokos, leaving nothing but the horny tips of their tails !"

Few of these specimens appear to have been preserved, for the *Sphenodon* continued to be an extreme rarity in English collections, and down to 1870 there was not, I believe, a single example in any American or Continental museum.

Since that date, however, attention has been directed to the island home of the Tuatara, and a considerable number of specimens have been from time to time secured and distributed among the local museums or sent to England.

One obtained by Captain Mair on the Rurima Rocks and sent home by Sir George Grey is, I believe, still living in the Zoological Society's Gardens, where I saw it occupying the same cage, in perfect amity, with some Australian guanas in the new reptile house.

A pair which I received from Captain Mair in 1869 were noticed in a communication to this Society on the 22nd October, 1870.* These were in my possession for many months, but I could never induce them to eat. They were sluggish in their movements, and, when molested, uttered a low, croaking note. The male measured thirteen and a half inches, and the female sixteen inches. They were obtained, like the rest, from Karewa Island, and my correspondent sent the following notes with them :—" It was just daylight when we reached the island, and the Titi and other birds

* "Trans. N. Z. Inst.," Vol. III., p. 9.

poured out of their nests underground in thousands. The whole place is completely honey-combed with their burrows, and you cannot move two steps without sinking to the knees in them. The Tuataras are very plentiful. They live in holes under the big rocks, and can only be got out by digging."

Since that date, however, the Tuataras have become very scarce on the island, and require to be closely hunted for. Captain Mair attributes this scarcity in a great measure to the large Hawk *(Circus gouldi)*, which of late years has become naturalized there, and subsists almost entirely on these lizards and their young.

In April last Captain Mair again visited the Island of Karewa, and succeeded in capturing seven fine specimens of the Tuatara, all of which reached me some weeks afterwards, in good order and condition. Two of these I presented to the Canterbury Museum. Two others I exchanged with the Colonial Museum for specimens from The Brothers; and the rest are still in my possession.

The largest of these (a female) measures exactly eighteen inches in length. It is stouter in the body than any other specimen I have seen; and, judging by the heavy nuchal folds, and by the flattened and worn condition of the dorsal spines, I take it to be a very aged Tuatara; how old it is impossible to say. Besides the natural indications of age I have mentioned, the crown of the head is deeply scored and scarred, the marks of old wounds, showing that this Tuatara, at any rate, has done some hard fighting in its day. One of the specimens which I sent to the Canterbury Museum (a medium-sized male) was remarkable for the extreme smallness of the dorsal spines, which were reduced to a line of mere points along the back.

Before proceeding, I may be allowed to quote a passage from Captain Mair's very interesting letter, which accompanied the specimens:—

"I have observed some interesting habits of the Tuatara lately. I think they must live to a great age. You will observe that one of those I am sending you, the largest of them, has some scars on his head and back, I think he must have got them in fighting with the sea-birds in their nests or burrows. Karewa Island is the breeding-place of millions of the small black sea-bird called 'Oi' by the Natives; a sort of petrel. The *Sphenodon* comes out of its burrow to bask in the sun, or to listen to any strange sound. I crept up to some which were listening most intently, with spines erect and head elevated at the sound of my voice. Upon my making too much noise, they at once made for the nearest burrow, and disappeared, the young sea-birds, occupying the burrow, fighting with and expelling the unwelcome intruder by pecking it most unmercifully. The Tuatara generally makes its own burrow by digging out a long hole under some flat rock. During the early part of the day it may be seen cautiously peering out of its hole, apparently waiting to pounce upon a fly, grasshopper, or perhaps some smaller lizard. I noticed that the excrement contains portions of grass and leaves undigested, legs of grasshoppers, spiders, and a small oval-backed black-beetle, which is found in great numbers in the sand and earth on the sea shore. A few months ago I caught some Tuataras on the Rurima Rocks. At the same time, I put a number of small lizards (*Naultinus pacificus*) into the box with them. There were at first about 20. I observed that these diminished every day, till at last only six were remaining, and these appeared quite paralyzed with fear. For, whenever the *Sphenodon* made a movement, the poor little creatures would crouch down and try and hide themselves under the dry leaves in the box. I watched the box very carefully, and at length found a Tuatara in the act of eating one of the small lizards. He had crushed it quite flat, beginning at the head, and rejecting about an inch of the tail. At the bottom of the box I found about a dozen tails. There were four or five little Tuataras about three inches long, but none of these disappeared. I generally found them perched on the heads of the big ones, asleep!

"Regarding the probable age to which these funny creatures live, I should have mentioned that I have seen an unusually large one which has been kept in an old kumara pit on Flat Island (Motiti) for over three generations. Could the old fellow only speak, what an interesting account he might give us of the fight on 'bare Motiti,' when the famous *tohunga*, Te Haramiti, and 170 of his warriors (the Ngatikuri) were killed and eaten by the Ngaiterangi, under the leadership of Tupaea! He may even have been an eye-witness when Tikiwhenua 'shuffled off this mortal coil' by blowing himself from the mouth of a gun, fired by his own red hand! You will not easily forget Judge Maning's graphic description of this original suicide in 'Old New Zealand.'"

I have only to add that, out of 26 small lizards (*Naultinus*,) put into the box with the Tuataras, to supply them with food, only two were surviving when the consignment arrived in Wellington; and that, after this cannibal feast, the Tuataras have fasted for three months without any apparent discomfort, and certainly without becoming emaciated in the body. I have tempted them with earth-worms, insects, and minced meat, but they seldom touch any of this food. They are fond of water, however, drinking freely, and continually bathing their bodies in the open vessel.

In Vol. III. of the "Transactions," pp. 151-153, will be found some very interesting notes by Major W. G. Mair, on the Rurima Rocks, a group of islets situated about four miles from the mainland, and five or six miles north-east from the entrance to the Awaateatua river, in the Bay of Plenty.

In his description of one of these islets, Moutoki, he says;—"It is on a cone-like hummock rising from its centre that the Tuatara (*Sphenodon punctatum*) is found. The area of this cone is not more than half an acre, and yet the Tuatara exists and has existed for ages in this limited preserve. Tradition says that they were plentiful on Whale Island, but does not account in a satisfactory manner for their extinction. * * In a few minutes we caught four Tuataras (the largest of which I forwarded to Mr. Kirk, the Curator of the Auckland Museum). They were found basking on the rocks and in holes in the loose soil. Whether these holes were the burrows of sea-birds or had been scraped by the lizards I could not tell. In one instance we found a Tuatara and a young Penguin in the same burrow. The Maoris, as a rule, have a perfect horror of lizards, and associate them with death or disaster; but a couple of Uriwera lads, who formed part of my crew, proved superior to superstitious influences, and pulled them out bravely, receiving, however, sundry sharp nips for their temerity. It is believed by some that the Tuatara feeds, for a portion of the year at least, on the eggs of sea-birds, but I could never coax one to eat an egg. From an examination of their excreta, I am of opinion that their food consists of insects, more particularly a shining black beetle about half an inch in length, with a longish neck, small head, and fluted elytra. It is commonly found under stones and old wood."

I think it is pretty evident that the Tuataras excavate their own burrows, or at any rate adapt existing cavities to their wants by that means, for I have observed that my captives are particularly fond of scraping and digging in the earth at the bottom of their cage.

They are very sluggish in their movements, but may be roused to activity by being rubbed or tickled in the ribs, when they wriggle violently, and sometimes utter a low rasping note.

The Tuataras to which the above notes refer have all, as already stated, been obtained on the rocky islets in the Bay of Plenty. Within the last few months, however, a considerable number of these lizards have been obtained on the Brothers Islands in the vicinity of Cook Strait), by the expeditions engaged in the erection of the Government lighthouse there. Over 20 specimens of all sizes (from the young measuring three inches to the full-grown animal measuring twenty-one inches) have been received at the Colonial Museum, the bulk of them being a donation from Mr. Lewis B. Wilson. Another batch obtained by Captain Fairchild of the "*Luna*" has been forwarded to England by Sir Julius Vogel, and other specimens preserved in cages are scattered among lovers of the curious in this city.

An examination of a large series of specimens has satisfied me that the Tuatara inhabiting the Brothers Islands is very different in appearance from that of the Bay of Plenty; so much so, in fact, that they must be regarded, if not as absolutely distinct species, at any rate as very strongly marked geographical races. My present opinion inclines to the view of their being distinct species, owing their parentage, of course, to a common ancestor, but sufficiently differentiated in their characters by long insulation as to warrant their specific separation. In form and size they resemble each other, but they are entirely different in colour. The Karewa Island form, with which we have long been familiar, is of a dark olivaceous-brown, appearing sometimes almost black, with minute white spots on the sides and limbs, while the lizards from the Brothers Islands are of a dull yellowish-olive, brighter on the sides and limbs, and irregularly spotted or marked all over the body with pale yellow. This variegated appearance is especially noticeable in the half-grown animal, in which the spotted markings are much lighter, and therefore more conspicuous.

Assuming that this form represents a distinct species, and that I have not been anticipated in the discovery by any of the recipients of those sent to England by Sir Julius Vogel, I propose to give it a distinctive name, and in doing so I am glad to have the opportunity of associating with this branch of our local zoology the name of the foremost among living herpetologists, Dr. Albert Günther, F.R.S. This is the more fitting, as Dr. Günther has so completely investigated the anatomy and systematic affinities of this singular form. I shall first give the description of the dark-coloured species taken from the Karewa specimens in my possession, and then the distinguishing characters of the supposed new species, founded on a large series of living examples of both sexes and of all ages.

1. *Sphenodon punctatum*, Gray.

Dark olivaceous-brown, more or less covered, especially on the sides and limbs, with minute spots or rounded specs of white; under parts yellowish-grey, shading into ashy-grey on the throat. The spines of the nuchal and dorsal crests are white, of the caudal dark brown; scales of the back, head, tail, and limbs small, granular, nearly uniform; the irregular folds of the skin fringed at the top with a series of rather large scales; an oblique ridge of large scales on each side of the base of the tail, and a few shorter longitudinal ridges of rather smaller ones on each side of the upper part of the tail. Irides rich brown with minute golden reticulations on the upper side, and a narrow elliptical black pupil; claws yellowish horn-colour, with brown tips.

The sexes vary appreciably both in size and colour. In the male there is a brighter tinge of olive, and the spots are clear and distinct, imparting sometimes to the entire surface a speckled appearance. The throat also has a bluer tinge, with numerous interrupted series of white scales from the chin downwards. In the female the colouring generally is darker and the spots are indistinct.

In the adult state the female is always larger than the male. The following are the measurements of the two finest specimens in my possession.

	Male.	Female.
Total length, measuring along the back...	16·0 in.	17·5 in.
From the chin to the vent	7·75 ,,	9·75 ,,
From the vent to end of tail	8·0 ,,	7·75 ,,

Note.—It should be mentioned that in the female described above the tail has at some period been broken, and has reproduced itself, giving a somewhat stumpy extremity, and a somewhat shorter measurement than it would otherwise yield.

2. Sphenodon guntheri, *sp. nov.*

Adult female: Entire upper surface greenish or olive-yellow, with numerous obscure, rounded spots of pale yellow or white, becoming darker on the tail; the nose, eyelids, sides of the head and outer margins of legs and toes bright yellow; spines for the most part pure white; irides dark brown with black pupil. On the nape, covering a part of the nuchal fold and roots of spines, there is a large spot of jet black, and on each side of the neck, in front of the shoulder a broad crescent-shaped mark of the same; under parts greyish-white, changing to pearl grey on the throat, with interrupted longitudinal series of perfectly white scales.

The female is considerably larger than the male, two of my specimens giving the following measurements:—

	Male.	Female.
Total length, measuring along the back	17·5 in.	19·25 in.
From the chin to the vent	8·0 ,,	9·25 ,,
From the vent to end of tail	9·0 ,,	9·25 ,,

The male, besides being smaller, is much darker in colouring than the female, the upper surface being shaded with brown. In this respect this species appears to differ from *S. punctatum*, in which the male has lighter and brighter colours than his mate.

Having had an opportunity of examining a number of specimens in various stages of growth, I am enabled to add some further notes descriptive of the young:—

1. *Very young state.*—Extreme length, 4 inches. General colour, earthy-brown; fore-part and sides of the head, insertion of the limbs and along the ridge of the tail, paler brown; transverse markings of darker brown on the cheeks, chest, and limbs; irides, mottled grey, having a linear, black pupil margined with white. It is noticeable that in this condition the colour of the lizard is so exactly assimilated to the ground which it

frequents, that, except when in motion, it is almost impossible for the eye to distinguish it.

2. *More advanced state.*—Extreme length, 8·25 inches. General colour, yellowish-brown, tinged with olive; on the sides of the tail, a rufous tinge; eyelids, inner surface of toes, and dorsal spines, bright olive-yellow, especially on the head, and mottled on the body with paler brown; irides, darker than in No. 1, with a narrow black pupil (which, however, is dilatable, and capable of being reduced to a mere line).

3. *Half-grown example.*—Head, dull olive-yellow, spotted with a paler colour; ring encircling the eyes, also the entire surface of the toes, bright yellow; upper parts generally dull yellowish-olive, shading to brown on the tail, and marked all over with irregular spots and blotches of ashy white, which are most conspicuous on the hind-neck and on the limbs; spines, whitish-yellow on the back, darker on the tail; under parts, greyish-white, shading into purer grey on the throat, where there are some broken series of white scales from the chin downwards; irides, rich brown, finely reticulated with golden; the pupil black, with golden edging; claws, horn-coloured. The light markings on the upper surface give a variegated appearance by which this species is very readily distinguished from *Sphenodon punctatum*.

It ought to be mentioned that in both species the colours of the skin come out with much more distinctness when the body is wet; also that, under certain conditions, the animal appears to exercise, to some small extent, the chameleon-power of changing its colours, the tints being apparently brighter at one time than at another.

POSTSCRIPT.—My *Sphenodon guntheri* is probably the "green lizard" referred to in the following paragraph which has recently appeared in one of the Auckland papers:—

"A novel exportation has been lately made to the Sydney Museum from the East Coast, namely, a dozen of large East Cape Island green lizards, which were caught and stuffed by some of the Kawakawa Natives, who received payment at the rate of four shillings each for them. These reptiles are found nowhere else in New Zealand but in East Cape Island, and the Maoris have a tradition amongst them that the lizards were discovered in that island on the arrival of the first of the Native race on the East Coast. There is no other species of lizard on East Cape Island but the green ones, which are the ugliest of all creeping things, with the exception of frogs."

It may be mentioned that East Cape Island, or Whangaokena, is only about half a mile from the mainland, and immediately off the Cape. It has an area of about five acres, and is thickly covered with vegetation.

Art. XXXI.—*Description of a new Lizard,* Naultinus pulcherrimus. By Walter A. Buller, C.M.G., Sc.D., President.

Plate.

[Read before the Wellington Philosophical Society, 11th November, 1876.]

In Vol. VI. of our "Transactions," at page 449, occurs the following passage, in the Proceedings of the Nelson Association for the Promotion of Science and Industry :—

"The Secretary exhibited a green and brown spotted lizard, found by Mr. William Hunter, on his run on the Upper Matakitaki, and which he presented to the Association. The colours of this lizard are much more vivid and quite different from any of the other specimens of the lizard species in the Museum of the Nelson Institute."—(May 21, 1874.)

This appears to be the only recorded notice of this very handsome species of *Naultinus* which I have the pleasure of bringing under the notice of the Society, and for which I propose the name of *Naultinus pulcherrimus.*

Some time last year, the Hon. Mr. Mantell received at the Colonial Museum a specimen of this new lizard, preserved in spirits, from a Nelson donor, together with a very characteristic water-colour drawing from life, by Miss Nairn. Mr. Mantell at once detected, and called my attention to, the orange-coloured tongue in the picture, which formed a good distinguishing character—irrespective of the difference in colour—from the blue-tongued *Naultinus elegans.*

In August last, Mr. Arthur Atkinson brought over from Nelson two live specimens (adult and young) which he was good enough to present to me. These were exhibited at one of our former meetings , and, as I have since canonized them in spirits of wine, I beg now to submit a coloured drawing which I was able to complete before the colours had lost any of their brilliancy.

The following is a sufficient description of the species for purposes of identification :—

Naultinus pulcherrimus. *sp. nov.*

Adult: General colours, green and brown, the latter predominating, and presenting a very elegant pattern. The ground colour, so to speak, is a vivid reddish-brown, and the green, which is quite as bright as in *Naultinus elegans,* is displayed in large diamond-shaped spots, arranged symmetrically on both sides of the spine, down the whole course of the back. Those flanking the crown of the head are more irregular in form, and the two on each side of the nape are confluent. In front of the ear, on each side of the head, there

NAULTINUS PULCHERRIMUS, n. sp.

CATOCALA TRAVERSII, n. sp.

J.B. lith.

is a crescent spot of white, margined with brown, and down the side of the body to the insertion of the hind legs there is a series of detached spots of white, surrounded more or less with green. On the tail the same character of colouring is continued, but it loses its distinctness, the markings becoming more blended. The whole under-surface of the body is pale whitish, or silvery-brown; irides, brown; tongue and inside of mouth, pale orange, or flesh coloured. Head, ·7; body, 2·5; tail, 3·5.

Young: General colour, bright pea-green, varied with transverse bands of paler green, and marked irregularly with minute specks of reddish-brown. Under surface, very pale green, inclining to white on the throat. From the angles of the mouth, and down each side of the body there is a series of irregular yellowish-white spots.

Mr. Atkinson informed me that these examples were captured together on a heap of firewood, at one of the Nelson and Foxhill railway stations, in the Waimea District. They had been in his possession for upwards of six weeks, and during that period had neither eaten nor voided anything. On examining them, we both remarked on the length and extreme flexibility of the tail, which was usually coiled up to the root, reminding one of the small fire-works known to school-boys as "Catherine-wheels." In this respect this species differs conspicuously from *Naultinus elegans*, which, although possessing a very mobile tail never coils it up in the manner described.

ART. XXXII.—*On the Ornithology of New Zealand.* By WALTER L. BULLER, C.M.G., Sc.D., President.

Plate.

[*Read before the Wellington Philosophical Society, 16th September, 1876.*]

IN continuation of my paper under the above title in last year's volume of "Transactions," I beg to lay before the Society some further notes and observations, adopting, for convenience, the nomenclature used in my "Birds of New Zealand."

Circus gouldi.

This fine Hawk is becoming perceptibly scarcer in many parts of the country, owing to its wholesale destruction by farmers. On a recent occasion I counted no less than ninety-six heads nailed up in imposing rows against the wall of an outhouse on a small sheep station. This crusade arises from the popular belief that the Harrier attacks and kills young lambs. That it occasionally does so in the case of weaklings is beyond doubt, but I am of opinion that the mischief done is very much exaggerated, and that the wholesale killing of Hawks in a country like this is a questionable policy, from a utilitarian point of view, as it tends to disturb the balance of nature, and to interfere with the general conditions of animal life, already too much disturbed by the operations of Acclimatization Societies. The rapacious birds have an important part to perform in the economy of nature; and species, like the present, which are partly insectivorous, are too valuable to the practical agriculturist, to be destroyed with impunity, although they may occasionally attack a sickly lamb in the flock, or swoop on a young turkey.

Mr. C. H. Robson, of Cape Campbell, sends me the following interesting note:—"In the spring of 1873, I observed a very large female Hawk of a brighter colour than usual, with very distinct markings, and presenting quite a yellow appearance as compared with the ordinary hawk. She rose, the first time I saw her, out of a piece of swampy ground near the beach, and, on a subsequent occasion, finding her in the same place, I hunted about and found her nest in a tussock, with two white eggs in it. Being anxious to secure the young birds, I did not handle the eggs, but visited the nest every week, each time coming quite close to the bird. In due time one of the eggs hatched out a little yellow-white chick, but a few days later, to my great regret, it was taken, I presume, by a rat. On flying off the nest the Hawk was joined by the male bird, not nearly so large as herself, and always too high in the air for me to observe his plumage."

Sceloglaux albifacies.

A specimen of this large Owl lately received at the Canterbury Museum, and forwarded to Europe by Dr. Haast, is sufficiently white about the face to justify the specific name bestowed by Mr. G. R. Gray. In ordinary examples, however, this is quite a subordinate feature.

Nestor meridionalis.

Of this species Captain Mair writes:—"In June last I was at Tuhua in the upper Wanganui. I found the Kakas there so fat that they could not fly. I actually caught fifteen of them on the ground, as they were unable to take wing.

Halcyon vagans.

On the feeding habits of this species, Mr. Henry C. Field of Wanganui has sent me the following interesting observations, which exhibit the Kingfisher in the new character of a frugivorous bird:—

"Knowing the interest you take in our New Zealand birds, I have thought you might like to be informed of the following trait in the habits of the Kotare, which I think is not generally known. About a week before Christmas my children reported to me that in what they took to be a rat's hole in the pumice bank of the stream, just behind my garden, there was something which growled at them whenever they passed the hole or looked into it. On the matter being mentioned a second or third time the hole was examined, and proved to be a Kotare's nest, containing four young ones about half-fledged. The old birds, of course, manifested a strong objection to the nest being touched, flying round, screaming, and darting at us whenever we went close to it. I desired the children not to meddle with the young birds, but told them that if they sat a little way off and watched they would see the old ones catch fish, lizards, and insects, and bring them to the nest for the young ones to eat. The children were very pleased to do this, but quickly discovered that very few fish, and apparently very little animal food of any kind was brought to the nest, and that the young brood were being reared on the cherries out of our garden. I at first thought the children were mistaken, but as they assured me they saw the birds fly to the trees, and bring back the cherries in their bills, I examined the nest, and from the quantity of cherry stones that it contained saw that the youngsters' eyes had not deceived them. It was evident, in fact, that up to the time they left the nest, fruit formed the chief food of the young birds. It has occurred to me that possibly the Kingfisher, from its habits, consumes a large quantity of fluid with its food, and that the juice of the fruit supplies moisture necessary to the proper growth of the young birds. At all events it is clear that young fruit forms an important article in their diet, though I never saw them eating it, or heard of their doing so at a later stage of their existence."

"POSTSCRIPT, June 25.—I accidentally got corroborative information as to the frugivorous habits of the Kotare lately. I met Mr. Enderby, who mentioned that he had been greatly annoyed by these birds this autumn. He said that scarcely a peach in the garden escaped having one or more large pieces pecked out of them, and that the birds did not meddle with the ripe fruit, but attacked it when it was just ripening, and before it became soft. This seems to indicate that, as in my case, the fruit was wanted not for the consumption of the old birds themselves, but as food for their young, and that it was taken therefore before it was too soft to be carried in the bill, or not required after the fruit was ripe, because the young birds were then fledged. Mr. Enderby was quite positive that it was the Kotares and not sparrows who were the depredators, as he saw them taking the fruit, and said he at first had a great mind to shoot them, till he noticed that they evidently carried it away to their nests."

Anthornis melanura.

I may mention, in proof of my former assertion that the Korimako, once the commonest bird of the country, is fast becoming extinct, that since my return from England two years ago I have positively not seen one, although

I have visited many parts of the North Island. Even in the South Island, where Captain Hutton states it is still abundant, I had lately to pay six-and-eight-pence for a pair of them!

Rhipidura fuliginosa.

In my "Birds of New Zealand" (p. 146) I mentioned a single instance of the occurrence of this South Island species on the northern side of Cook Strait, in the winter of 1864. Another specimen was killed about two years ago near a streamlet in the Pirongia Ranges, Waikato; and I have now to exhibit to this meeting the skin of a third obtained by my son in a shrubbery near Wellington on the 2nd April last. I may add, further, that a pair of these black fantails visited my garden on Wellington Terrace on the 15th of the same month, and, as I would not allow them to be molested, returned on several successive days. They disappeared together, and I have not seen them since; but it is to be hoped that they will breed with us this season, and that this pretty bird may become at length fairly acclimatized in this island.

Ocydromus earli.

It is a notorious fact that this species, notwithstanding its feebly developed wings, rendering it quite incapable of flight, is getting every year more plentiful in the settled districts of the North Island. The reason is doubtless to be found in the fact that while its natural enemies, hawks and wild cats, diminish with the progress of settlement, the cultivation of the country increases its advantages in the every-day struggle for existence. The nocturnal cry of the Woodhen is now quite familiar in districts where a few years ago it was quite unknown.

On the synonymy of this species Captain Hutton sends me the following:—

"I am sure that you are right about the identification of *Ocydromus earli*. I always agreed with you, and I don't understand how Finsch thinks otherwise. I think the following is about right:—

"1. *O. earli*, Gray; 'Ibis,' 1862, p. 26; also, *O. australis*, Gray, *ibid* in part; Buller, 'Birds of New Zealand.' Whether or not it is the *Rallus rufus* of Ellman I have no means of judging.

"2. *O. fuscus*, Dubus; *R. troglodytes*, Forster, 'Descr. An.' p. 110; *R. fuscus*, Ellman?; Buller, 'Birds of New Zealand.'

"3. *O. australis*, Sparr.; Gray, in 'Voyage, "*Erebus* and *Terror*'" (young only); Buller, 'Birds of New Zealand,' in part (not the figure).

"4. *O. troglodytes*, Gml.; *O. australis*, Gray, 'Voyage, "*Erebus* and *Terror*" (adult); and Buller, 'Birds of New Zealand,' in part, with figure.

"I doubt *O. brachypterus*, Lafr., being a synonym of either of these. Finsch thinks it is the same as *O. hectori*, mihi., which is very probable. I have had two specimens of *O. fuscus* sent to me from the Waiau district, on the eastern side of the alps—the region of *O. finschi*, mihi., so I now think that *O. finschi* is probably only the young of *O. fuscus*."

Apterix mantelli.

I have already placed on record my own views as to the specific value of the North Island Kiwi, as compared with *Apteryx australis* of the South Island, and I have seen no reason since the publication of my work to change or modify them, It is desirable, however, to have the arguments on both sides stated fully, and I have therefore taken the trouble to translate from the German Dr. Finsch's last published remarks on this subject in the "Journal für Ornithologie," from which it will be seen that this naturalist is still opposed to the recognition of *A. mantelli*:—

"As hitherto, I have had no opportunity of examining any reliable specimens from the North Island—it naturally was not possible for me to make sure about the value of those characters. I am indebted now to the kindness of Dr. Buller for two specimens from the North Island, so that I am able to make a direct comparison of specimens from both islands. Besides the two specimens from the North Island, I have four old birds (two male and two female), and a young one from the South Island before me; also, an old one and a half-grown bird, without any definite locality, consequently a total of nine specimens in different stages and conditions of age and sex. To refer, in the first place, to the tinge of colour. I had before this, opportunities of observing that in specimens from the South Island the colour is by no means constant, but on the contrary varies from greyish-brown to rusty-red brown. The latter tone of colour, as is well known, is produced by the terminal third-part of the feathers being of that shade. Each individual feather is coloured either dark brownish-grey or brown, changing gradually towards the tip into rusty brown; the single filaments or barbs of the feathers, which stand far apart from each other, terminate, however, in black hair-like tips, which impart to the whole plumage the peculiar bristle-like character. In this fundamental point of colouring the specimens from both islands absolutely agree, and the feathers which I have before me, and which have been carefully pulled out, do not betray differences of any kind. Only, as I have already said, the intensity of the rust-brown on the third part of the tip of each feather is sometimes stronger, sometimes feebler, and on this depends the general colouring of the specimen. One specimen from the North Island shows the same darker, and of a more vivid rust-brown than examples from the South Island. It does not, however, appear quite so dark as a specimen in the Bremen collection, without a positively defined locality, of which I have already made mention. The other specimen from the North Island, however, so perfectly agrees in regard to the rust-brown tone of colour, with specimens from the South Island, that in point of fact not the slightest difference is observable. Consequently the tinge or colouring as a specific character must be considered as absolutely worthless. The case is different, however, in regard to the relative hardness or softness of the plumage, which is perceptible to the touch. I am in a position to confirm the statement that in general the specimens from the North Island possess more strongly developed feather shafts, which project beyond the barbs in the shape of naked tips, and consequently appear more like bristles and have a harsher feel. This peculiarity is very perceptible on stroking the feathers the wrong way, or on carefully feeling them; but cannot be distinguished on stroking with the palm of the hand along, or in the direction of the feathers. If stroked in this way even the most delicately sensitive hand would be unable to detect any difference at all between certain specimens from the North and South Islands respectively. It is worth mentioning here that on patting the plumage of *Apteryx oweni* (in the manner described) the same difference as compared with *Apteryx australis* becomes at once apparent. What has been said in regard to the relative hardness or softness due to the more or less pronounced development of the projecting naked shaft-tips, which differ again in *Apteryx oweni*, has reference moreover to the plumage of the upper side of the rump. With that which covers the hindhead and neck the case is different; and here perhaps might be found a single criterion, or distinguishing mark, which is appreciable not merely to the touch but also to the eye, and which might be considered as a sufficient specific character for the North Island *Apteryx*. The feathers of the back of the head and the back of the neck have stronger and more projecting shafts, with the barbs composing the webs further apart and consequently less numerous. These hair-like barbs not only feel harder to the touch, but the longer and protruding hair-like filaments are quite apparent to the eye. This peculiarity I find borne out in all the specimens before me. If therefore one intends to acknowledge the *Apteryx* of the North Island as a distinct species, a distinguishing character could only be found in this visible difference of plumage on the hind-head and back of neck. On the front and sides of the neck the peculiarity I have described is scarcely perceptible, Still, I do not venture as yet to set up this character as a constant one, as possibly there may be exceptions. Besides this character alone does not appear to me of sufficient importance to differentiate a species. In my judgment therefore, for the present, this *Apteryx* of the North Island is only a slightly deviating form of the known *Apteryx australis*. I doubt whether it will be possible to define with certainty specimens, the origin of which is not warranted, without direct comparison in all cases."

Numenius cyanopus.

Dr. von Haast writes to me that two specimens of a Whimbrel, which he refers to this species, have recently been added to the New Zealand collection in the Canterbury Museum. One of these was obtained on the 2nd of April last on the Kaiapoi Bar, where it was consorting with a flock of Godwits; and the other was shot on the 27th June, at the mouth of the Ashley River. Both of these proved on examination to be males.

The breeding-ground of this species has not yet been discovered, but the bird is very abundant on the shores of Tasmania, and there is reason to believe that it retires to the high lands of the interior for the purpose of reproducing. Its range extends, however, all over Australia, and it is just one of those species that might reasonably be looked for as stragglers on our coasts.

It will be remembered that in the course of a paper which I read before this Society in February, 1875, describing several ornithological novelties in the Colonial Museum, I mentioned, on the authority of Dr. Hector (through whose hands the specimens had passed) that an example of this species was shot by Liardet in the Wairau district. Curiously enough, the bird was in company with another straggler from Australia, *Numenius uropygialis*, a notice of which will be found in the paper referred to.*

Himantopus leucocephalus.

The following is the description of a young bird of this species shot by my son on a mud-bank in the Wanganui River on the 25th March :—Crown of the head, nape, and hind-neck dusky black mottled with white; shoulders spotted with black, darkening towards the back; upper part of back and scapulars brownish-black; upper surface of wings glossy black; the median coverts, as well as the feathers of the back, narrowly tipped with brown; lower part of back and rump white; tail feathers dull black, tipped with brown, their coverts (which are very fluffy) plumbeous at the base, white in their apical portion, and tipped with yellowish-brown: lining of wings black; bill black, brownish towards the base; irides reddish-yellow; legs pale yellow; the claws brown; upper mandible, 2 inches; tibia, 1·75; tarsus, 2·75.

Tringa canutus.

A beautiful specimen of this bird in full summer plumage, shot in the vicinity of Christchurch on the 2nd April, and preserved in that Museum, presents the following measurements :—Extreme length, 9 inches; wing from flexure, 6·4 inches; tail, 2·25 inches; bill, along the ridge, 1.15 inches, along the edge of lower mandible, 1·15 inches; bare tibia, ·55 inch; tarsus, 1·15 inches; middle toe and claw, 1·15 inches; hallux, ·25 inch.

* "Trans. N.Z. Inst.," Vol. VII., p. 225.

Anous stolidus.

Dr. Finsch and myself concurred in omitting the Noddy Tern from the New Zealand list, in the absence of more positive evidence of its occurrence in our seas. I think it is probable, however, that we shall have in the end to restore it. There is a specimen in the Canterbury Museum, shot by Mr. Minerzhagen, near the Sandwich Islands. The forehead and vertex in a line with the eyes is white, passing into grey on the crown, and shading into the sooty colour which prevails all over the body; quills and tail-feathers black.

Procellaria cookii.

I am indebted to Mr. C. H. Robson for a very perfect specimen of this Petrel obtained by him at Cape Campbell.

Thalassidroma nereis.

I have lately received several fine specimens of this diminutive Petrel from Cape Campbell.

Diomedea exulans.

In a paper which I had the honour of reading before this Society in January last, I described a perfectly mature example of the Wandering Albatros, presenting a feature which appeared to me quite a new fact in natural history. It has since been noticed by Dr. Kidder * in the following terms:—"All of the nesting Albatroses that I saw, without exception, showed a slight pinkish discolouration of the neck, as if a blood-stain had been washed out (usually on the left side), and extending downward from the region of the ear."

I find, however, that I was not the first to record this peculiarity of colouration. Captain Hutton, in his "Notes on the Petrels of the Southern Ocean,†" mentions "a rose-coloured streak on each side of the neck," and adds, "I have never seen this on either the young or very old birds; and the only one I ever captured with it was a male. I have also only seen these marks between June and August, and I am therefore disposed to believe that they distinguish the middle-aged male bird previous to the breeding season; but I am not sure of this."

Mr. Hood, a Wharekauri settler, informs me that the Chatham Island Natives periodically visit two groups of small islands—the Sisters and the Forty, for the purpose of collecting young birds. In August last year, he saw the boats return with seven hundred young Albatroses. The Natives had caught them on the nest and wrung their necks. After this they were tried down in their own fat and potted for future use.

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* "Birds of Kerguelen Island," p. 20.

† Read before Natural History Society of Dublin, March 3rd, 1865.

Diomedea cauta.

Captain Hutton writes me that he has added this fine Albatros to the New Zealand list, a specimen having been obtained at Blueskin Bay, in Otago. In 1871, I saw a beautiful specimen on board of a man-of-war in Wellington Harbour, but I found that it had been captured too far from the shores of New Zealand to warrant my including the species in my book.

Mr. Gould named it the Shy Albatros, in allusion to its cautious habits, for it seldom approached the ship sufficiently near for a successful shot. He states that it is "rapid and vigorous on the wing, and takes immense sweeps over the surface of the ocean." The stomachs of those he obtained in Recherche Bay (Tasmania), where they were attracted by the floating fat and other refuse from the whaling-station, contained blubber, the remains of large fish, barnacles, and other crustaceans.

The New Zealand Avifauna now embraces six recognized species of Albatros, viz.—*Diomedea exulans*, *D. melanophrys*, *D. chlororhyncha*, *D. culminata*, *D. fuliginosa*, and *D. cauta.*

Phalacrocorax carunculatus.

Some specimens of this fine species have lately been brought from Queen Charlotte Sound, and the skins manufactured into ladies' muffs by Mr. Liardet, of Wellington.

The bird which I exhibited at one of our former meetings, and which I proposed to distinguish as *Phalacrocorax finschii*, if it should prove to be new is, I rather suspect, only a seasonal state of this species. In Dr. Kidder's work* there is the following significant mention of this Shag:—"Only a single adult skin of this Cormorant was preserved and brought home, a female in nuptial plumage. There is no better reason, I am afraid, for this omission, than the fact, that the birds were exceedingly plentiful, and the preparation of the skins a very tedious job, so that it was put off from day to day for rarer specimens, until, in the haste of an unexpectedly hurried departure, it was omitted altogether. From memory, I can only say that the young birds were of much more sober plumage than the females, destitute of the crest and brilliant blue eyelid, and generally rather smaller. All had white breasts and bellies; but there were many minor variations in plumage, which I suppose went to indicate differences in age." I do not absolutely sink the new species, because, in Mr. Travers' specimens, the bill is appreciably larger and more robust than in ordinary examples of *P. carunculatus;* but it will be necessary to obtain further specimens for examination and comparison before any satisfactory conclusion can be arrived at.

* "Contributions to the Natural History of Kerguelen Island," Bulletin of the U.S. National Museum, 1875.

On the habits of *P. carunculatus*, as observed on Kerguelen Island, Dr. Kidder gives the following particulars :—" They do not differ materially in habits from other species of Cormorant, diving and swimming well, feeding entirely on fish, and often congregating for hours upon a projecting rock or headland, where, in pairing time, they enact various absurd performances, billing and curvetting about one another in a very ridiculous manner. The note is a hoarse croak, which never varies, so far as I have observed. They seem to be on particularly good terms with the *Chionis*, and are often joined by gulls when sunning themselves. They build upon shelves, for the most part in the precipitous faces of cliffs overlooking the water; the base of the nest being raised sometimes as much as two feet, and composed of mingled mud and excrement. Upon this pedestal is constructed a rather artistic nest of long blades of grass. Apparently, they continue to use the old nests year after year, adding a new layer each season, and thus building the nest up. The first eggs were found November 5th; there being sometimes two and sometimes three in a nest. They were procured at first by the kind assistance of Mr. Stanley, and a length of rope which tied us together, one end being knotted round the waist of each. One would then remain above and hold on, while the other clambered a little way down the face of the cliff and secured the eggs. After a time, however, I discovered a lot of nests, near a rookery of Rock-hopper Penguins, accessible from below, where, on December 4th, the young birds were first observed. Eggs, green, with white chalky incrustation. The young are most ridiculous-looking objects, being pot-bellied, naked, and perfectly black, and seem to be less advanced in development at the time of hatching than most birds, the bones of the tarsus and foot being not yet ossified. Small fish were generally lying by the nests. The old birds were very solicitous about their young, hissing and stretching out their necks, and refusing to leave their nests until pushed off. Yet, when I took one of the young away from the nest, and placed it close by on the rock, the mother seemed neither to recognize its constant chirping nor to be aware that one of her brood was missing. Certainly she paid no attention to it. The odour in the neighbourhood of the nesting-places was most offensive. The young birds are infested with a tick of prodigious size,"

Phalacrocorax finschii.

Under this name Mr. R. B. Sharpe has distinguished from *P. brevirostris* a specimen in the British Museum, having a white spot on the wing coverts.

Mr. W. T. L. Travers, who has just returned from the Hot Springs, informs me that, in Lake Tarawera, he observed a small Shag, differing apparently from *P. brevirostris*, being of inferior size and marked with white on the wings. He was unable to obtain a very close inspection, but it seems not unlikely that this is the bird described by Mr. Sharpe.

Eudyptula undina.

In further illustration of my view that this bird is specifically distinct from *Eudyptula minor*, I beg to submit sketches of the bill (Figs. 3 and 4, Plate) shewing the relative size. These sketches are from specimens in the Colonial Museum.

ART. XXXIII.—*On the Occurrence of the Royal Spoonbill* (Platalea regia) *in New Zealand.* By WALTER L. BULLER, C.M.G., Sc.D., President.

[Read before the Wellington Philosophical Society, July 29th, 1876.]

I HAVE much pleasure in laying before the Society a fine specimen of the Australian Spoonbill, recently obtained at Manawatu, and kindly forwarded to me by Mr. Charles Hulke, of Foxton, to whom I am further indebted for the following notes:—"This Spoonbill was shot in April last, near the mouth of the Manawatu River, by Mr. Blake, who, from having served under Messrs. Speke and Grant in Africa, never loses sight of any curiosity if possible. It was sitting on the sand in company with three Paradise Ducks (*Casarca variegata*). Mr. Blake saw that the bird was a stranger, and he was attempting to get the four birds in line, when his dog startled them, and up they flew. Sacrificing the ducks for the sake of getting the stranger, he fired and the bird fell upon the sand with a heavy thud. It measured 4 feet 2½ inches from tip to tip of wings, and when laid on the table preparatory for skinning, it measured from the tip of the bill to the end of the tarsi 3 feet 9 inches. The body was about the size of a small goose; legs, bill, and skin of throat jet black, marked with orange round the eyes, assuming the form of a narrow streak below, and a crescent mark above. I observed that the tongue was very short, and that the passage to the gullet was furnished with small fringed flaps, or valvular appendages, somewhat similar to those at the base of the tongue, but much deeper. Having very little time at my disposal, I was unable to make a very minute examination of the specimen. It struck me, however, that the wing-shoulders were placed well back, indicating great power of flight, From the small size of the occipital crest, I judged that the specimen was a female. It was evident, also, that it had almost finished moulting.

"This bird has been seen for some five or six months about the lagoons in the vicinity of Mr. Robinson's homestead. By his sons it had been taken for a White Shag. Only one had been seen by them, but I have been informed by a person who is in the habit of crossing the country between Foxton and Rangitikei, that he is confident he has seen another specimen near the Rangitikei River. No other specimen has, however, been seen in company with the one sent herewith."

Mr. Ellman, in his paper on the "Birds of New Zealand,"* states that a Spoonbill was known to the Natives residing at Castle Point, on the east coast of Wellington, who called it a "*Kotuku-ngutu-papa.*" Mr. Ellman proposed for it the name of *Ardea latirostrum.*†

The specimen now exhibited is undoubtedly referable to the species first described by Mr. Gould in the "Proceedings of the Zoological Society" as the Royal Spoonbill (*Platalea regia*), and this may be regarded as the first authentic record of its occurrence in New Zealand. It is tolerably common on the eastern and northern coast of Australia, and (according to Gould) although a rare visitant there, it has been killed within the colony of New South Wales.

As Mr. Gould has pointed out in his "Birds of Australia," this fine species may be readily distinguished from the *Platalea leucorodia* of Europe by the nudity of its face, which, even considerably beyond the eyes, is entirely destitute of feathers, and is of the same black colour as the bill. In other respects, both as to size and plumage, little difference exists between the two species. As with the European Spoonbill also, the fine crest which adorns the head of birds in full feather is assumed only in the pairing and breeding season. "In its habits and disposition it as closely assimilates to its European prototype as it does in general appearance, for like that bird it takes up its abode on the margin of those marshy inlets of the sea that run for a considerable distance into the interior, and on the banks of rivers and lakes, and feeds upon small-shelled molluscs, frogs, insects, and the fry of fish, which are readily taken by its beautifully organized bill."—(Gould)

The example before us is of course an accidental straggler to our shores from the Australian Continent, but it is none the less interesting as a conspicuous addition to the recognised Avifauna of New Zealand.

Art. XXXIV.—*Observations on a species of Shag inhabiting Queen Charlotte Sound.* By Walter L. Buller, C.M.G., Sc.D., President.

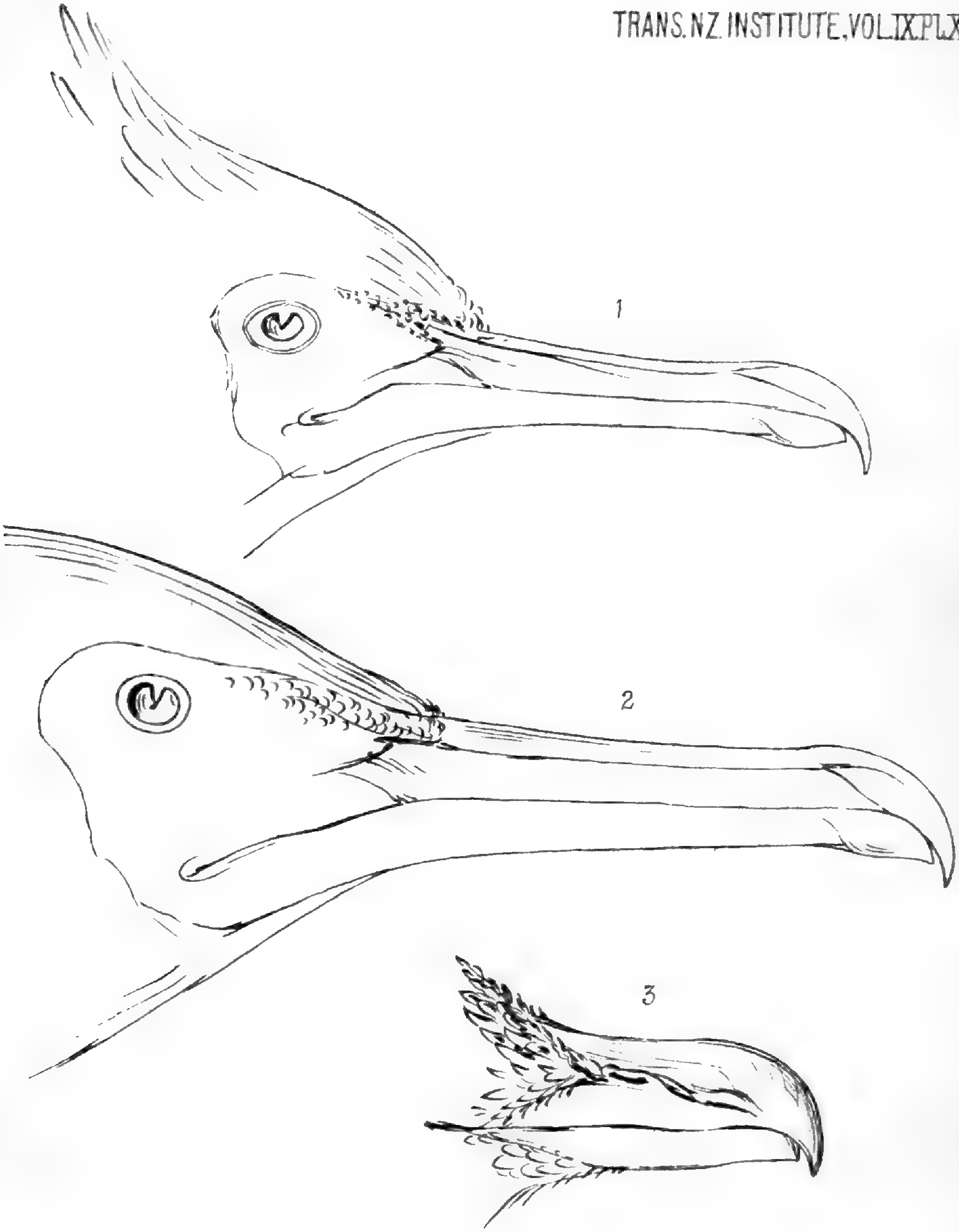
Plate.

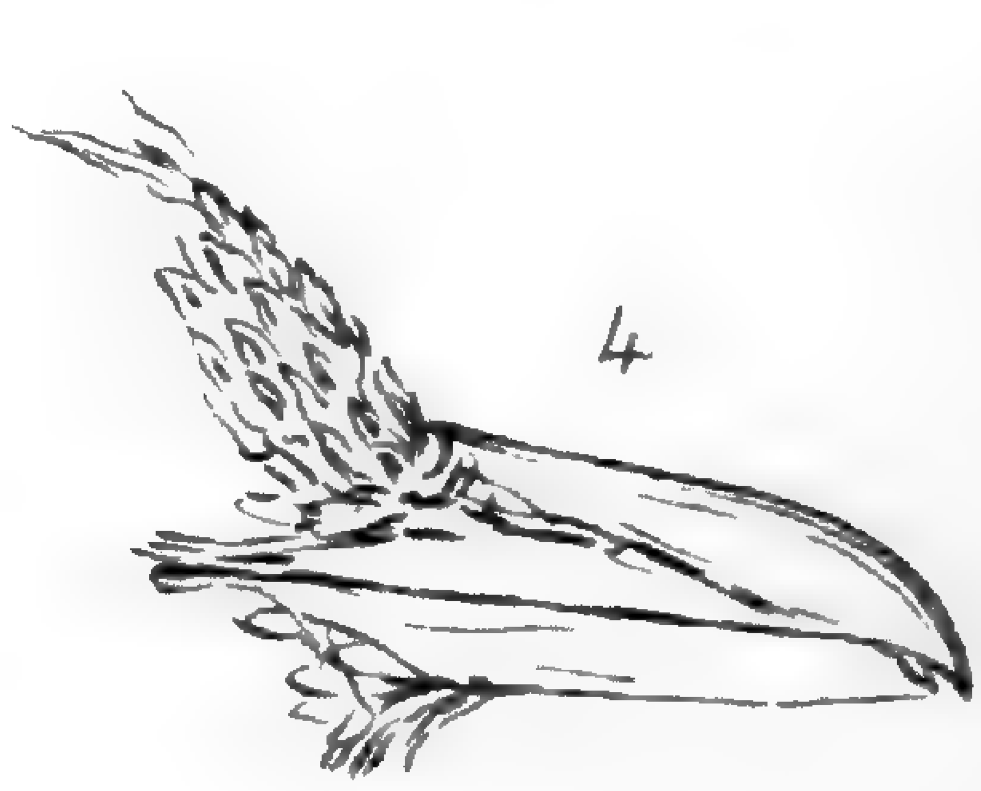
[*Read before the Wellington Philosophical Society, November 25th, 1876*]

At a meeting of this Society, held last year, I exhibited three specimens (male, female, and young) of a species of Shag from Queen Charlotte Sound, which appeared to differ in some of its characters from *Phalacrocorax car-*

* Published in the "Zoologist" of 1861; see Buller, "Trans. N.Z. Institute," Essay on Ornithology, Vol. I., p. 16. *n.e.*, I., p. 228.

† "Zoologist," 1861, p. 7469.





Figs. 1 2. FORMS OF PHALACROCORAX.

3 EUDYPTULA MINOR.

4 " UNDINA.

W. L. Buller, del. J. B. lith.

unculatus. I did not venture to pronounce the species distinct, but I suggested that if it should prove to be new, it might be fittingly named in honour of Dr. Otto Finsch, the well-known ornithologist. As already explained, however (p. 336), I have been anticipated by Mr. R. B. Sharpe, of the British Museum, who has named another recently discovered species from New Zealand, *Phalacrocorax finschii*. Strange that two ornithologists, working at opposite corners of the globe, should have independently and almost at the same moment decided on dedicating a new Shag to one of the Continental *savants!* That the true *P. finschii* will stand, I have very little doubt, for I have had frequent opportunities of observing how extremely cautious Mr. Sharpe always is in the discrimination of species. As to the bird for which I had designed the same honour, in the event of its proving to be new, it will be remembered that in the paper which I read before the Society on the 29th of July last, I expressed a strong doubt as to its being really distinct from *Phalacrocorax carunculatus*. I have lately, however, received, by purchase, two fine specimens lately killed at Queen Charlotte Sound, and on comparing these with the only determined example of *P. carunculatus* in the Colonial Museum, I observe so much difference that I have thought it right to exhibit the specimens and to make some observations upon them.

It will be observed that there is considerable difference in the size, the respective measurements being as follows:—

	P. carunculatus.	*Sp. exhib.*
Extreme length	26·0 inches.	32·0 inches.
Wing, from flexure ...	10·75 ,,	12·5 ,,
Tail	5·0 ,,	5·75 ,,
Bill, following curvature	2·25 ,,	3·0 ,,
Tarsus	2·25 ,,	3·0 ,,
Longest toe and claw ...	4·25 ,,	5·0 ,,

Another conspicuous difference is that one form is crested and the other is not. Mr. Henry Travers assures me that these characters are constant. He met with *P. carunculatus* in large numbers at the Chatham Islands, and there was always a crest, or some indications of it, in both sexes. The other bird he found nesting on the White Rock in Queen Charlotte Sound; and although it was the height of the breeding season, in a colony of some 40 or 50 nests, with birds of both sexes and of all ages frequenting them, he did not observe a single example with a crest, or anything approaching it.

On comparing the heads it would be seen that the bill is much larger and stronger in one than in the other (see Figs. 3 and 4, Plate); and although the colours of the soft parts are no safe criterion in dried specimens, it would appear that the naked spaces, which in *P. carunculatus* are orange-red, are of a bluish colour in the other bird, with the exception of the patch of papillæ extending from the base of the upper mandible towards the crown.

The general style of colouring is the same in the two birds, although the tints altogether are duller in the uncrested form. There is the same conspicuous alar bar of white, formed by the middle wing coverts; but in addition to this the uncrested bird has a patch of the same on the outer scapulars. All the specimens of the latter which I have examined have two closely approximating spots of white, nearly of the size of a crown-piece, about the centre of the back. On a close inspection of the example of *P. caruncalatus*, now exhibited, I observe, on disturbing the feathers, some indications of these white markings, but they are so well concealed that they escaped my notice when I originally described this bird.*

I think I have now sufficiently indicated the differences which may on further observation prove of specific value as distinguishing characters; but it is evident that the subject requires further elucidation before any definite conclusion can be arrived at.

Art. XXXV.—*On a tendency to deformity in the Bill of* Nestor meridionalis.

By Walter L. Buller, C.M.G., Sc.D., President.

Plate.

[Read before the Wellington Philosophical Society, 25th November, 1876.]

In my account of the Kaka Parrot, in "The Birds of New Zealand," I have mentioned † a living example which had been in the possession of the Upper Wanganui tribes for a period of nearly twenty years, and presented the curious feature of its over-grown mandibles completely crossing each other—a circumstance which I attributed to its having been constantly fed on soft food, thus depriving the bill of the wear and tear incident to a state of nature.

It would appear, however, that even in the wild state this species is liable to an abnormal development or deformity of growth in this respect, as will be manifest from the accompanying drawings.

Fig. 1 represents a specimen in the Canterbury Museum; and Fig. 2 another in the British Museum, which was brought under my notice by Dr. Günther. Fig. 3 shews the normal condition of the bill in a healthy bird.

* "Birds of New Zealand," p. 332.

† *l.c.*, p. 48.

W. L. Buller del.

DEFORMITIES IN BILL OF NESTOR.

J. B. lith.

Art. XXXVI.—*On the alleged intercrossing of* Ocydromus earli, *and the Domestic Fowl.* By Walter L. Buller, C.M.G., Sc.D., President.

[*Read before the Wellington Philosophical Society, 25th November, 1876.*]

In my history of the North Island Wood-hen,* I ventured, in opposition to the advice of one or two scientific friends in England, to put on record the following statement:—

"In spite, however, of the natural wildness of this bird, and the apparent impossibility of fully taming it, in localities contiguous to its native haunts, it is sometimes seen mingling with the domestic fowls; and, however incredible such a fact may appear, there are several well-authenticated instances of its crossing with the barn-door hen and producing a veritable hybrid! I saw one of these, many years ago, at a settler's homestead, at Waikanae; and, more recently, I carefully examined another in the possession of Dr. Hewson, at Otaki. I was informed that Dr. Hildebrand, of the Wairarapa, had a clutch of several from one hen; and several other instances might be cited. The hybrid is covered with a peculiar hairy plumage of a yellowish-brown colour, and unites with a general fowl-like appearance a disproportionately long head, Rail-like legs, and a genuine Weka's tail."

This statement was sharply criticized by Captain Hutton,† who ex- who expressed astonishment that I had not preserved Dr. Hewson's specimen of the hybrid, or ascertained what it "developed into;" my answer to this being that the bird, although promised to me, was unfortunately shortly afterwards consigned to the pot, thus putting an end both to the specimen and its "development."‡

I have never since had an opportunity of personally verifying my former observations; but Captain Mair, of Tauranga, who declares that such intercrossing is a common occurrence in that part of the island, has favoured me with the following notes:—

"In the small isolated native villages in the Rotorua district, I have observed several instances of crossing between the Weka-rail and the Barn-door Fowl, and the natives tell me that they are by no means rare.

"For some years a native chief at Wairoa has had a number of these hybrids amongst his fowls, of which he keeps a large number. In 1872–3–4, detachments of my Native Contingent were stationed at Paeroa and Nihootekiore, and at both these places my fowls mixed with the Weka, and several small broods of hybrids were produced. I have never known this

* "Birds of New Zealand," pp. 165-169.

† "Ibis," Jan., 1874.

‡ "Trans. N.Z. Institute," Vol. VI., p. 133.

to happen in the case of large well-bred fowls, but rather with those of a very inferior type, such as are generally seen at Native villages.

"The specimens I observed most closely were some belonging to two Native chiefs at Wairoa, Aporo and Waretini. I several times had these birds in my hands, for they were quite tame. I remarked that in all cases they were female birds, smaller than the hens they had been hatched under, and presenting mixed characters, those of the Weka largely predominating. They had the head and body more elongated than in ordinary fowls; there was a total absence of comb; and the wings, which were feebly developed, had a covering of hairy feathers of a rich reddish-brown, transversely marked with black, as in the true Weka. The tail also was short, and like that of a Rail. I further remarked that these birds walked about after the manner of the Weka, in a peculiar furtive and prying way, with the head carried low. *Ocydromus earli* is very common in the district I have mentioned, particularly in the vicinity of Native cultivations on the edge of the forest. I fancy the fowls have been lost in the thickets, and, being separated from the male birds of their own kind, had consorted with the Weka, and produced a hybrid form. I may add that on one occasion, at Tauranga (in March, 1868), I observed two Wekas running with some tame fowls in a Native clearing. There could be no doubt about this, because I shot both Wekas from the door of a pataka. I have written to my nephew, Mr. Fraser, to procure me a specimen of this interesting bird, and will also put myself in communication with Aporo Whare-kaniwha, who may still possess some of them."

To the above I may add the following note, received to-day from Mr. T. E. Young, of the Native Department:—

"I have seen two birds at Otaki, running among the common fowls at the hotel there, which I was informed were a cross between the common fowl and the Weka. The feathers appeared to be more like hair, and very thick, of a brownish-grey colour.

"Wekas are heard every night in the neighbourhood.

"I was informed a few years ago, by a settler at the Upper Hutt, that the Wekas bred with his fowls. The Wekas were then very abundant in the neighbourhood."

XXXVII.—*Insect Architecture, or notes on the habits of the Black Spider-wasp of New Zealand.* By Walter L. Buller, C.M.G., Sc.D., President.

Plate III.

[*Read before the Wellington Philosophical Society, 11th November, 1876.*]

Among the *Hymenoptera* in New Zealand, the *Pompilidæ* are represented by two recorded species—*Pompilus fugax* and *P. monarchus;* but, as the descriptions are not at present accessible here, I cannot say with any certainty to which of these species (if either) the specimen which I exhibit this evening is referable. My object, however, in bringing the subject under the notice of this meeting, is not so much the identification of the species, which will follow in due course, but rather to call attention to some very interesting facts in the natural history of this Native Wasp, and more particularly as bearing on the study of insect architecture.

In his remarks on the *Hymenoptera*, Kirby says: "The functions which are given in charge to the several members of this Order are various. Some, like the predaceous and carnivorous tribes of the *Diptera*, appear engaged in perpetual warfare with other insects; thus the wasps and hornets seize flies of every kind that come in their way, and will even attack the meat in the shambles; the Caterpillar-wasp *(Ammophila)* walks off with caterpillars, the Spider-wasp *(Pompilus)* with spiders, and the Fly-wasp *(Bembex)* with flies. But the motive that influences them will furnish an excuse for their predatory habits. They do not commit these acts of violence to gratify their own thirst for blood, like many of the flies, but to furnish their young with food suited to their natures. The wasp carries the pieces of flesh she steals from the butcher to the young grubs in the cells of her paper mansion. The other wasps I have mentioned each commit their eggs to the animal they are taught to select, and then bury it; so that the young grub, when hatched, may revel in plenty."*

The family *Pompilidæ*, or Spider-wasps, of which about 700 species are known, have a wide geographical range, extending from the temperate regions to the tropics, the genus *Pompilus* alone containing some 500 recorded forms. The whole group, it would appear, are parasitic in their habits, and, in depositing their eggs in their skilfully-constructed cells, they take care to lay up a store of spiders' bodies by way of provision for a future family. The manner of doing this will be presently described.

* "History, Habits, and Instincts of Animals," p. 241.

The Black Spider-wasp of New Zealand, like many of its congeners, is an accomplished builder in clay. On this account it is generally known as the "Mason Bee;" but this name is wrongly applied, inasmuch as the Mason Bees *(Osmia)* form a very distinct section of themselves. They also construct clay houses with much skill and ingenuity, or form tunnels and burrows underground, but, like true and orthodox bees, they lay up a supply of pollen or honey in their cells for the nourishment of their larvæ.

The nest which I have now the honor to place before the Society, and a vertical section of which is shown in the accompanying sketch (Fig. 1, Plate III), is a fair sample of the way in which the Black Spider-wasp constructs a habitation for her family. The masonry is firm and compact, the walls as well as the interior partitions, dividing one cell from another, being formed of yellow clay, which hardens by exposure to the atmosphere. The exterior surface is finely corrugated, or covered with minute striæ, presenting a vermiculated appearance; and the whole structure, before being closed up and hermetically sealed, is very neatly finished. On opening the nest by making a longitudinal cutting, it is found that each cell, which is completely shut off from the adjoining ones, contains one or more spiders, not lifeless but apparently in a state of unconscious torpor, and performing their last offices in the economy of insect-life, which is patiently to await the hatching of the parsitic grub, and then to supply the larder with their own bodies. I have not been able to watch the hatching operations of this insect; but, judging from what we know of its allies, we may, I think, conclude that the Spider-wasp deposits its egg in or upon the body of its victim; that the larva hatches out in due time, and then feeds on the spider till it has attained its full size, when it spins itself a thin integument, or cocoon, and remains in an inactive state until the following Spring, when it completes its transformations.

In the specimen of the nest now exhibited, the cocoon stage has been reached, and of the original spider-stores nothing is left but the shrivelled remains. This nest was taken on the last day of October, from the outer wall of a house on Wellington Terrace. It was found, among many others, in the wall-chinks, behind a verandah-panel, the situation having become exposed in the course of necessary repairs to the building. The cocoons are sometimes oval, sometimes elliptical in form, and of a yellowish-brown colour.

The spiders captured and stored in the manner mentioned are not killed, but are rendered insensible by the injection of some occult poison from the body of the Wasp. The sting of the insect appears to penetrate the nervous centres, and to paralyze the victim without depriving it of life, so that it may exist in a comatose or torpid state for many weeks, or till required to furnish living food for the future grub. Caterpillars, after being stung by the Caterpillar-wasp (*Ammophila*), will transform into chrysalids, though too weak to change into moths. A writer in South Africa, Mr. Gueinzins, observes that "large spiders and caterpillars become immediately motionless on being stung; and I cannot help thinking that the poisonous acid of *Hymenoptera* has an antiseptic and preserving property; for caterpillars and locusts retain their colours weeks after being stung, and this, too, in a moist situation under a burning sun." So potent is this animal poison, that it enables another member of the same group, *Pompilus formosus*, which inhabits Texas, to paralyze with a single sting that immense Tarantula, the *Mygale hentzii*, known as the Bird-killer. Having inserted its egg in the body of this huge spider, it proceeds to bury it in a nest dug out of the ground to the depth of five or six inches. There is a tropical species belonging to the genus *Ampulex*, which inhabits Zanzibar, and oviposits in the body of the cockroach; and the dead bodies of the cockroaches are often found with the empty cocoon of the Wasp occupying the cavity of the abdomen. An observer, who has watched the attacks of this Wasp, writes:—"The cockroach, as if cowed at its presence, immediately yields without a struggle. The *Ampulex* stings and paralyzes its victim, and then flies away with it."

Like many of the allied species, our Black Spider-wasp, whilst engaged in nest-building, and likewise when manipulating the spiders, emits a continuous buzzing sound, similar to that of a large house-fly entangled in a web. In its other habits, I am not aware that it differs in any respect from its congeners, Like the *Pompilus formosus*, or Tarantula-killer, just mentioned, it appears to feed upon the honey and pollen of native flowers, and its favourite nourishment is taken from the fragrant blossoms of the Kahikatoa (*Leptospermum scoparium*), or tea-tree scrub of the colonists.

The following communication, under the head of "Notes on the Mason Bee," was made to the Auckland Institute, by Major Mair, R.M., on the 14th June, 1875, and I have obtained his permission to embody it here. I ought to add, however, that Major Mair expressed a doubt as to whether he was right in designating the insect a Mason Bee:—

"The accompanying account, clipped from a newspaper, agrees to some extent with my own experience of the habits of this insect, but here they confine their nests to wood-work. I first observed them building in my verandah in December last, and now (April 17th) they are still at work. Numbers of nests have been made in the crevices between the shingles and under the edges of the weather-boarding. In two instances, auger-holes in the wall-plates have been utilized. The latter have been broken and resealed several times. I have seen nests four inches long, with a diameter of three-quarters of an inch, containing six cells in a single row; but they are seldom found in places from which they can be easily removed, and are so fragile, that, after many attempts, I have only succeeded in getting one nest in anything like good preservation. I have not seen any with the cells in pairs. Upon opening a nest, the grub (one in each cell) may be found half coiled round the body of a spider which it is devouring. These spiders, though apparently lifeless, are not dead. The old nests contain the heads and legs of spiders, but in no instance have I met with any other insect in them. I can hardly believe that this remarkably fly is indigenous, though it may be closely allied to the one that captures small insects promiscuously and buries them in the ground, I suppose for the same purpose :—

"Last summer, a correspondent at Marton drew attention to a fly which attacked, and apparently killed spiders; and another, who seemed to know the insect, stated it to be an Ichneumon fly. This year they are not so numerous; but ample opportunities have been afforded for observing their habits, and it appears that they have also the character of Mason Bees, or Wasps. They construct nests consisting of a double row of cells, each of which is about a quarter of an inch in diameter, and half an inch deep. These cells are composed of clay, which the fly collects; and while forming them it emits a shrill sound like that of a blowfly entangled in a spider's web. As soon as a couple of cells are completed, the fly crams each of them full of spiders, alive, but apparently paralysed, and along with them, or in one of them, deposits an egg, which in a short time becomes a grub, resembling a bee or wasp grub, that devours the spiders. As the cells are filled, they are closed with clay, which forms the bottom of a second pair, and so the process goes on till a nest several inches long is formed and stocked with its living inmates. The nests are built against the angles of ceilings, rafters of verandahs, and other sheltered places, and a favourite situation seems to be the folds of a cloth, or other similar articles. In some houses as many as a dozen or more such nests have been destroyed this summer; and a survey-party working a few miles inland, have been quite annoyed by the insects, three or four nests per day having been built in the spare garments of the party, or in the folds of the bag which held their bedding and provisions. The fly is of a dark grey colour, almost black, and about the size of an ordinary bee, but rather longer and thinner. The walls of the cells are about a sixteenth of an inch thick, so that the insect, which, after devouring its stock of food, no doubt changes from a grub into a chrysalis, and thence into a perfect fly, will have no difficulty in breaking out of its prison. The fly is indigenous, but from some cause evidently on the increase, and seems quite harmless to anything but spiders."

On the same subject, Captain Gilbert Mair has lately furnished me with the following notes :—

"In January, of the present year, a Mason-wasp commenced building its nest inside a small hut at Tauranga. It plastered it obliquely on the inner partition above a bedstead. When the door was closed, the Wasp made its ingress through a small hole in the window every few minutes, loaded with a little ball of damp mud which it carried in its feelers, all the time making a loud buzzing noise. It continued its building operations till the end of March, when the nest, which consisted of a single row of cells, had reached a length of sixteen inches. It was round on the outer surface, three-quarters of an inch in diameter, and marked with longitudinal stripes. It contained twenty separate cells, in each of which were a number of small brown spiders in a torpid state, and one or more of the Wasp's eggs. Upon the completion of each cell, the Wasp flew to a paling-fence, over which it hovered in search of a victim, on capturing which it immediately pierced it in the back. It might then be seen proceeding, tail-first, in the direction of the house, tugging lustily a spider more than its own weight, which it would drag along the ground, up the side of the house, and through the aperture to its nest, in spite of every obstacle. Unfortunately, the nest was knocked down and broken into many pieces. The spiders were still alive, though they had been imprisoned for several months. I believe this insect to be indigenous to New Zealand, for I observed some capturing spiders in a similar manner in 1857, but they appeared larger, and were of a more brilliant black than the attenuated specimens now in the Museum."

I feel no doubt myself that the species is indigenous, being quite familiar with it in this district, and having, I believe, met with it in the North more than twenty years ago. But, for some unexplained reason, it makes a sudden appearance in great numbers at one season, and becomes scarce in the next, as though its occurrence were determined by fitful or irregular migrations from one part of the country to another. Major Mair, in writing to me only a few weeks ago, says he does not remember seeing many of them last summer, although they were so very abundant the year before. This summer, again, they are as numerous as ever in the Waikato.

Fig. 2, Plate III., in the accompanying sketch, represents the outer surface of the Spider-wasp's clay nest.

Art. XXXVIII.—*Note on the Maori Rat.* By Captain F. W. Hutton, C.M.Z.S.

[*Read before the Otago Institute, 24th October, 1876.*]

Plate III.

In the collection obtained by Mr. Booth from the Maori cooking-places at Shag Point, were several skulls and other bones of the Maori Rat. These skulls differ considerably from those of *Mus decumanus,* and it is remarkable that they all have the teeth ground quite flat, exactly as in old Maori skulls.

These skulls resemble very closely the figure and description of the English *Mus rattus* given by Mr. Salter in the "Pro. Lin. Soc," 1862, Zoology, p. 66; but they differ from it in the following particulars:—

They are much smaller. The nasal bones are not so obtuse at the anterior end; there is a slight process projecting backward from the anterior edge of the zygomatic fossa; the ridges on the frontal bones are widely bowed out and extend backward quite across the parietal bones, but become very small posteriorly; the foramen magnum is higher in proportion, and strictly pentagonal in outline; the foramen ovale is considerably larger than the foramen rotundum; the posterior nares are longer, a line from the front edge of the zygomatic arch crosses them slightly in front of the centre. (See Plate III.)

These differences appear to be sufficient to distinguish the Maori Rat from English specimens of *Mus rattus.* It will be interesting to compare these skulls with specimens of the Black Rat from Polynesia, for they will probably be found to be identical.

The following are the more important dimensions of the skulls from Shag Point:—

Length	1·37 inch.
Width at zygomatic arch	·85 ,,
Foramen magnum, height	·17 ,,
,, ,, width	·23 ,,

The Black Rat described by Dr. Buller under the name of *Mus novæ-zealandiæ,** and the one described by myself,† seem to be larger than the present specimens; they probably belong to the true *Mus rattus.*

I have compared the lower jaws of the rats from Shag Point with those from the Earnscleugh Cave, and I find them to be identical. The Earnscleugh Cave rat is therefore not *Mus decumanus,* and the argument that I drew from the remains of these rats as to the recent age of the remains of *Clangula finschi, Cnemiornis,* and *Dinornis* in this cave,‡ falls to the ground.

* "Trans. N.Z. Inst.," Vol. III., p. 1.

† "Trans. N.Z. Institute," Vol. IV., p. 183.

‡ "Trans. N.Z. Institute," Vol. VII., p. 138.

ART. XXXIX.—*Notes on the New Zealand* Delphinidæ. By Captain F. W. HUTTON, Director of the Otago Museum.

[Read before the Otago Institute, 4th July, 1876.]

A. Head beaked.

DELPHINUS NOVÆ-ZEALANDIÆ.

D. novæ-zealandiæ, Quoy et Gaimard, "Voyage '*Astrolabe*,'" Zool., I., p. 149, Pl. 28, Fig. 1. *D. delphis*, Forster (nec L.), "Descriptiones," etc., p. 280. *D. forsteri*, Gray, "Voyage '*Erebus*' and '*Terror*,'" p. 42, Pl. 24 (copied from Forster). *D. fosteri*, Hector, "Trans. N.Z. Inst.," Vol. V., p. 158, Pl. III.

Beak at least half the length of the gape. Pectoral fins shorter than the gape. Teeth, $\frac{43-44}{44-47}$. Above, brown; below, white; the white extending above the eye; caudal, dorsal and pectoral fins dark, the dorsal and pectorals with a large white blotch. Length, about six feet.

Habitat: The North Island of New Zealand as far as Cook Strait, Tasmania, and the sea between Norfolk Island and New Caledonia. Forster gives the *habitat* as the Pacific Ocean.

A careful comparison of the descriptions and figures of Quoy and Gaimard, with those of Forster, leaves no doubt as to the identity of *D. fosteri* with *D. novæ-zealandiæ*.

B. Head not beaked.

CLYMENIA OBSCURA.

Delphinus obscurus, Gray, "Spic. Zool.," Vol. II., Pl. 2, Figs. 2, 3; Quoy et Gaimard, "Voyage, '*Astrolabe*,'" Zool., Vol. I., p. 151, Pl. 28, Fig. 3. *Clymenia obscura*, Gray, "P.Z.S." 1866, p. 215, and 1868, p. 147, Fig. 1; Hector, "Trans. N.Z. Inst.," Vol. V., p. 160.

Head not beaked; dorsal fin falcate; pectorals longer than the distance from the muzzle to the eye. Teeth, $\frac{24-28}{24-26}$. Back and fins blackish, muzzle and belly white; a white band from below the dorsal fin sloping obliquely downward and backward towards the tail. Length, about five feet; teeth, five in an inch.

Habitat: Not uncommon in Cook Strait. The original type is from the Cape of Good Hope, but in his synopsis of the whales and dolphins, Dr. Gray gives the South Pacific as the *habitat*. Dr. Gray has referred *D. cruciger*, Quoy et Gaimard, and *D. bivittatus*, Lesson ("Voyage, '*Coquille*'"), to this species, but they are certainly distinct, having white pectoral fins. They come from Cape Horn.

TURSIO METIS.

T. metis, Gray, "Zool." '*Erebus*' and '*Terror*,'" p. 38, Pl. 18 (skull); Hector, "Trans N.Z. Inst.," Vol. V., p. 162; Hutton, "Ann. Nat. Hist.," 1875, p. 357, and Fig.; "Trans. N.Z. Inst.," Vol. VIII, p. 180.

Beak rather less than one-third of the gape. Pectorals equal to the distance between the muzzle and the eye. Teeth, $\frac{22-23}{21-23}$. Above and upper jaw, dark slate-blue, passing gradually into white below; fins, slate-blue; length, seven to ten feet; teeth, two to three in an inch.

Habitat: West Coast Sounds to Cook Strait.

This species was founded by Dr. Gray on a skull brought home by the Antartic expedition of the "*Erebus*" and "*Terror*," without a *habitat*. Subsequently in his supplement to the "Catalogue of Seals and Whales," he gave West Africa as its *habitat*, probably by mistake. In 1872 Dr. Hector determined a skull found in Dusky Bay as belonging to this species, and the subsequent capture of specimens by Captain Fairchild showed that he was right, and that the skull had been correctly referred by Dr. Gray to *Tursio*.

ELECTRA CLANCULA.

Lagenorhynchus clanculus, Gray, "P.Z.S.," 1849, p. 2. *Electra clancula*, Gray, "Synopsis of Whales and Dolphins," p. 7, Pl. 35 (skull), Hector," Trans. N.Z. Inst.," Vol. V., p. 160, Pl. (not good).

Head not beaked; dorsal fin truncated; pectorals slightly longer than the distance from muzzle to eye. Teeth, $\frac{31-33}{31-32}$. Above, pale grey. Lower jaw, throat, and belly white, the white on the belly being divided by a transverse band of grey just behind the pectoral fins; nose and forehead white; a white band from beneath the dorsal sloping obliquely upwards and backwards towards the tail; sides of the head, a transverse band just behind the blow-hole, and pectorals, dark slate-gray; the dark band behind the blow-hole shading off gradually behind; length, four to five feet; teeth, five in an inch.

Habitat: Abundant all round the coasts of New Zealand; South Pacific Ocean.—(Gray.)

In the "Trans. N.Z. Inst." Vol VI., p. 89, Dr. Gray gives *D. superciliosus*, Lesson, as a synonym of this species. Previously, in his "Catalogue of Seals and Whales," he had given it doubtfully as a synonym of *Clymenia obscura*. But it is evidently quite distinct from either *C. obscura* or *E. clancula*, for it is a beaked species, and looks like a *Tursio*. It was observed by Lesson off Cape Horn.

ART. XL.—*On the New Zealand Earth-worms in the Otago Museum.*

By Captain F. W. Hutton, C.M.Z.S.

[*Read before the Otago Institute, June 6th, 1876*]

Plate VII.

I am not aware that any earth-worms have been as yet described from New Zealand, except *Megasolex antarctica*, Baird ("Pro. Lin. Soc.," Vol. XI.,

p. 96), a large species seven inches long, and I offer the following as a contribution towards a better knowledge of them.

LUMBRICUS ULIGINOSUS, sp. nov.

Plate, Fig. A.

Length, eight or nine inches; colour reddish; body thick, cylindrical, and slightly tapering in front; quadrilateral behind. Setæ rather short and thick, in four rows, each row consisting of an approximated pair of bristles. Segments from 180 to 200; clittellum large, but not very distinct, composed of six segments, from fifteen to twenty. Male genital openings in two pairs, situated on the ninth and tenth segments respectively. Vulvæ large, on the three last segments of the clittellum. Cephalic lobe large and rounded, completely dividing the buccal segment superiorly into two parts, and with a transverse sulcus on the posterior superior portion, between the divided halves of the buccal segment. Anterior margin of buccal segment deeply emarginate inferiorly.

Habitat: Dunedin, in peaty ground.

LUMBRICUS CAMPESTRIS, sp. nov.

Plate, Fig. B

Length, two to three inches. Colour reddish, or olivaceous-green, paler below. Clittelum red, or reddish-brown. Body cylindrical and tapering in front, subquadrate, and tapering behind. Setæ in four double rows, each row consisting of a rather distant pair of bristles. Segments, 100 to 140. Clitellum generally conspicuous, of five or six segments; its position irregular, commencing on any segment between ten and twenty. Male genital openings on the ninth segment. Vulvæ on the two last segments of the clitellum. Cephalic lobe large, sub-conical, completely dividing the buccal segment superiorly into two parts. Anterior margin of buccal segment entire, or slightly eroded inferiorly.

Habitat: Dunedin and Wellington. Common. A very variable species. The olivaceous specimens occur in the bush.

LUMBRICUS LEVIS, sp. nov.

Plate, Fig. C.

Length, three to four inches. Pale flesh colour. Body cylindrical, tapering in front. Setæ feeble, in four rows behind the clitellum, absent before the clitellum. Segments, 130 to 150; the first thirteen simple or bi-annulate, the remainder tri-annulate. Clitellum conspicuous, brownish-red, composed of six or seven segments, commencing between the fifteenth to twenty-fifth. Male genital openings on the tenth to fifteenth segment. Vulvæ on the two last segments of the clitellum. Cephalic lobe, small, conical, simple. Anterior border of buccal segment slightly emarginate superiorly, entire inferiorly.

Habitat: Dunedin and Hampden, in gardens and fields. This species differs from *L. communis* in having no setæ before the clitellum, and in not having any tubercles on the sides of the clitellum.

A variable species, sometimes of a greenish hue. In the young the setæ are often found in front of the clitellum.

LUMBRICUS ANNULATUS, sp. nov.

Plate, Fig. D.

Length, about three inches. Colour, pale brownish-red; each segment with a dark reddish-brown transverve band in the centre; inferior aspect much lighter. Body cylindrical in front, sub-pentagonal behind, tapering to both ends. Setæ in four rows. Segments, 70 to 100, bi or tri-annulate. Clitellum, well marked, smooth, and shining, consisting of five or six segments, commencing at the twenty-sixth; not tuberculated inferiorly. Male genital openings in the sixteenth segment. Cephalic lobe, small and flattened, divided into anterior and posterior divisions inferiorly. Anterior border of buccal segment emarginate superiorly, entire inferiorly.

Habitat: Dunedin, in gardens.

In colour this species much resembles *L. fœtidus* of Europe, but is distinguished by the shape of the cephalic lobe, the position of the male genital openings, and the well-marked clitellum.

MEGASOLEX SYLVESTRIS, sp. nov.

Plate, Fig. E.

Length one and a half to two inches. Colour, dark red-brown. Body, cylindrical, tapering before and behind. Setæ, numerous, arranged in about thirty double rows all round the body. Segments, 70 to 80; bi-annulate. Clitellum, inconspicuous, composed of three segments, from fifteen to seventeen.

Male genital openings on the second segment behind the clitellum, and with a pair of elongated curved setæ in front of each. Cephalic lobe, small, flattened, with a deep transverse groove superiorly, and divided into anterior and posterior portions inferiorly. Anterior border of buccal segment, deeply excavated superiorly, entire inferiorly.

Habitat: Dunedin, in rotten wood in the bush.

MEGASOLEX LINEATUS, sp. nov.

Plate, Fig. F.

Length, two inches. Colour, reddish-brown, finely longitudinally striated with lighter. Body, cylindrical, tapering before and behind. Setæ, very minute, in simple rows all round the body. Segments 70 to 80. Clitellum inconspicuous, composed of four segments, from the fourteenth to seventeenth.

F. W. Hutton, del.

NEW ZEALAND EARTH WORMS.

J. B. lith.

Male genital openings on the second segment behind the clitellum, without any specialised setæ in front of them. Cephalic lobe, small, rounded, completely dividing the buccal segment superiorly into two parts. Anterior border of buccal segment, slightly emarginate inferiorly.

Habitat: Queenstown, under dead leaves.

EXPLANATION OF PLATE.

First four segments of New Zealand Earth-worms:—*a*, viewed from above; *b*, viewed from below; *c*, viewed from the right side; *d*, transverse section behind clitellum.

ART. XLI.—*Contributions to the Ichthyology of New Zealand.* By Captain F. W. HUTTON, Director of the Otago Museum.

[Read before the Otago Institute, 5th September, 1876.]

SCORPIS HECTORI, Hutton.

Dr. Günther has identified this fish with his *Anthias richardsoni*, and it is also certainly the same as *Perca lepidoptera*, Forster ("Desc. Anim.," p. 138); so its name will have to stand *Anthias lepidoptera*. I agree with Dr. Hector in separating *A. fairchildi;* I should have done so, but was doubtful of the true form of the original specimen of *S. hectori*, which had been preserved in carbolic acid and dried.

PAGRUS UNICOLOR, Quoy and Gaim.

To this species belongs *Sciæna aurata*, Forster.

MENDOSOMA LINEATA.

Sciæna lineata, Forster, is identical with *Latris hecateia*, Richardson; so that this species should stand, *Mendosoma lineatum*, Gay.

LATRIS ÆROSA, sp. nov.

B. 6, D. 15 | $\frac{1}{42}$; A $\frac{3}{35}$; L. Lat. 116; L. Trans. 10/32.

Length, three times the height, or three and three-quarter times the length of the head. No teeth on the vomer or palatine bones. Top of the head and cheeks, scaly; snout, naked. Nine simple pectoral rays. Above, coppery. Lateral line, and one or two irregular narrow streaks above it, lead-blue. Pectoral, anal, dorsal, and caudal fins, reddish-brown; blackish at the tops. Belly, silvery.

Habitat: Otago Heads.

Type stuffed in the Otago Museum. This fish has the same fin formula as *L. bilineata*, Castlenau, but it differs both in form and colour, and has no prolonged filament from the fourth anal ray.

SEBASTES PERCOIDES, Solander.

To this species belongs *Scorpæna cottorides*, Forster.

GASTEROSTEUS PUNCTATUS, Forster. (*Scomber punctatus*, Bl. Schn.)

This species has not been recognized since Forster's time.

Auchenopterus compressus, Hutton.

I think that this fish is the same as *Trypterygium fenestratum*, Forster.

Trypterygium nigripenne, C. and V.

This is the same as *Blennius varius*, Forster.

Trypterygium forsteri, C. and V.

This is the same as *Blennius tripennis*, Forster. A specimen of this fish, obtained near Dunedin by Mr. Bourne, is in the Otago Museum. It is quite distinct from *T. nigripenne*, and easily distinguished by its large scales.

The fin formula of the specimen is—

D 3 | 16 | 13, A 23; L. Lat. 40; L. Trans. 6/12.

Cyclopterus littoreus, Forster.

This species has not since been identified.

Labrichthys psittacula.

This is the same as *Sparus rubiginosus*, Parkinson (*Julius (?) rubiginosus*, Rich., 1843), and *Labrus coccineus*, Forster (1844). As Dr. Günther has shewn that our fish is not identical with the type of the species from Tasmania, its name must be changed; and as Parkinson's name has been used by Schlegel for a fish from Japan, it will be better to adopt Forster's name for ours. I cannot agree with Dr. Günther that our fish may be the adult of *L. celidota*, because I have seen specimens of *L. coccinea* smaller than well-marked specimens of *L. celidota*; and the stations of the two are very different.

LABRICHTHYS CINCTA, sp. nov.

D $\frac{9}{11}$; A $\frac{3}{10}$; L. Lat. 25; L. Trans. 3/9.

A small posterior canine. Cheeks with five rows of scales. Caudal, truncated, slightly rounded in the centre. Purplish-grey, getting darker on the back and head; a broad black transverse band on the body behind the tips of the pectorals, passing on to the dorsal between the sixth and eighth spine.

Habitat: Coasts of Otago.

Rare. Type stuffed in the Otago Museum. This species differs from *L. richardsoni*, Castlenau, in having five series of scales on the cheeks, and no black spot on the extremity of the operculum, as well as in general colour.

Monacanthus convexirostris, Günther.

This is certainly the *Balistes scaber* of Forster.

ART. XLII.—*Contributions to the Entomology of New Zealand.* By F. W. HUTTON, Director of the Otago Museum.

[Read before the Otago Institute, 24th October, 1876.]

THE following notes embody the result of the work done in the Otago Museum during the past year towards obtaining a better knowledge of the habits of our insects. Owing to the lateness of the season when we commenced, these results are not so numerous as could be wished, but I hope next year to present you with a larger budget. The larvæ were all collected and reared by Mr. F. J. Bourne, Museum Assistant. I am also much indebted to Mr. R. W. Fereday for assistance in determining several of the species, especially those named by M. E. Guenée.

PYRAMEIS GONERILLA, Fabr.

Caterpillar.—Back, black or brown, with numerous white dots; two interrupted yellow lines down each side. Under surface, brown, with white dots. Each segment with five elevated setose papillæ. Head, hairy, variable in colour. Legs, black or greenish, with black rings. Pro-legs and dorsal papillæ, bright green. Spiracles, edged with white. Length, one inch.

Chrysalis.—Pale brown, finely veined with black. Dorsal surface with six golden spots in two rows. Anterior end with two projecting points. A compressed dorsal spine on the thorax, two lateral ones on each side; each segment of the abdomen with a pair of dorsal spines.

Hatches in December, feeds for a month or six weeks everywhere, spins a slight web suspended from its food, and changes to a chrysalis in January or February. The perfect insect appears in January, February, or March.

NYCTEMERA ANNULATA, Boisd.

Caterpillar.—Hairy. Dark velvetty-black, with three longitudinal stripes of reddish-orange. Each segment with eight tufts of long black hairs, two between each of the red stripes. Head and legs, black. Length, one inch.

Chrysalis.—Blackish-brown, each ring on the dorsal surface with a row of large, yellowish, rectangular blotches, each of which is partly divided into two in front; three of these blotches in each segment. Head and last segment, dark brown. Below, the abdominal segments are marked as on the back. Sternal elements, dark brown, with longitudinal linear markings of yellow.

Hatches in November, and feeds for four or five weeks. Feeds on groundsel in preference to any native vegetation. Chrysalis hung to trees, palings, grass, etc. Moth appears in midsummer.

Porina variolaris, Guenée.

Caterpillar.—Smooth, shining, about two or two and a half inches in length. Pale yellowish-brown, each ring with four annulated brown spots, from each of which arises a long hair. The two anterior of these spots are larger, and placed nearer together than the others. These marks are not found on the three anterior segments, which are darker than the others. Last segment but one, with a row of four occellated spots anteriorly, and seven posteriorly. Sides, head, legs, and pro-legs, with a few scattered long brown hairs. Spiracles, margined with black.

Chrysalis.—Light reddish-brown, with a few scattered brown hairs. Each segment with two rows of small, flattened, triangular teeth pointing backward on the dorsal surface. The last segment but two, with a stronger row of teeth on the ventral surface. Spiracles, darker.

Hatches in January to March, lives underground, and feeds on wood and roots of plants. Feeds through the autumn and winter, and changes to a chrysalis in November. The chrysalis is found from two to six inches below the surface. The moth appears in December, January, and February.

A considerable number of this species have been reared in the Museum, and although they varied slightly, none were like *P. signata*. I, therefore, think that Mr. Butler is wrong in uniting the two species.

Declana floccosa, Walker (?).

Caterpillar.—Brown, slightly vermiculated with yellowish; a very few scattered black hairs. A pair of small tubercles placed transversely on the penultimate segment. Two pairs of pro-legs only. Skin, rather rough, and produced along each side below the spiracles into a row of pectinated tufts. Length, one inch.

Feeds on *Aristotelia* and *Ulex*. The moth hatched out on 12th July, after having been nearly two months underground.

Nitocris comma, Walker.

Caterpillar.—Smooth, with a few scattered whitish hairs, which are most abundant on the head and legs. Brownish-grey, mottled with darker; two irregular longitudinal bands of lighter down the back, and a similar band on each side; ventral surface, paler, yellowish-brown; legs, pale yellow; jaws, rich brown; head, black. Length, rather more than an inch.

Chrysalis.—Light red, slightly marbled on the back with brown. Feeds on groundsel, grass, garden vegetables, etc. Spins a cocoon about one and a half inches under the earth at the end of November. Moth appears in January. The caterpillar is a great pest in gardens.

Euplexia insignis, Walker (?).

Caterpillar.—Purplish-grey, longitudinally marked with darker; a greyish-white line down the middle of the back. Generally with a small yellow spot, sometimes with a black centre, on each side on every segment. Sometimes with an irregular dash of black above each spiracle. A few scattered hairs on the back. Length, 1·5 inch.

Feeds on *Clematis* and *Aristotelia.* Moth appears in September, and lays pale-green eggs.

Hadena lignifurea, Walker.

Caterpillar.—Brown, or olive-brown, variegated with blackish-brown; under surface, pale olive-green; a white or pinkish lateral line below the spiracles, and above it on the anterior part of each segment, an oblique black line sloping downwards and backwards. Head, brownish-olive, with scattered hairs. Legs and pro-legs, yellowish-olive. Smooth, with a few scattered pale hairs. Length, 1¼ inch.

Chrysalis. — Smooth, round; light red, abdominal segments rather darker; the anterior part of each segment brown, and with a band of shallow punctures.

The caterpillar changes into a chrysalis in February, and the moth appears in January, February, and March.

This species differs from *H. mutans* by always having a short, longitudinal, basal black stripe on the anterior wings.

Anchmis composita, Guenée.

Caterpillar.—Reddish-pink, with fine longitudinal black bands; under-surface, pink. Head and first segment, pale yellow marked with black; legs, pale yellow; pro-legs, yellow tipped with black; claspers, yellow. A few scattered yellowish hairs; head, smooth. Length, ¾ inch.

Feeds on grass. The moth comes out from January to March.

Ninety-seven individuals of a small undescribed Ichneumon came out of a single caterpillar of this species.

Asthena subpurpureata, Walker.

Caterpillar.—Pale brown, longitudinally marked with darker; nearly smooth. A curved black mark, convex backwards, on the back, over the last pair of pro-legs. Length, 1·1 inch.

Feeds on the manuka (*Leptospermum ericoides*). The moth appears in March.

Hybernia boreophilaria, Guenée.

Caterpillar.—Grey, marbled with brown; two pairs of white spots margined with black on the dorsal surface of each segment. A few scattered black hairs. Legs and pro-legs pale. Length, 1 inch.

The moth is hatched in April.

Larentia semisignata, Walker.

Caterpillar.—Green, or yellowish-green; smooth, with a few scattered yellow hairs. A narrow yellow ring round the base of each segment. Length, ¾ inch.

Some of these caterpillars were obtained feeding on the common dock, others on the sow-thistle.

The moth appears in March.

Larentia corcularia, Guenée (?).

A moth very like this, but darker than the specimens sent me by Mr. Fereday, laid red eggs.

Eupithecia indicataria, Walker (?).

Caterpillar.—Brown, rough segments transversely corrugated. The sixth, seventh, and eighth segments with a pair of dorsal papillæ; those of the seventh segment much larger than the others. Length, ·65 inch.

Feeds on *Clematis indivisa.* The moth comes out in April.

Coremia robustaria, Walker (?).

Caterpillar.—Shining, brown marbled with grey. A large tubercle on the back with a small one in front of it. Length, 1·1 inch,

Feeds on the Kahikatoa (*Leptospermum scoparium.*) Moth appears in March.

Coremia inamœnaria, Guenée.

The eggs of this species are yellow.

Pædicea privatana, Walker.

Caterpillar.—Pale yellowish-green, smooth, tuberculated, with scattered white hairs. Head brown; anal segment, brownish. Length, ½ inch.

Feeds on hawthorn, manuka, fuschia, and broad-leaf. Moth hatches in April.

Art. XLIII.—*Corrections and additions to the list of* Polyzoa *in the Catalogue of the Marine Mollusca of New Zealand (1873).*

By Capt. F. W. Hutton, Director of the Otago Museum.

[*Read before the Otago Institute, 5th September, 1876.*]

Catenicella geminata, Wyv. Thomson, "Nat. Hist. Rev.," 1858.

"Axial cell, geminate. The secondary cell developed alternately on either side of the axis. Axial cells, pyriform; a large gaping avicularium on the angle opposite the secondary cell; secondary cell giving off by a terminal horny tube a single wedge-shaped peripheral cell. Cell mouth, large; a deep notch in the centre of the lower lip. In the primary and secondary axial cell four or five blunt spines surround the upper margin of the mouth, which is surmounted in the peripheral cells by two longer ear-like processes. Front of cell tuberculated."

A small species epiphytic on red algæ.

New Zealand, Dr. Joliffe.

Catenicella carinata, Busk, "Voyage of '*Rattlesnake*,'" Vol. I., p. 363.

"Cells oval, narrowed at each end; lateral processes (without avicularia?) projecting horizontally outwards from the side of the aperture, which is nearly central. Mouth with a small tooth on each side, and below it a triangular space with three strong conical eminences. A few scattered papillæ on the surface of the sides and back. Ovicelligerous cells geminate."

New Zealand, Dr. Joliffe.

Menipea buskii, Wyv. Thomson, "Nat. Hist. Rev.," 1858.

"Cells, elongated, attenuated downwards, three in each internode. Cell-mouth, large, oval, oblique, the lower third filled up by a tuberculated calcareous plate; upper lip prolonged, and fringed with from four to five spines, attached to the lip by horny joints, and one of them, usually the second from the outer edge, very long, curved, and pod-like. There is often an additional spine on the upper and inner margin of the cell mouth. Operculum spine, strong and clavate, stretching upwards and outwards from the lower and inner lip of the cell-aperture. Connecting horny tube between the internodes, double. Ovicell, spherical, with a richly granular surface, imbedded among the cells, on the cavities of two of which it encroaches."

New Zealand, Dr. Joliffe.

Scrupocellaria scrupea, Busk, "Ann. Nat. Hist.," 2nd Ser., Vol. 7., p. 83.

"Operculum, reniform, entire, four or five marginal spines above."

New Zealand, Dr. Joliffe.

Salicornaria (?) *hirsuta*, "Cat. Marine Moll.," p. 91.

This is identical with *Cellaria hirsuta*, Lamx. Mr. Busk has made it into the type of a new genus of *Salicornariidæ*, under the name of *Onchopora*.

ONCHOPORA.

Cells, ventricose, coalescent; not bordered by a raised margin. Ovicells, inconspicuous.

Onchopora hirsuta, Lamx., "Hist. des Polyp.," cor., p. 126.

The corneous tubes are not vibracula as I supposed.

Bugula prismatica, Gray. (*Acamarchis.*)

Zoarium rather rigid, compressed, dichotomously branched, erect, reddish-brown. Cells, distant, alternate, cylindrical; aperture, entire, produced into a dentiform angle at the outer margin, from which a keel descends obliquely to the inner and lower corner of the cell. Ovarian cells, globular, white, situated in a single row on the front of the zoarium.

Motauau, Canterbury; and Ocean Beach, Dunedin, [F.W.H.]

Family, *Gemellariidæ.*

CALWELLIA, Wyv. Thomson.

Cells in pairs, joined back to back. Each pair of cells arising by tubular prolongations from the pair next but one below it. Each pair having a direction at right angles to the next. At a bifurcation, each cell of the primary pair giving off a secondary pair. Ovicell, sub-globular, placed immediately above and behind the posterior margin of the cell aperture.

Calwellia bicornis, Wyv. Thomson, "Nat. Hist. Rev.," 1858.

The only known species.

New Zealand, on *Catenicella hastata*, Dr. Joliffe.

Family, *Vincularidæ.*

Zoarium rigid, calcareous, unarticulated; cells disposed alternately round an imaginary axis, forming dichotomously dividing branches. Surface of polyzoary not areolated.

VINCULARIA.

Branches of zoarium not tubular; front of cells surrounded by a raised border, arcuate above, nearly straight below. Ovicells, immersed, opening above the mouth of the cell upon which they are placed.

Vincularia neo-zelandica, Busk, "Jour. Micros. Science," N.S., I., p. 155.

"Zoarium simple, rooted at the base by radical tubes; areæ of cells, sub-pyriform; anterior wall perforated; margins smooth; orifice arched above; lower lip with a broad central denticle."

New Zealand, Dr. Lyall.

Dimetopia spicata, Busk. This species is pink when alive.

Crisia eburnia, "Cat. Mar. Moll.," p. 100.

This is *C. patagonica*, D'Orb., "Voy. Amer. Mend.," Polypiers, p. 7.

"Cells 9–19, straight, very distinct; branches arising from second or third cell; joints black."

Crisia aculeata, "Cat. Mar. Moll.," p. 101.

This is *C. edwardsiana*, D'Orb., *loc. cit.*, p. 7.

Zooœcia two or three in an internode.

Homera gouldiana et *H. squamosa*, "Cat. Mar. Moll.," p. 101.

These two species belong to the genus *Retihornera*, as defined by Busk. *H. squamosa* is identical with *R. foliacea*, M'Gillivray. Mr. Busk thinks that his *H. gouldiana* belongs also to the same species, but I am inclined to keep them separate.

Idmonea radians, Lamark, "Hist. d. an. s. Vert.," 2nd ed., p. 279.

"Zoarium usually procumbent, stipitate, sometimes sub-erect; branches, dichotomous, radiating more or less regularly in a circular form from the centre, very angular in front; dorsal surface, perforated; cells, one to four in each series, the innermost the longest; aperture (when quite perfect) bi-labiate."

Idmonea marionensis, Busk, "Cat. Mar. Pol.," Vol. III., p. 13.

To this species, which was obtained off Marion Island at a depth of 80 fathoms, Mr. Busk refers *Crisina (?) hochstetteriana;* Stoliczka, found fossil at Orakei near Auckland.

Pustulipora delicatula, "Cat. Mar. Moll.," p. 102.

This is not the same as Mr. Busk's species. I am disposed to think that it is not a Polyzoan at all, but an Annelid. There is a specimen in the Otago Museum from Mauritius.

Pustulipora parasitica, Busk, *loc. cit.*, p. 21.

"Zoarium about a quarter inch high, usually formed of one to three branches, short and truncate; cells, usually deeply immersed, and very slightly prominent, except in very young specimens. Colour, brown, with white spots."

Always parasitic upon a species of *Catenicella*.

Pustulipora proboscidea, "Cat. Mar. Moll.," p. 102.

This is not Milne-Edwards' species. It may be called *P. purpurascens*.

P. porcellanica, Hutton.

The surface of fresh specimens is coarsely pitted, and the orifice is slightly raised.

Tubulipora glomerata, Hutton.

This may perhaps be identical with *T. fungia*, Couch, from Europe.

Tennysonia stellata, "Cat. Mar. Moll.," p. 103.

The species that I placed under this name is very different from Mr. Busk's, and perhaps does not belong to *Tennysonia* at all. It is intermediate between *Discoporella* and *Defranceia*. The zoarium is stipitate, broadly expanded, lobed, and curled. The cells are disposed in elevated branching rays, which form the denticulated margin of the lobe.

Discoporella hispida, "Cat. Mar. Moll.," p. 104.

This is not the *hispida* of Johnston. Mr. Busk has described it under the name of *D. ciliata*.

"Discoid; cells uni-serial, 4–6 in each row; diameter of mouth less than that of the interstitial cancelli; peristome, much produced on one side, nearly vertical, divided into several (2–4) long, acute, slender spines.

Discoporella novæ-zealandiæ, Busk, *loc. cit.*, p. 32.

"Discoid, cupped; cells, tubular, projecting, connate in uni-serial radii; peristome bifid; central area (unoccupied by cells) depressed; cancelli, large, becoming smaller towards the periphery."

On *Catenicella*, Dr. Lyall.

Art. XLIV.—*Corrections and Additions to the Catalogue of New Zealand* Echinodermata (1872).

By Captain F. W. Hutton, Director of the Otago Museum.

[*Read before the Otago Institute, October 31st, 1876.*]

Coscinasterias muricata, Verrill.

Specimens of this species taken to Europe by Dr. H. Filhol have been identified in Paris with *Asterias calamaria*, Gray.

Pteraster inflatus, Hutton.

This species belongs to the genus *Palmipes*.

Cidaris tubaria, Lam.

This is, I think, *Goniocidaris geranioides*, Lam. It is not the true *C. tubaria* of Lamark.

Strongylocentrotus tuberculatus, Lam.

This species is said by Mr. Agassiz to be found in New Zealand. I have seen no specimens.

Sphæechinus australis, A. Agass.

This species is said to occur in New Zealand by Mr. Agassiz. I have seen no specimens.

Echinus angalosus, Leske.

There are specimens in the Museum from Brighton, near Dunedin, collected and presented by Mr. G. M. Thomson.

Echinus albocinctus, Hutton.

This is the same as *E. magellanicus*, Phil.

Echinus chloroticus, A. Agass.

This belongs to the genus *Evechinus* of Verrill.

Echinus elevatus, Hutton.

This is *Amblypneustes formosus*, Val.

Laganum rostratum, Agass.

This belongs to the genus *Peronella*. It is doubtful whether it really is found in New Zealand.

Echinoneus ventricosus, Agass. and Desor.

This species must be omitted from our list.

Arachnoides zealandiæ, Gray.

Mr. Agassiz unites this to *Echinarachnius placenta*, L.

Amphidotus zealandicus, Gray.

Mr. Agassiz unites this to *Echinocardium australe*, Gray.

Art. XLV.—*Remarks on Dr. von. Haast's Classification of the Moas.*

By Captain F. W. Hutton, Director of the Otago Museum.

[*Read before the Otago Institute, October 24th, 1876.*]

In his Presidential Address to the Philosophical Institute of Canterbury, in March, 1874, Dr. von Haast gives his views as to the proper classification of the Moas,* dividing them into two families, each of which consists of two genera.

The first of these families, *Dinornithidæ*, is characterised by having no hind toe, by the bill being narrow and pointed, and by the metatarsus being comparatively long. The second family, *Palapterygidæ*, is characterised by having a hind toe, by the bill being obtuse and rounded at the tip, and by having the metatarsus short. This classification is given as the result of his researches, but, owing no doubt to the nature of the address, no proofs are adduced as to the correctness of his diagnoses, although they directly contradict some of the results of the researches of Professor Owen. Since the publication of this address, a large and very valuable collection of Moa remains has been brought together in the Otago Museum, and an examination of it has compelled me to reject Dr. von Haast's classification, and to agree on almost every point with Professor Owen.

In the first place none of the differences pointed out by Dr. von. Haast are sufficient, in my opinion, to warrant us in dividing the Moas into two families. The skeletons of all the species are remarkably alike. Between no two is there anything like the difference that exists between the skeletons of the Ostrich and the Rhea, which are always considered as belonging to one family. Nor is the difference so great as between the Emu and the Cassowary, which also belong to one family. The presence or absence of a hind toe, even if Dr. von Haast had been correct on this point, is by no means of sufficient importance to be used as a family character, for several families of birds contain genera both with and without hind toes. Neither can the absence or presence of a scapulo-coracoid be deemed of much importance in classification, for it is functionless or nearly so. Dr. Haast, however, uses this as a generic character only. Consequently we must, I think, consider all the Moas as belonging to one family, *Dinornithidæ*. Whether they should or should not be considered as forming one or more genera is a more difficult question in the present imperfect state of our knowledge of their anatomy. If, however, it should be thought advisable to divide them, many of the characters given by Dr. von Haast cannot be used.

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* "Trans. N.Z. Inst.," Vol. VI., p. 426.

In the collection of Moa remains in the Otago Museum there are five feet, and metatarsi of individual birds, in which the hind toe still remains. Of these two belong to *D. ingens*, one to *D. casuarinus*, and two to *D. gravis*. If to these we add *D. robustus*, the hind toe of which has been figured by Professor Owen,* we have four species in which the hind toe is known, and of these, three belong to Dr. von Haast's family, *Dinornithidæ*, one of the distinguishing characters of which is said to be the absence of a hind toe.

Next with regard to the shape of the bill. There is in the Otago Museum a nearly complete skeleton of *D. robustus*, obtained singly at Highly Hill. In this specimen the bill is exceedingly broad, rounded at the tip and somewhat depressed, exactly like that described by Professor Owen,† and Professor Owen has shown ‡ that the bill of *D. ingens* was of the same shape; whereas Dr. von Haast gives the diagnosis as "beak narrow and pointed."

Nearly all the Moa bones found at Shag Point belonged to *D. casuarinus* or *D. gravis*, but a few to *D. crassus*. None of the skulls had pointed bills. In the Hamilton Swamp the commonest species were *D. elephantopus* and *D. crassus*, and here we found several skulls, all larger than that of *D. crassus*, with pointed bills, and answering to that described by Professor Owen § as *D. elephantopus*.|| I am therefore inclined to think that Dr. von Haast is wrong in ascribing to *D. elephantopus* a bill very obtuse and rounded at the tip. At any rate I must think so until Dr. von Haast publishes the reasons for his opinion. A single small skull with a very pointed bill was found in the Hamilton Swamp. This, from its size, I agree with Dr. von Haast in ascribing to *D. didiformis*. In *D. crassus* the bill was obtuse and rounded, but more compressed than in *D. robustus*. This is proved by a skull and vertebral column from Shag Point, which agrees exactly with the skeleton from the Waitaki in the Otago Museum. I have already pointed out** that it is doubtful whether this skeleton should be referred to *D. crassus* or *D. elephantopus*; but since Professor Coughtrey identified the skull of *D. elephantopus* from the Hamilton Swamp, I am inclined to think that the Waitaki specimen must be *D. crassus*, and that it can be distinguished from *D. elephantopus* by the shape of the bill.

The sternum in *Dinornis* is a very variable bone, and often unsymmetrical. Those in the Museum belonging to *robustus*, *casuarinus*, *elephantopus*, and *crassus* agree very well with Dr. von. Haast's remarks. The sterna of *D. gravis*, however, from Shag Point, are not longer than broad, but resemble

* "Trans. Zool. Soc.," Vol. IV., p. 1.

† "Trans. Zool. Soc.," Vol. V., p, 344.

‡ *Loc. cit.*, Vol. VII., p. 142.

§ "Trans. Zool. Soc.," Vol. VII., p. 123.

|| Determined for me by Professor Coughtrey.

** "Trans. N.Z. Inst.," Vol, VII., p. 276.

that of *D. elephantopus* in miniature. Dr. von Haast also gives the existence of two sternal ribs only as a character of *elephantopus* and *crassus*; but the Waitaki skeleton, which certainly belongs to one or the other, has three sternal ribs articulating with the sternum on each side, like all the other Moas.

Again, Dr. von Haast has included *D. rheides* in his genus *Euryapteryx*, of which he tells us the metatarsi are short and broad; but the metatarsi of *D. rheides* are proportionately longer than those of *D. casuarinus* or *D. didiformis*.

It is hardly necessary to remark that no difference in structure, such as Dr. von. Haast supposes to exist between the bones of what he calls *Palapterygidæ* and *Dinornithidæ*, can be made out. The differences mentioned by Dr. von. Haast are found among all fossil bones.

It is evident, therefore, that if the Moas are to be divided into two or more genera, Dr. von Haast's classification will have to be modified. His genus *Euryapteryx* is quite unnecessary, as *D. rheides* should go with *D. didiformis*, and *D. gravis* with *D. crassus*. If the Moas are to be classed by the relative proportions of their metatarsi, then perhaps the three other genera of Dr. von Haast might stand, but the name *Palapteryx* must, according to the rules of zoological nomenclature, be given to the *ingens* group, that of *Dinornis* to the *elephantopus* group, while *Meiornis* will remain for *rheides* and *didiformis*; but this appears to be hardly necessary. If, however, the shape of the bill be taken as the more important character, then *Palapteryx* would remain as before; but *elephantopus*, *rheides*, and *didiformis* would have to be brought into one group, and *crassus*, *casuarinus* and *gravis* into another. On the whole, I am inclined to agree with Professor Owen that one genus is sufficient for our present information.*

Art. XLVI.—*On a second discovery of Moa-bones at Hamilton.*†

By Mr. B. S. Booth.

[Read before the Otago Institute, October 24th, 1876.]

Moa-bone Pit, No. 2—on the Cornishman's Claim, Hamilton—was discovered in August, 1875. It was situated about thirty yards from the first pit, and laid six feet deeper. It was sixty feet long by an average width of twelve feet.

The bed of clay in which the basin of the first pit was formed, over-laid

* See "Trans. Zool. Soc.," Vol. VII., p. 145; and Vol. VIII., p. 375.

† In continuation of the description of the Moa Swamp, Hamilton, published in the "Trans. N.Z. Inst.," Vol. VIII., p. 12.

pit No. 2 with a thickness of six feet. The deposit of bones was from one to two feet in thickness. All the more porous bones of *Dinornis*, such as the pelves, sterna, ribs, and vertebræ, were, with the exception of a few vertebræ, in an advanced state of decay. I should judge that there were double the amount of bones in this pit that there were in the first. The bones of *Cnemiornis* appeared to have resisted decay better than those of *Dinornis*. I do not think that it would be far from the mark to say that fully one-third of the birds in this pit were *Cnemiornis*, one-third adult *Dinornis*, chiefly of the smaller species, and one-third young Moas. I only saw one long metatarsus, and that belonged to a young bird.

The bones were deposited in peat and silt, the same as in the first pit. Both pits are now washed away by the diggers, and during the progress of washing I kept an eye to the affair. I traced the gutter from which the spring water rose in the first pit, to pit No. 2, and the same red shingly gutter continues on up the flat. This establishes, beyond a doubt, in my mind, that the first pit was a spring; and further, that pit No. 2 had at some far remoter period been also a spring fed from the same source. A like discovery may never be made again.

Art. XLVII.—*On Insects injurious to the Kauri Pine* (Dammara australis.) By Captain Broun.

[*Read before the Auckland Institute, July 3rd, 1876.*]

It has often occurred to me that if entomologists were to communicate their knowledge of the insect fauna of New Zealand by the publication of papers descriptive of the habits of some of the more important groups, the subject would be treated in a manner more attractive to the members of the Institute, as well as other readers of its "Transactions," than could be done by the mere record of the number of species inhabiting these islands. Moreover, the perusal of even the best classified list would afford but little information respecting the modes of life of numbers of insects which play an important part in the economy of nature; and which, it is desirable, should be fully understood by those most concerned.

I am well aware that certain prejudices exist with reference to this subject, and that there are many who rather affect to despise that branch of natural history from which entomologists derive their chief delight; but if such were to have the matter presented to them so as to demonstrate the necessity of acquiring some knowledge of the functions of certain tribes of insects which materially affect their interests, I rather think their indifference might be changed to deep concern.

The difficulties which have hitherto beset New Zealand entomologists, desirous of recording facts illustrating the habits of insects, are now being gradually removed; it will be sufficient for my purpose merely to allude to one, and perhaps the most difficult to surmount, viz., their inability to determine accurately the name of any particular species which may have been the subject of special observation.

The remarks offered in the present instance will, I trust, convey a tolerably correct idea of certain beetles that are known to infest Kauri timber.

The Kauri Pine *(Dammara australis)*, when in a healthy-growing state, so far as I have had opportunity of observing it, seems capable of resisting the attacks of every New Zealand insect with which I am acquainted, though subsequent researches may prove it vulnerable to those that are being gradually introduced, as, for example, *Otiorhynchus sulcatus*, an European species of the weevil tribe, of which I captured one individual whilst it was feeding, amongst the roots of the stunted herbage near the summit of Mount Eden (Auckland).

The gum, after the tree has been cut down and the bole divided into logs, serves as a protection against the ravages of numbers of insects generally disregarded by casual observers, but which, when favourable opportunities offer, soon discover themselves to even the most inexperienced individual, by the palpable deterioration in the value of the timber, caused by their destructive propensities.

Perhaps the most conspicuous, and, to owners of Kauri forests, most detested beetle, is a species recently described by Mr. T. V. Wollaston, under the name *Xenocnema spinipes*, one of the most important yet yielded by these islands, in a scientific point of view, inasmuch as it connects, in the most complete manner, the family *Scolytides*, with the other groups of the *Curculionidæ*.

So long as the Kauri logs retain their gum undeteriorated, *Xenocnema spinipes* evinces no partiality for them, but no sooner does the action of the atmosphere cause its partial decomposition, and destroy, or even lessen, the adherence of the bark, than this insect immediately begins its insidious operations; in fact, the logs are then in a condition exactly suited to the habits of this peculiar weevil.

The first operation consists in forming irregular galleries under the bark, wherein the female at once deposits her eggs, which, so far as I have been able to ascertain, assume the next stage of their metamorphoses in an incredibly short space of time, as I have found both the perfect beetles and larvæ industriously engaged in piercing the sap-wood of logs that could not have been many weeks on the ground.

If the logs were permitted to remain undisturbed for many months, I have no hesitation in asserting that *Xenocnema spinipes*, in the larvæ and perfect states, would render them comparatively useless for commercial purposes, so far at least as ship and house building are concerned.

I have noticed shingles split from heart of Kauri, *en route* from districts north of Auckland, and even doors of dwelling-houses, completely perforated in several places; data clearly proving that it reaches even the centre of the logs. Generally, however, the practice which obtains amongst bushmen of rolling the logs into the adjacent creeks, down which they are afterwards driven during freshes to the "booms," as soon as possible, prevents this destructive weevil from penetrating beyond the sap-wood.

I have already indicated that the shelter of the bark appears to be a necessity to this insect during the earlier stages of its operations; it may, therefore, be inferred, that if bushmen were required to remove the bark as soon as the tree had been cut down, *Xenocnema spinipes* would not have the power of materially injuring the timber. The only other practicable method I can propose for the preservation of the timber is to "drive" the logs down to deep water at once; but, as this proceeding depends entirely on the weather, it can only be resorted to under favourable circumstances.

Although *Xenocnema spinipes* has its habitat in Kauri forests, it may be met with many miles distant from the nearest tree of that species, owing chiefly to its powerful flight when on the wing. I have seen specimens occasionally on the windows of buildings erected near the sea-shore, as well as on the foliage of isolated plants, but I have not, under these conditions, observed any damage to wood or foliage that could be attributed to its action.

This beetle varies greatly in the form of its rostrum, and though the colour and sculpture are constant wherever visible, yet I have remitted several specimens to British entomologists, with notes as to habitat, etc., in the hope of having their assistance in determining whether this important creature is in reality of one variable species, or, as I believe, consists of the genus *Xenocnema*, having two or more distinct species.

The insect which next claims attention is a new species of the *Xantholinidæ*, named by Dr. Sharp of Dumfriesshire, "*Metoponcus brouni*," which I discovered under the bark of Kauri logs, in company with the weevil already alluded to, during the winter of 1875; and found on other occasions, as well as during other seasons, subsequently. This beetle, however, does not injure the timber any more than two or three species of the genus *Cryptanurpha*, or the numerous centipedes found associated under Kauri bark, and all of which, I need scarcely say, are destroyed when the logs arrive at deep water. I regret that the time at my disposal did not enable me to make a minute examination with my pocket lens, but had time been sufficient, the assistance of a miscroscope, an indispensable instrument when investigating the habits of insects, as well as their structural characters, was not within reach. I could only note that the flattened elongated form of the larva was one admirably adapted to its habitat.

The beetle which continues the work of destruction after the others have been disposed of, is "*Dryoptherus bi-tuberculatus*," a species of the *Cossonides*, so named by White ("Voyage, '*Erebus*' and '*Terror*,'" Insects) but its generic name will be eventually altered, the insect having been referred to a genus to which it has no near affinity. It is tolerably abundant in districts possessing Kauri forests, and is occasionally found upon the foliage of other trees and shrubs, when it is usually enveloped in, or only partially covered with, a thick white pubescent coating, which has disappeared by the time it is found embedded in Kauri logs.

Dryoptherus bi-tuberculatus seems indifferent to the shelter of the bark, so essential to the other weevil whose habits have been described, and being more fastidious, requires the almost complete decomposition of the gum, in order that suitable food may be available for its offspring. Logs in the condition indicated are pierced with holes corresponding to the size of the insect, and the eggs deposited therein; when these have arrived at the larval stage of their existence, the real work of destruction begins in earnest, and is carried on uninterruptedly by the perfect insect, until the entire bulk of the sap-wood is so completely perforated as to resemble honey-comb.

Fortunately, however, it is generally only the outer portions of this valuable tree which are thus rendered valueless as a marketable commodity, and it is satisfactory to be assured that only those logs that are negligently treated, suffer the injury which this insect is so well capable of inflicting.

The logs having been passed through the saw-mill, and used in house building, would, it might be supposed, be exempt from further attacks by insects of the weevil tribe; such a supposition would be incorrect, as I have noticed unpainted weather-boards of buildings in the town of Auckland with small cylindrical holes bored into them in such a way that one might cast the blame on *Xenocnema spinipes*; in this instance, however, it is not the delinquent, the real perpetrator of the mischief being a species of the *Scolytides*, which is, as yet, I believe, nondescript.

It might be imagined that the depredations committed by the weevils already mentioned, would be sufficient proof of the destructive propensities of insects, but I am assured by Mr. John Macfarlane, the Manager of the Tairua Saw-mills Company's property, that a large "grub," said to be eaten with avidity by the Maoris, frequently perforates the solid wood. I have not had an opportunity of personally inspecting such logs, but from the description given to me I suspect the so-called grub to be the larva of our largest longicorn beetle, *Prionoplus reticularis*, which I know passes three or four years of its existence in the larval state, in logs of various trees.

The investigation I have bestowed upon this subject within the last two years clearly establishes the value of the gum as a temporary protection against the attacks of indigenous *Coleoptera*, which would, but for its presence, inflict an incalculable amount of pecuniary injury, not only on owners of Kauri forests, but also on whole communities engaged in the preparation of this timber for use in a variety of manufactures.

I now present to the Institute, specimens of the beetles adverted to in this paper, and as pieces of logs in the damaged conditions specified, will serve more fully to illustrate the subject, I now deposit in the Museum the piece of a board sawn out of a Kauri log, showing the injury done by *Xenocnema spinipes*, as also a small portion cut from another log as an example of that inflicted by *Dryoptherus bi-tuberculatus*.

When visiting localities which were being denuded of this valuable tree, the conviction was at once forced upon me that the practice which obtains of selecting the bole of the tree only for use involved a serious loss, but a consideration of the circumstances compels one to admit that the remainder of the tree cannot be profitably utilized either for fencing-posts or firewood, unless a forest has convenient water-carriage, or is so situate that inexpensive bush-tramways could be constructed to a point within easy reach of a good market, but if colonial agriculturalists were more cognizant of their real interests, they would devise means for converting the refuse timber, not only into a valuable ingredient of the manure heap, but even of the soil itself.

The money so often lavishly invested in the purchase of foreign guano might be much more beneficially employed in reducing the waste timber to charcoal, which, by its remarkable property of condensing and absorbing ammonia, would fully answer the purpose of ammoniacal manure, particularly on most of the clay lands that so often refuse to yield more than a scanty crop. Moreover, it has been incontestably proved that charcoal induces healthy growth in diseased plants.

Were farmers to satisfy themselves by experiments on a small scale, such as adding this substance to one part of a manure heap, and leaving the remainder to be deprived of its most useful gases and liquids as is usually done, and then use the two portions separately, the results would be so obvious that further action in the matter might be safely left to them.

If steps were taken for utilizing the timber now allowed to decay, the saw-dust produced at the mills ought also to be charred—an operation which could be readily effected by any intelligent engineer, by constructing an iron receptacle for it in proximity to the mill furnace; or it might be charred by means of freshly-burnt lime, which, in conjunction with the charcoal, would form a compound particularly valuable on a clay soil, but more especially when its application had been preceded by an efficient system of drainage.

These concluding remarks may be regarded rather as an addenda than strictly within the scope of what was originally intended as an entomological paper, but as some of the suggestions may invite discussion on the subject, and perhaps ultimately lead enterprising individuals to desire practical methods for reducing the amount of waste now permitted in all our forests, public and private, their introduction may be excused.

Art. XLVIII.—*Descriptions of new species of* Coleoptera. By Captain Broun

[Read before the Auckland Institute, 7th August, 1876.]

Anchomenus punctulatus.

Head, shining black; anterior, as far as eyes, rugose; less so on the vertex; remainder faintly punctured. Thorax, sub-quadrate, broader in front; anterior angles, obtuse; lateral margins, moderately reflexed; a broad, oval, tranverse line near anterior margin; another near the base; both connected by a longitudinal line; a deep impression near each posterior angle; superfices with finely impressed transverse lines, most conspicuous near the base; colour, black. Elytra, dark blue; sub-ovate, somewhat depressed; striate; the nine lines slightly punctured; a row of shallow impressions on the interstices between the eighth and ninth striæ, most closely placed near posterior femoræ; lateral margins slightly reflexed of a faint reddish hue; suture, ferruginous. The whole surface of the elytra is very finely punctured. Antennæ, palpi, and tarsi, ferruginous Femoræ and tibiæ, fuscous. Length, 7 lines.

Habitat: Auckland.

Trichosternus hispidus.

Colour, deep black, except the palpi and tarsi, which are ferruginous. Antennæ, fourth to eleventh joints, pilose. Head, with an irregular H-shaped impression in front; two round foveæ near inner margin of each eye, from each of which proceeds an erect ferruginous bristle. Thorax, quadrate, rather flat; somewhat contracted and sinuate behind; wider than head; anterior angles, rounded; posterior, obtusely pointed; a deeply impressed line extends from the base nearly to anterior margin; a large, deep, elongate fovea near each posterior angle; lateral margins, reflexed, two foveæ near front angles in marginal channel, and a third near the middle, from each of which proceeds an erect ferruginous bristle; another bristle proceeds from each hind angle, directed backwards; superfices with many very faintly impressed transverse lines. Elytra, sub-ovate, rather widest after the middle; strongly sinuated near apices; lateral and posterior margins reflexed; disc, with seven longitudinal, distinctly punctured lines, but only the three nearest each side of suture reach the apices; interstices, moderately convex; the sides just beyond the seventh striæ rather suddenly bent down, and marked with a row of irregularly formed impressions, connected together by an impressed line. These foveæ are largest just behind posterior femoræ; suture, indistinct. Hairs on femoræ, tibiæ, and tarsi, ferruginous. Length, 6¼ lines.

Of this species I have but one mutilated specimen, which I found under rushes in Kikuwai Forest, Tairua.

Hister grandis.

Form, ovate, moderately convex; colour, black. Head, minutely punctured; a punctured longitudinal fovea extends along inner side of each eye to the base. Thorax, humeral margins slightly reflexed; a transverse punctured fovea, near anterior margin, extends as far across as the head; from each terminal point there is a succession of irregular punctures along the lateral and posterior margins, larger and more deeply impressed near humeral angles, and becoming more and more minute after rounding the posterior angles; one round fovea near the centre of posterior margin. Elytra: near the humeral margin of each elytron there are three longitudinal foveæ arranged in line, and a fourth, irregular in form, close to humeral angle. Two longitudinal foveæ are placed near outer posterior margin, with a third, which is prolonged in the form of a gradually decreasing impressed line to within a line of the base. A deeply impressed line extends from near the humeral angle along the lateral and posterior margins, broader and more irregular in form near the middle, and terminated at the suture, up which it extends a short distance in the shape of a curve. The exposed segments of abdomen are coarsely punctured. The grooves in anterior tibiæ for the reception of the tarsi, when in repose, are deeply hollowed out. Length, 4 lines.

My unique specimen of this remarkably fine species was captured whilst sedately marching into the kitchen of my house at Tairua, on the 19th March, 1876.

Cerathognathus zealandicus.

In general form this species resembles *M. irroratus.* Mandibles, porrect and recurved in front; setose; punctate. Antennæ, dark red; a few bristles on scape, directed forwards; leaflets, rather short, densely pilose.

Head, dark red; coarsely punctured; a row of elongate yellow scales placed in a curved line near inner margin of each eye. Thorax, quadrate; broader than long; somewhat produced laterally after the middle; coarsely punctured, except a smooth space on the centre; rather convex; ornamented with elongate yellow scales, mostly directed forwards, most closely set near lateral margins; colour similar to that of head. Elytra, thrice as long as thorax; slightly margined; coarsely punctured; suture, distinct; of a dark red colour, ornamented with scales similar in form and colour to those on the thorax, and so disposed as to give them a chequered appearance when viewed with the naked eye. Femoræ, moderately thickened; tibiæ, spined, and serrated on the outside; setose. Length, 7½ lines. Breadth, 3 lines.

Though not the largest, this species is decidedly the finest of the New Zealand *Lucanidæ*; is well differentiated from White's *M. irroratus*, the most nearly allied species, by its larger size, comparatively smaller antennæ, and peculiarly formed thorax. Mr. C. M. Wakefield, when in Canterbury, found one specimen clinging to the under-side of a log, whilst I obtained one at Stoke Point, in 1874, and two others in the vicinity of Tairua in the following year.

Ancistropterus pilosus.

Head, granulated, fuscous; beak, ferruginous; eyes, prominent and coarsely facetted. Thorax, dull black, coarsely granulated. Elytra, almost black; ten rows of deep punctures on each; humeral angles, produced, but not so acutely pointed as in *A. quadrispinosus*, only slightly directed posteriorly, the points red. The tubercles placed after the middle are ferruginous; apices, fuscous; the whole surface clothed with fuscous hairs, with a few whitish bristles intermingled. Antennæ, bright brown; legs, fuscous, lighter near the joints. Length, 3½ lines.

I discovered this species in February last at Tairua, but have only one example of it. It may be at once distinguished from the other species of this genus by its granulated head and thorax, and pubescent elytra.

Platyomida niger.

Somewhat similar in form to White's *P. binodes*, but rather more elongate, with more parallel-sided elytra, and the thorax rather narrower in front. Head and beak, granulated, with an indistinctly defined ridge extending from between the eyes to tip of beak. Thorax, covered with small obtuse tubercles, so deposed as to give it the appearance of being transversely granulated; a longitudinal fovea near anterior margin, but not extending so far down as in *P. binodes*. Each elytron impressed with eleven longitudinal rows of large punctures; the interstices finely punctured; each elytron with a compressed tubercle near the suture beyond the middle; a few thick fulvous bristles scattered over its disc. The round pink scales so conspicuous on *P. binodes* are almost entirely absent. Antennæ and tarsi ferruginous. Length, 5 lines.

The only exponent of this species in my collection I obtained from the foliage of *Fagus cunninghami*, in October, 1875, at Tairua.

Hybolasius concolor.

This species has rather a more elongate outline than *H. crista*. Head and thorax, with sparingly distributed pubescence. Thorax, striate. Elytra, coarsely punctured; suture, distinct; pencillated crests of dark bright orange colour. The pubescence occurs in small patches of longish hairs irregularly disposed. The femoræ are more distinctly clavate, and the tarsi more dilated than in *H. crista*. Colour, pitchy red. Length, 3 lines.

One specimen taken at Tairua.

Coccinella whitiangii.

Form, ovate and convex; colour, fulvous. Thorax, minutely punctured. Two large fuscous patches extend from the base to beyond the middle, the space between being greatest near the base. Disposed over its entire disc are small patches of a lighter colour. The lateral and anterior margins have a distinct rim. Elytra, punctured throughout; on either side of the suture there is a well-defined row of fuscous impressions; suture, distinct; the lateral rim of each moderately reflexed. Length, 2¼ lines.

One specimen I found at Whitiangi (Mercury Bay), in 1873.

Art. XLIX.—*Descriptiom of a new species of the genus* Cicindela.

By Captain Broun.

[*Read before the Auckland Institute, 7th August, 1876.*]

The difficulty so frequently experienced in obtaining duplicates of many species of the indigenous Coleoptera, and the delay caused by referring them to British entomologists for identification, have induced me to offer for publication in the "Transactions of the New Zealand Institute" the following description of a new species of the genus *Cicindela*, which I found on the bank of a creek flowing through the Hikuwai forest, about ten miles inland from Tairua, during January last.

In order to ascertain whether any of our local entomologists were acquainted with the insect, I sent a brief description of it to Captain Hutton, Director of the Museum at Dunedin, who, in reply, informed me that he believed it to be a new species, of which he had discovered two specimens at Martin Bay, on the north-west coast of Otago.

CICINDELA HUTTONI, n. sp.

Similar in form to *C. tuberculata*, but less robust.

Antennæ, basal, and four terminal joints, fuscous; remainder, tawny. Head and thorax only slightly lustrous. Elytral discs covered with minute tubercles irregularly disposed; impunctate; without trace of green foveoles; fuscous and lustreless. The lateral white stripe of each elytron is interrupted in front of the middle fascia; the humeral fascia distinct, slightly prolonged as a curved streak towards the suture; distinctly punctured throughout. The femoræ, tibiæ, and tarsi are almost destitute of the bristles so conspicuous in the other species; dull and concolourous. Under side of body non-setaceous, fuscous, and lustreless. Long. 4½ lines.

I have named this interesting species after Captain Hutton, who has so greatly contributed to our knowledge of the insect-fauna of these islands.

ART. L.—*On the* Anthribidæ *of New Zealand.* By D. SHARP.

[*From the "Annals and Magazine of Natural History," June, 1876.*]

AT the present time the insect-fauna of New Zealand seems to be receiving a fair share of the attention to which it is entitled by its intrinsic importance. It is well known to naturalists that the fauna and flora of the islands in question possess many features of peculiar interest; and there is reason to suppose that when the insect-fauna is adequately known it will be seen to accord in its character with the other component groups of the fauna and flora.

In the present paper I deal with the species of the family or sub-family of Coleoptera, known as *Anthribidæ;* and though I have only twelve new species to describe, I have not found my task an altogether simple one. The greatest difficulty I have had to contend with has been that of ascertaining the limits of the genera and larger groups in use, for the purpose of classification. The family *Anthribidæ* itself is separated only in a vague and uncertain manner from some of the other families of Coleoptera: indeed, by some authorities it is considered to be only a sub-family of *Curculionidæ:* while those who accept the name as representing a distinct family are not altogether agreed as to the amount of its components—Lacordaire, for instance, excluding from it *Urodon*, which is included in the family by C. J. Thomson.

At present, however, about 430 described species compose the family; and these species are distributed among no less than 108 genera, being an average of just four species to a genus. The study of these genera and their groups is attended with great difficulties; for they are divided from one another by no strongly marked peculiarities, and in many cases the generic characters vary from species to species of the same genus in a very marked manner, as may be readily seen by any one who will make a slight examination of four or five of our European species of *Tropideres* (such as *T. cinctus*, *T. sepicola*, *T. niveirostris*, and *T. albirostris*).

I am acquainted with seventeen species of the family from New Zealand; and on examining these, with a view to giving names to the new ones and indicating their affinities, I found myself, as I have said, to have undertaken a task which I could not readily execute with satisfaction. For I found these seventeen species to display such a wide range of difference in their structural characters, that it was clear that, in conformity with the recognized systematic arrangement of the species composing the family, they would have to be ascribed to a considerable number of distinct genera; and on a further examination, the fact was also revealed that only a very few of the species could be placed satisfactorily in already established genera. And, again, on attempting to arrange these New Zealand species, with a view to grouping them into genera, I found that, even omitting all consideration as to their relations with insects found outside New Zealand, the task was no easy one, owing to the fact I have above alluded to, viz., the variation of generic characters from species to species. This point was rendered very evident to me by my examination; and when I considered it in connexion with the additional fact that it is certain that a good many more species of the family than are yet known to me exist in New Zealand, it became quite clear to me that I could not deal with the generic questions in anything like a satisfactory manner, and that, if I attempted to meddle with these at all, I should very probably only encumber the nomenclature of entomology with a number of indefinite names.

I have, therefore, adopted a course which I hope will facilitate the study and advance our knowledge of these insects, and yet will cause no difficulty to the students and systematists who are to follow me. I have drawn up descriptions of the new species, and given what I hope will prove to be a useful and permanent name to each of them, by using the term "*Anthribus*" as the first part of the permanent appellation of each species; while as regards the few already described species, I have left their names intact as originally given to each by its describer; and in my descriptions of new species I have, where it appeared important to do so, given also its most important structural characters. To complete the work, I have drawn up a table which will, I hope, facilitate the preliminary determination of the species; and in this table I have also indicated what appears to me at present to be the most convenient grouping or synthesis of the species.

Previous to the researches of the last few years only two species of this family had been described from New Zealand, viz., *Anthribus incertus*, White, and *A. phymatodes*, Redt. White's species, I believe, is not among those I am acquainted with; and his description offers as striking an example as could well be pointed out of the use of hastily selected and indefinite terms for what purports to be a scientific description.

Redtenbacher's description of *A. phymatodes*, on the other hand, is a very good one; but yet I have some little doubts whether the species to which I have given that name be really the one intended by the talented Austrian entomologist (the sad news of whose death has reached me while writing these lines); for his description indicates a rather larger insect, and one having a more uneven surface of the thorax than the specimens before me.

Three species of the family have been previously described by myself, two of them with the generic name *Lawsonia*, which Mr. Pascoe, who is a great authority on this family, states to be synonymous with his *Exillis*, Lacordaire having assigned that genus an erroneous position as regards one of its important and easily seen structural characters. I do not on this account consider it necessary to change at present the names of my two species; but in case it should be ultimately considered that this should be done, I will take the opportunity to propose the name of *Exillis lawsoni* in place of that of *Lawsonia longicornis* used in the present paper.

Mr. Pascoe himself has recently described a species of the family; and as he has kindly sent me a type thereof, I am certainly right as to the insect to which I apply his name.

I acknowledge with great pleasure the kindness of Capt. T. Broun, of Tairua, and Mr. T. Lawson, of Auckland, who have collected the insects here described. Each of these entomologists has discovered so many interesting and unexpected additions to the New Zealand insect-fauna that it is to be hoped they will continue their researches, and so acquire for us a knowledge of many species which, if not speedily accumulated, will become extinct, as has already, indeed, been the case with many species of some other insular faunas, as well as with some of the most interesting of the larger components of the New Zealand fauna.

Table.

I. Antennæ inserted at sides of rostrum or head. (Species 1 to 11.)

A. Thoracic carina not contiguous with elytra. (Species 1 to 8.)

* Eyes entire.

Group 1.

Sp. 1. Eyes oval, elytra almost even .. .. *Anthribus brouni.*

Sp. 2. Eyes oval, elytra with elevations .. .. *Anthribus bullatus.*

Group 2.

Sp. 3. Eyes circular and very prominent .. .. *Anthribus vates.*

** **Eyes emarginate.**

† Thorax punctured.

Group 3.

Sp. 4. Eyes slightly emarginate; ninth joint of antennæ only a little longer than the two following ones together *Anthribus discedens.*

Sp. 5. Eyes distinctly emarginate; ninth joint of antennæ gradually thickened from base to apex, at most only a little longer than the two following ones together .. .. *Anthribus hetæra.*

Sp. 6. Eyes distinctly emarginate; ninth joint of antennæ thickened at extremity only, twice as long as the two following ones together .. .. *Anthribus phymatodes.*

†† Thorax without punctures.

Group 4. Genus *Lawsonia (? Exillis,* Pascoe).

Sp. 7. Ninth joint of antennæ only a little longer than the two following ones together .. .. *Lawsonia variabilis.*

Sp. 8. Ninth joint of antennæ much longer than club .. *Lawsonia longicornis.*

B. Thoracic carina contiguous with base of elytra. (Species 9-11.)

* Eyes emarginate.

Group 5. Genus *Etnalis.*

Sp. 9. Hind angles of thorax spinous .. .. *Etnalis spinicollis.*

** Eyes entire.

Group 6. Genus *Cratoparis,* Lac.

Sp. 10. Hind angles of thorax obtuse .. .. *Anthribus altus.*

Sp. 11. Hind angles of thorax acute .. .. *Anthribus huttoni.*

II. Antennæ inserted on the front of rostrum or head, near to the edge, but nearer to the middle than the eye is. (Species 12-17.)

A. Thoracic carina contiguous with elytra. (Species 12-15.)

* Antennæ thickened at extremity, but not clubbed.

Group 7. Genus *Aræocerus.*

Sp. 12. Eyes very prominent .. .. *Aræocerus pardalis.*

** Antennæ with ninth joint much thicker than eighth.

† Eyes rather large, but scarcely prominent.

Group 8.

Sp. 13. Elytra without bullæ near apex .. .. *Anthribus crassus.*

Sp. 14. Elytra with bullæ near apex .. .. *Anthribus nanus.*

†† Eyes small, but prominent.

Group 9.

Sp. 15. Thorax without sculpture .. .. *Anthribus atomus.*

B. Thoracic carina not contiguous with elytra. (Species 16 and 17.)

Group 10.

Sp. 16. Thorax shining, sparingly punctured .. .. .. *Anthribus inflatus.*

Sp. 17. Thorax not shining, densely rugose .. .. *Anthribus rugosus.*

Anthribus brouni, n. sp.

A. capite rostrato, oculis prominulis, ab antennis remotis, oblongus, variegato-tomentosus, antennis pedibusque testaceo fuscoque variegatis; elytris punctato-striatis. Long. corp. $2\frac{1}{2}$–4 m.m.; antennarum $1\frac{2}{3}$–3 m.m.

Antennæ variable in length, yellowish, the joints more or less marked with dark fuscous, so as in some individuals to be nearly entirely black, the three apical joints forming a broad, flat club; first joint short, only moderately thickened; second rather longer than first, third longer and more slender than second; eighth distinctly stouter than the preceding joints. Head distinctly rostrate, the rostrum dilated towards the apex; its front margin slightly emarginate behind the labrum; the eyes prominent, oval, widely separated; the antennæ inserted at the sides, very near the apex, and separated from the eye by a space about equal to the length of the eye; the antennal cavities elongate foveæ, and abruptly limited behind; its surface densely and rather finely rugose-punctate, and bearing hairs a little variegated in colour. Thorax about as long as broad, much narrowed towards the front, its carina moderately distant from the elytra and gently bent forwards along the sides without forming an angle; the sides of the thorax behind the carina a good deal narrowed: the surface is densely but rather indistinctly rugosely sculptured, and bears variegated hairs as its clothing. Elytra much variegated, the sides and extremity being darker than the discoidal part, and near the sides there is a slight metallic appearance; they bear rows of punctures, which are rather coarse, but much obscured by the clothing. The legs are yellowish, more or less variegated with dark marks. Tarsi rather slender, second joint rather deeply emarginate, third small.

Sent from Auckland and Tairua by Captain Broun and Mr. Lawson.

Obs. I. This species varies much in size and in the development of the antennæ, and also a good deal in colour. The specimens which I consider to be females are small, and the antennæ are shorter and more slender than in the other sex; the rostrum also varies much in length.

Obs. II. This species in general structure much resembles *Tropideres niveirostris*, the antennæ of the two species being very similar. The rostrum, however, is much more produced in *A. brouni;* and its form, as well as that of the head, is different; the eyes are more entirely lateral in *A. brouni*, and the antennal cavities are different in form. *Tropideres sepicola*, however, in all these respects appears to approach *Anthribus brouni* more closely; so that the generic qualifications (if I may use this term) of *A. brouni* must be considered doubtful.

Anthribus bullatus, n. sp.

A. capite breviter rostrato, oculis prominulis, oblongus, variegato-tomentosus, antennis pedibusque testaceis; elytris pone medium quadrifasciculatis; pygidio quadrato. Long. corp. $2\frac{3}{4}$ m.m.

Antennæ formed much as in *A. brouni*, but with the joints of the club more laxly articulated, and with the eighth joint scarcely differing from the seventh. Rostrum similar in form to that of *A. brouni*, but yet much shorter, so that the posterior margin of the antennal cavities is near to, though quite distinctly separated from, the eye; it bears two patches of dense white pubescence, which are conjoined behind though divergent in front. Thoracic carina distinctly sinuate on each side, and without any angle, and very gradually bent forwards. Elytra rather densely clothed, the shoulders and apex paler than the other parts, just above their declivity with a dense pencil of dark hairs, and with another but less distinct pencil just behind the middle; pygidium yellowish, quadrate; ventral plate of apical segment of hind body prominent and peculiarly flattened in the middle; basal joint of hind tarsus scarcely longer than second and third together.

Tairua: a single individual sent by Captain Broun. I believe it to be a male; and it is very probable that the peculiar form of the apex of the abdomen is peculiar to that sex.

Obs. Though much resembling the *Anthribus brouni*, the *A. bullatus* is readily distinguished therefrom by the short broad rostrum and by the waved thoracic carina.

Anthribus vates, n. sp.

A. capite rostrato, oculis perconvexis, piceus, tomento griseo fuscoque vestitus; prothorace conico, angulis posteriorbus minus discretis, carina ab elytrorum humeris remota. Long. corp. 5 m.m.

Antennæ moderately stout, shorter than the body, obscure reddish; second joint rather elongate, third nearly one and a half times length of second. Head with a short, broad rostrum; antennal cavities large but not sulciform, placed quite at the side of rostrum, and distinctly prolonged on its under face, the space separating the hind edge of these cavities from the eye small but distinct; the eyes are almost hemispherical. Thorax conical, not quite so long as broad; its carina in the middle is separated by a short distance only from the base of the elytra, but is curved so that its angle is twice the distance from the elytra that the middle is; the angle of the carina is almost a right angle (but not sharply marked), and it is only produced a very short distance forwards along the side; behind the carina the sides of the thorax are narrowed, so that a very evident gap is left on each side, between the angles of the thorax and those of the elytra. The elytra are covered with a dense variegated tomentum, which conceals their lines of punctures.

Tairua: a single male specimen sent by Captain Broun. The ventral segments in this sex are distinctly flattened and impressed along the middle.

Obs. Though this species in general structure is closely allied to *A. huttoni*, it is very readily distinguished therefrom by the difference in the form of the basal parts of the thorax. The legs and antennæ are similar in structure to those of *A. huttoni*, but are rather stouter, and the second joint of the antennæ is more elongate in *A. vates*. *Anthribus incertus*, White, is possibly an allied but rather larger species.

Anthribus phymatodes, Redt. (?).

A. oblongus, angustulus, pube grisea leviter variegata vestitus; antennis pedibusque testaceis, his fusco maculatis; elytris quadricallosis, callositatibus posterioribus pone medium sitis. Long. corp. 3–4 m.m.

Antennæ elongate, reddish. Eyes moderately deeply emarginate; upper border of antennal cavity near, but distinctly separated from the eye. Thorax as long as broad, its carina very distinct, quite separated from the elytra, forming a rounded angle at the side, and extending forward about halfway to the front of thorax; hind angles of thorax quite indistinct, and not applied to shoulders of the elytra, so that a gap or notch is left on each side between the thorax and elytra; its surface is covered with fine, greyish, somewhat variegated hair-like scales. Elytra rather long and narrow, clothed with somewhat variegated greyish scales, and in front of the extremity bearing a transverse blackish mark; they bear near the suture four rather strongly elevated callosities, the scales on which are black; the front pair of these elevations are near the base, the hind pair just behind the middle. The legs are yellowish, with indistinct darker marks.

Sent from Tairua by Captain Broun.

Obs. I. I have seen only three mutilated individuals of this species: two of them bear a pair of strongly elevated tubercles on the head just anterior to the eyes; the other specimen is smaller, and has the head and rostrum narrower, and has no trace of the tubercles just mentioned. It is perhaps a female, while the larger individuals are no doubt males.

Obs. II. This species is very distinct from *Lawsonia longicornis* and *variabilis*, by its tuberculated elytra, by the differently formed basal portion of the thorax, by the differently shaped eyes, and by the greater space between these and the upper margin of the antennal cavities.

Anthribus hetæra, n. sp.

A. oblongus, angustulus, pube grisea leviter variegata vestitus; antennis testaceis, clava nigricante, et articulis 3^{o}–8^{m} apicibus nigris, iisdem apicibus vix nodosis, pedibus testaceis, nigro maculatis; elytris quadricallosis, callositatibus posterioribus pone medium sitis. Long. corp. 3 m.m.

Antennæ just about as long as the insect (3 millims), yellow, with the club black, and the apex of each joint from the third to the eighth also black, but the extremity of each of these joints only indistinctly nodose, the ninth joint not quite so long as the tenth and eleventh together.

Tairua : a single individual sent by Captain Broun.

Obs. This insect differs from *A. phymatodes* only in the colour and form of the antennæ; and if the individual of that species with untuberculated head prove to be only an undeveloped male, then *A. hetæra* will perhaps be found to be only the female of *A. phymatodes.*

Anthribus discedens, n. sp.

A. oculis vix emarginatis, oblongus, pube grisea et nigro-fusca vestitus; antennis pedibusque rufis, illis articulis apice, his femoribus medio fuscis; elytris basi bicallosis. Long. corp. 3½ m.m.

Antennæ elongate and slender, reddish, joints 3–8 each a little thickened, but scarcely nodose at their apex; ninth joint quite as long as the tenth and eleventh together; antennal cavities large, their upper edge approaching very close to the eye; the eye itself is scarcely emarginate. The thorax is not quite so long as broad, is densely and rather coarsely punctured, and clothed with variegated hair-like scales; its carina distinct and forming an obtuse angle on each side. Elytra with rows of rather strong punctures, clothed in large part with blackish hair-like scales, and elsewhere with similar but greyish hairs, at the base with a pair of quite distinct callosities, and with indications of a second pair of callosities just on the middle.

Tairua : a single specimen sent by Captain Broun.

Obs. The different form of the eye very readily distinguishes this from the other allied species; the form of the thorax is similar to that of *Lawsonia longicornis* rather than to that of *A. phymatodes.* At first sight it would be thought that the eye in this species is not emarginate; but on a comparison with allied species it is seen that we have here an emarginate eye, in which there is a concomitant change of form, so that it appears like a round eye with a pointed projection above the cavity for the antennæ.

Anthribus altus, n. sp. (*Cratoparis*).

A. oblongus, dense tomentosus, antennis pedibusque testaceis fusco variegatus, illarum clava fusca; rostro ante oculos fovea minuta, oblonga; elytris basi bicallosis, pone medium penicillis duobus. Long. corp. 4 m.m.

Antennæ shorter than the head and thorax; second joint oval, about as long as first; of the following joints, 3–8, each is a little shorter than its predecessor, 9–11 forming an abrupt loosely articulated club. Rostrum short and broad, a good deal constricted in front of the eyes, and in the middle showing a small oblong depression. Thorax not so long as broad, a good deal narrowed in front, its disc forming an indistinct elevation or callosity; elytra with the basal part on each side the scutellum much elevated, and behind the middle each bearing an elevated tuft of pubescence;

they, like the rest of the surface, are densely clothed with tomentum, and show a more or less distinct circular mark between the four elevations. Legs yellowish and not very distinctly spotted.

Two individuals have been sent to me by Captain Broun. I do not know their sex.

Obs. I. This species seems to agree very well with the characters assigned by Lacordaire to the genus *Cratoparis*, except that it has the rostrum decidedly contracted at its base.

Obs. II. The two individuals before me are very different in the colour of their clothing, though they agree exactly in other respects.

Anthribus huttoni, n. sp.

A. capite rostrato, oculis prominulis, cinereo-griseo-fuscoque tomentosus; antennis femoribusque piceis, tibiis tarsisque rufescentibus: prothorace conico, angulis posterioribus acutis, carina basi subcontigua. Long. corp. 4½ m.m.

Body clothed with grey, ashy, and fuscous hair-like scales, which form on the elytra an indistinct tessellated pattern. Antennæ dark red or pitchy, either shorter than the length of the insect, or nearly reaching that length; they are moderately stout; second joint about equal in length to the first, rather more slender than it; third joint longer than any of the others; eighth joint similar in shape to the seventh, and but little shorter than it; ninth almost triangular, becoming gradually broader from its base to its extremity; the three apical joints form a rather broad, flattened club, of variable length. Head in front of the eyes with a broad flat rostrum, which is a little dilated towards the extremity, its front edge being scarcely emarginate; the antennal cavities are near the apex of the rostrum, rather widely separated from the eye; they are foveiform, being slightly prolonged towards one another on the under face of the rostrum; the eyes are large and prominent, not emarginate, their front part encroaching a little on the front of the rostrum. Thorax only about half as broad at its front margin as at its base, its carina very close to the elytra (but not applied to them) in front of the scuttellum, then gently sinuate on each side so as to form the hind angle of the thorax, which is acute and extends quite as far outwards as the shoulder of the elytra; the lateral portion of the carina forms the lateral margin of the hind portion of the thorax, and does not extend quite so far forwards as half the length of the thorax. The elytra are very convex transversely, and so densely clothed that their sculpture is quite obscured. The legs are long and slender, and the basal joint of the tarsi is as long as the three following together.

In the male the antennæ are variable in length, but are generally longer and stouter than in the female; in this latter sex also they appear to be variable in their development. The two sexes may be readily distinguished by the form of the last ventral plate, which in the female is much more elongate than in the male, and is shaped so that its middle part forms a sort of projection.

Auckland and Tairua: sent by Mr. Lawson as well as by Captain Broun, but apparently rare.

Obs. I. In certain specimens the elytra are marked by a dark transverse fascia across the middle, of which there is no trace in other specimens.

Obs. II. This species is one whose position in the accepted classification of the group I should find it very difficult to define. In respect to the peculiar form of the hind angles of the thorax, and the position of the thoracic carina, it forms a decided point of connection with *Etnalis spinicollis*, from which, however, it is very distinct by reason of its emarginate eyes and more rostrate head.

Obs. III. I have named this interesting species in honour of Captain F. W. Hutton, of Dunedin, to whom science is largely indebted for its recent progress in New Zealand.

Anthribus crassus, n sp.

A. capite haud rostrato, oculis subconvexis, brevis, transversim convexus, niger, nigro-tomentosus et minus distincte cinereo-maculatus; elytris disco fascia abbreviata transversa, cinerea; antennarum basi tarsisque rufo-testaceis. Long. corp. 2 m.m.

Carina of thorax quite basal; antennæ inserted at inner margin of eyes. Head small, and much inserted in thorax, with a fine, dense, and indistinct punctuation. Eyes rather large, but not very prominent, their inner edge scarcely rounded and taking an oblique direction; along this inner edge of the eye and at some little distance behind its most anterior part is the point of insertion of the antennæ; there is no distinct cavity for their reception. The parts of the mouth are very small, and the front of the clypeus is truncate. The antennæ are pitchy, except the two basal joints, which are yellowish; they are slender, and about as long as the thorax; the first joint is rather slender, and has its inner edge only moderately curved; the second joint is about as stout as the first, and rather shorter than it; joints 3–8 are very slender, each is distinctly shorter than its predecessor, the eighth being but short; joints 9, 10, and 11 form a long, slender, and very laxly articulated club, each of them being quite narrow at the point of insertion. Thorax rather large, a good deal narrowed towards the front, the disc a little elevated, covered with a dense, fine, rugose sculpture, and only with excessively indistinct pubescence; its carina is close to the elytra, and follows the direction of their base so as to form the hind angle of the thorax, which is about a right angle; it is continued at the sides not quite halfway forward to the front; this part of it, however, is but little conspicuous. Elytra clothed with a fine black pubescence, and on the middle with a small ash-coloured mark; the basal part of each near the suture is a little elevated, and the rest of the surface is rather uneven with indistinct elevations and depressions; the rows of punctures are distinct, but not very regular. The pygidium is moderately large; and the penultimate dorsal segment appears to be grooved in the middle for the apex of the elytra. The legs are nearly black, except the tarsi, which are reddish. The anterior coxæ are quite contiguous; the middle and hind coxæ are rather widely separated. The second joint of the tarsus is but little distinctly emarginate; the third joint is small and cleft to the base, so as to consist of two narrow lobes.

Tairua: a single individual sent by Captain Broun.

The nearest described ally of this species is probably the *Dysnos semiaureus* of Pascoe, from the Malay Archipelago. The appearance or that species is said to be that of a Scolytid; *Anthribus crassus* suggests to me rather the appearance of a minute *Chlamys*-like insect. The fine pubescence, which forms on the thorax and elytra indistinct pale spots, only strikes the eye when a careful glance is directed to them.

Anthribus nanus, n. sp.

A. capite haud rostrato, oculis subconvexis, piceus, transversim convexis, vix distincte tomentosus, antennarum basi, tarsisque rufo-testaceis; elytris superficie valde inæquali. Long. corp. $1\frac{2}{3}$ m.m.

This species appears to be very closely allied to *Anthribus crassus*, but is smaller, and has the surface of the elytra much more uneven, there being before the apex some elevations which do not exist in *A. crassus*; this unevenness of their surface renders the lines of punctures very irregular. The pale spots of fine pubescence seen in *A. crassus* appear to be absent in my individual of *A. nanus*.

Tairua: a single individual sent by Captain Broun; it shows me no indication of its sex.

Anthribus atomus, n. sp.

A. capite nullo modo rostrato, oculis minoribus, sat convexis, oblongus, transversim convexus; prothorace sericeo-opaco, impunctato, setis depressis pallidis parce vestito; elytris fere nudis, striatis, striis indistincte punctatis. Long. corp. 1 m.m.

Antennæ as long as the thorax, yellowish, with the club darker; the joints 1 and 2 largely developed, and together almost as long as joints 3–8, which are small; of these each is a little shorter than its predecessor, and also very slightly stouter; joints, 9–11 form a rather large flat club, the first two of these joints being transverse. Thorax not so long as broad, its front part greatly deflexed, its carina contiguous with base of elytra; its surface without sculpture, but exhibiting a peculiar silky opacity, and clothed with distinct scanty hairs. Elytra rather deeply striated, but the striæ only indistinctly punctured. Legs rather long, yellowish.

Sent both from Auckland and Tairua by Messrs. Lawson and Broun.

Obs. I. This minute little species, which is of the size and form of an *Atomaria*, is variable in colour and size. Sometimes it is nearly entirely black, with the legs and basal portion of the antennæ paler; in others the general colour of the upper surface is yellow, with the middle of the thorax and variable marks on the elytra of a dark colour.

Obs. II. In this species the diminution of the head and rostrum seems to reach the greatest point it attains in the *Anthribidæ*. The antennæ are inserted in a cavity situated at the inner side and front part of the eye, which is small, but prominent, and about circular in form. The natural position of the head seems to be that of deflection or inflection; and the prosternum is much reduced in size, so that in the position of repose the head is brought near to the mesosternum. The basal line of the thorax is curved forwards along the sides, but is fine and indistinct; the front coxæ are continuous, and the middle ones are only a little separated from one another; the metasternum is very short; the penultimate dorsal segment of the hind body is deeply grooved for the extremity of the elytra, and the groove extends to the basal part of the pygidium. The basal joint of the tarsi is rather small; the second is distinctly emarginate; and the exposed part of the third joint is scarcely so large as the second.

I do not know any very near ally of this insect, of which the place in classification at present should be near to *Choragus*. It is undoubtedly closely allied to *Anthribus inflatus*, but differs therefrom by the diminished basal portion of the prothorax.

Anthribus inflatus, n. sp.

A. capite haud rostrato, oculis minoribus sat convexis, piceus, nitidus, nudus, antennis pedidusque testaceis, illarum clava infuscata; prothorace parce punctato, lateribus, rotundatis, carina a basi sat remota; elytris minus fortiter, striato-punctatis. Long. corp. $1\frac{1}{2}$–$1\frac{2}{3}$ m.m.

Var. Prothoracis marginibus et elytrorum basi apiceque plus minusve dilutioribus.

Antennæ about as long as the thorax, yellow, with the club infuscate, the joints bearing fine and somewhat scanty, but quite distinct outstanding setæ; first joint dilated towards the extremity, and rounded on the inner side; second joint almost as long as first and rather more slender than it; joints 3–8 slender, each shorter than its predecessor; joints 9–11 forming a rather large, loosely jointed club; the middle joint being transverse. Eyes rather prominent, but small and transverse; the antennæ inserted just at their inner and front edge; the rostrum very short and rather sparingly punctured. Thorax rather large, convex, longer than broad, the sides curved; the carina not close to the base in the middle, and curved away from it towards the sides, and appearing not to be distinctly bent up, but gradually curved forwards, and quite indistinct in its lateral portions; the surface of the thorax is covered with moderately coarse but rather distant punctures. The elytra are short and convex, curved at the sides, and each one bears nine rows of shallow, moderately coarse punctures. The legs are yellow, but the knees and the apex of tibiæ and base of the tarsi are a little infuscate.

Sent from the Northern Island both by Messrs Broun and Lawson. Though I have examined several individuals, I see no external sexual marks.

Obs. The nearest ally of this species as yet known is doubtless the *Notioxenus rufopictus*, Wollaston; but the *Anthribus inflatus* differs, I judge, from that species by the form of the basal portion of the thorax. The carina in *A. inflatus* is simply curved, so that its lateral portions are more distant from the elytra than the middle portion is; behind this carina the basal part of the thorax is depressed, and at the sides is much narrowed towards the base. The metasternum in *A. inflatus* is excessively short, and the legs are long; the second joint of the tarsi is smaller than usual in the *Anthribidæ*, so that the third joint about equals it in size.

Anthribus rugosus, n. sp.

A. piceus, opacus, antennis pedibusque testaceis, elytris testaceo signatis; thorace dense, fortiter profundeque punctato; elytris striatis, striis profunde impressis fortiterque punctatis, interstitiis angustis. Long. corp. 1½ m.m.

Antennæ yellow, with the club more obscure in colour; rostrum and vertex coarsely punctured. Thorax with a very dense and coarse punctuation, and bearing a few fine hairs. Elytra black, with two small spots at the base of each and a very large apical patch, yellow; they bear each nine broad and deep striæ, so that the interstices between these are very narrow; the striæ also are coarsely punctured. Legs yellow, with the knees and tarsi a little infuscate.

Tairua: a single specimen sent by Caytain Broun.

Obs. In size, form, and structure, this species seems almost exactly similar to *A. inflatus*; but the sculpture of the upper surface is extremely different.

POSTSCRIPT.

Since the preceding paper left my hands I have received from Captain

Broun a few species of New Zealand Coleoptera; and among them are three very interesting new *Anthribidæ*. The descriptions of these I have thought it well to publish in company with those of the preceding species and as they are not indicated in the tabular arrangement, I have pointed out the nearest ally of each. Captain Broun informs me that he can at present give no further information as to the habits of these three species, than that they are found on birch and are excessively rare.

Anthribus spinifer, n. sp.

A. capite longius rostrato, oculis convexis, niger, fusco-nigro tomentosus; capite ad oculorum margines, prothorace basi utrinque scutelloque tenuiter ochraceo lineatis; coleopteris brevibus latis, sutura medio acute elevata apice bipenicillata. Long. corp. (rostro incl.) 5 m.m.

Antennæ reaching to the back of the thorax, black, with the eighth joint clothed with white hairs; first and second joints rather long, about equal to one another; of 3–8 each is a little shorter than its predecessor; eighth joint slender, much longer than broad; ninth joint dilated gradually from base to apex, distinctly longer than broad; tenth transverse; eleventh longer than tenth. Head produced into a rostrum, which is greatly dilated at the extremity and is rather shorter than the thorax: the eyes are quite entire, very prominent, and nearly circular; the antennæ are inserted near the apex, quite at the sides, in short cavities which are very slightly prolonged backwards and downwards: it is black in colour, with a line of yellow scales at the inner margin of each eye. Thorax a good deal narrower than the elytra, rather longer than broad; the carina distant from the base, nearest to it in front of the scutellum, and gradually curved forwards towards the sides, and not continued forwards after the termination of the curve: in front of the curve it is a good deal narrowed towards the front, and is constricted behind the curve; it is impunctate and clothed with a very fine black tomentum; at the base, at a distance from the middle on each side, is a patch of yellow scales; and there are some yellow scales in front of the scutellum, which is densely covered with yellow tomentum; there are also some indications of these marks being carried forwards towards the front of the thorax. Elytra short and broad, and quite rounded at the extremity, bearing rows of distant punctures, and clothed with a fine dark tomentum, and with a pale mark at the humeral angle; just about the middle of the suture is a large elevation, which is furcate at its apex, and clothed with a long pointed pencil of black tomentum. Tarsi nearly black, ariegated with white hairs. Under surface impunctate and sparingly clothed with very fine tomentum.

A single individual has been sent me by Captain Broun, labelled No. 167.

Obs. This very curious species should be placed, in my arrangement, at the head of the New Zealand species, on account of its elongate rostrum; I anticipate, however, that it will prove to be more nearly allied to *Anthribus vates* than to *A. brouni*, on account of the form of its thorax and antennæ.

Anthribus ornatus, n. sp.

A. capite breviter rostrato, oculis rotundatis convexis, robustus, latior, elytris tuberculis sex magnis; dense subtiliterque scabroso-punctatus, olivaceus, subtus pallide tomentosus, in rostro et ad marginem anteriorem prothoracis albido-tomentosus, tuberculis plus minusve aureo-vestitis; tibiarum apice tarsisque nigris; antennis medio testaceis, basi apiceque fuscis. Long. corp. 7½ m.m.

Rostrum short and very broad; mandibles very broad; antennæ inserted at the sides in a large fovea, widely separated from the eye, which is moderately large, very prominent, and nearly circular. Antennæ short; the two basal joints rather slender, the second rather the longer; of 3–8 each is a little shorter but not broader than its predecessor; 9–11 forming a stout club, the eleventh being the largest of the three. The rostrum bears a deep fovea on the middle; and round this is a space clothed with nearly white scales. Thorax sinuate at the sides and much depressed at the front angles; the carina strongly elevated, very near to the elytra except in the middle, it forms on each side a well-defined right angle, and is continued forwards to near the front; the disc of the thorax bears two coarse tubercles or angular elevations, it is of a greenish colour, densely and finely punctured, and clothed with very fine hairs, with a dense patch of irregular shape at the front angles nearly white, and at the base on each side of the middle with some golden-coloured hairs, and with some similar ones about the tubercles. Elytra with a very fine and dense punctuation, and with some rather larger punctures, which are indistinctly arranged in rows; each one bears three very large tubercles placed at a little distance from the suture, and each is notched at the base so as to expose the rather large and elevated scutellum; the suture just behind the scutellum is elevated, and there is a fine but distinct sutural stria; the surface bears extremely short and fine and indistinct pale hairs, which are more conspicuous about the tubercles than elsewhere. Under surface rather densely clothed with a pale grey pubescence. Legs pale green, with the apex of the tibiæ and the tarsi black.

Obs. This very remarkable insect is readily distinguished by the rounded scutellar angles of the elytra; its place among the New Zealand species at present known is next to *Anthribus altus*, and, in the present state of the classification of the *Anthribidæ*, should find its place near the species of *Cratoparis*.

Anthribus rudis, n. sp.

A. oblongus, fuscus, variegato-pubescens, prothorace macula basali albida; elytris tuberculatis, tuberculis fulvo-tomentosis; metasterno medio rugoso-punctato. Long. corp. 4¾ m.m.

Antennæ about as long as head and thorax, rather stout, obscure reddish in colour; second joint about equal to first; ninth joint longer than broad, gradually dilated from the slender base to the broad apex; tenth shorter than ninth, slightly longer than broad; eleventh smaller than tenth, obtusely pointed. Head distinctly rostrated, but the rostrum broad and short, hardly longer than broad; the eyes narrow oval, convex, very obliquely placed, not emarginate. Antennæ inserted at a distance from the eyes in a rather large cavity at the side, the hind part of which is slightly directed down; the surface is covered with a somewhat variegated pubescence, and is finely carinate on the middle near the front. Thorax almost as long as broad, a good deal narrowed towards the front; the surface uneven, but not distinctly tuberculate, covered with a rather variegated pubescence, in which a white spot at the base is very conspicuous; on each side of this white spot is a smaller black one; the carina is placed at a distance from the base, and is a little sinuate or waved, is more distant from the elytra at the angles than in the middle. Elytra rather short and broad, their surface uneven, it being elevated into some indistinct tubercles, which are clothed with a tawny tomentum; the rather coarse rows of punctures are concealed by a rather dense, somewhat variegated tomentum. The metasternum bears very coarse punctures, which on the middle are rugose; the legs are reddish, and not very distinctly variegate.

A single individual, sent by Captain Broun, with the number 120 attached.

The species is allied to *A. brouni* and *A. bullatus*, but is larger than either of those species; the uneven elytra and coarsely punctured sternum distinguish it from the former species; from *A. bullatus*, to which it is probably more closely allied, the much larger size and the light-coloured tomentum on the elytral elevations readily distinguish it.

Art. LI.—*On the* Colydiidæ *of New Zealand.* By D. Sharp.

[*From the "Annals and Magazine of Natural History," July, 1876.*]

My object in this paper is to describe, in as brief a manner as is consistent with utility, the new species of New Zealand *Colydiidæ* which have been sent me by Captain Broun, of Tairua, and by Mr. T. Lawson, of Auckland, by the hands of his brother, Mr. R. Lawson, of Scarborough. These species are eighteen in number; and in addition to them six previously described species are known to me. These are:—

1. *Enarsus bakewellii*, Pasc. A very distinct and remarkable form.

2. *Bolitophagus antarcticus*, White. This species should be referred to the genus *Ulonotus*, Er.; with this latter name *Pristoderus*, Hope, is, according to Mr. Pascoe, synonymous; but Mr. Hope's name may be with advantage dropped into oblivion, as it has not been accompanied with any characters by which it can be recognized, and its place in classification was erroneously indicated.

3. *Tarphiomimetes viridipicta*, Woll. This is closely allied to, and congeneric with, *Ulonotus brouni* here described, and should be classed with it and *Bolitophagus antarcticus* in the genus *Ulonotus*; concerning which name I may here remark that the characters with which it was associated by Erichson were but insufficient, and no species was described; so that I should have almost preferred to use Mr. Wollaston's *Tarphiomimetes* had it not been objectionably polysyllabic.

4. *Tarphiomimetes lawsoni*, Woll. This species may also be at present classed in the genus *Ulonotus*, though it is aberrant from the sides of the thorax being without notches.

5. *Tarphiomimus indentatus*, Woll. With this *Ectomida lacerata*, Pasc., is specifically identical, as I judge both from the descriptions and from information received from Mr. Pascoe.

6. *Bitoma insularis*, White, which is at present correctly associated with the generic name given to it by White.

I have included in the eighteen species I have described a very interesting insect allied to *Aglycyderes setifer*, West. Though *Aglycyderes* has not yet been referred to the *Colydiidæ*, it appears to me that this may at present be done with advantage.

Thus the number of species of *Colydiidæ* at present known to me from New Zealand is twenty-four. This number, though large, will undoubtedly be much increased (more than doubled I have no doubt, and highly probably even quadrupled); and it is pretty certain that, like the Atlantic islands, New Zealand will prove to be very rich in species closely allied to *Tarphius*; the genus *Syncalus*, indeed, here described, is especially close to the European and Atlantic *Tarphius*. I anticipate that some very interesting comparisons will be suggested when the New Zealand forms of the family are better known, as I hope may soon be the case.

The *Colydiidæ* form one of the less specialized of the Coleopterus families. Many species appear to feed on the woody tissue of phanerogamic plants, others on dry cryptogamic products, while others, again, are found amongst much-decayed leaves and woody matter in dark woods. Other species, on the contrary, prey on the larvæ of wood-feeding Coleoptera; and these species are often slender, elongate, and subcylindric in form, to enable them to penetrate the burrows formed by their victims. It is probable that New Zealand species will be found of all these groups.

Ulonotus brouni, n. sp.

U. oblongus, piceus, supra variegatus, inæqualis (et in elytris tuberculatus), subtus setulis brevissimis tenuissimisque adspersus; prothorace lateribus bis indentatis; antennis, tibiis tarsisque rufo-ferrugineis, clava, tibiisque in medio nigrescentibus. Long. corp. 4½ m. m.

This species is very closely allied to *Tarphiomimetes viridipictus*, Woll., but is larger, and has the indentations at the sides of the thorax considerably deeper, and the setæ of the under surface much finer. The surface of the thorax and elytra is very similar in the two species (the green nodules of *T. viridipictus* being, I judge, not constant in colour); the surface of the thorax is very uneven, but still without distinct nodules; the elytra bear numerous nodules, which, however, are not very distinct, and their colour is a patchwork of sober green and grey, with a little black intermixed.

Three individuals sent from Tairua by Captain Broun.

Ulonotus asper, n. sp.

U. piceo-ferrugineus, marginibus dilutioribus, antennis pedibusque rufis; oblongus, subdepressus; prothoracis lateribus trilobatis, lobis duobus posterioribus angustis, et bene separatis; elytris crebre asperatis, ante apicem tuberculis nonnullis sat elevatis. Long. corp. 3¼ m. m.

Antennæ, including the club, red. Thorax transversely convex, with the surface rough, and showing some indistinct depressions; the front angles acute and prominent; at the sides in the middle is a broad and deep indentation, and in front of the hind angles there is a second rather smaller indentation; the part separating these two indentations is narrow; and the third or posterior lateral lobe is, though very prominent, very narrow. The elytra are pitchy in colour, with the base and the margins pitchy; their surface is very dull, and is densely covered with very rough granules, and a little before the apex there are three or four not very distinct tubercles on each; the lateral margin is finely and densely serrated. The legs are entirely red; and the under surface is nearly destitute of any pubescence or scales.

Tairua: a single individual sent by Captain Broun.

This species in its form resembles *Tarphiomimus indentatus*, Woll.; but it cannot be associated with that species, on account of the minute basal joints of the tarsi. It much resembles a small *Endophlæus spinosulus;* and, as in that species, the surface on its protected parts is covered with a peculiar pale exudation.

Coxelus dubius, n. sp.

C. oblongus, angustulus, parallelus, piceus, antennis pedibusque rufis, supra dense breviterque hispidulus, subvariegatus, subtus breviter griseo-setosus; tibiis extus hispidulis. Long. corp. $2\frac{1}{3}$ m.m.

Antennæ short, red, 11-jointed, the basal joint scarcely visible from above; second a good deal larger than the following ones; third small, but distinctly longer than the following joints, the fourth to eighth being small, ninth small but transverse, tenth broad and transverse, eleventh short and not quite so broad as the tenth. Eyes bearing a few short coarse setæ. Thorax about as long as broad, nearly as broad as the elytra, only slightly narrowed behind, and the sides very little curved towards the front angles; the surface a little uneven, bearing short coarse setæ or scale-like hairs; the lateral margins densely fringed with such setæ. Elytra apparently rather coarsely and closely sculptured, but their sculpture rendered indistinct by the dense short setæ with which they are clothed; these setæ are a little variegated in colour; there are no tubercles or depressions. Head with rather long cavities beneath, directed backwards, so as to be parallel along the inner margin of the eyes; sides of the thorax near the front angles slightly depressed, so as to indicate the rudiments of cavaties for the protection of the antennæ. Legs red; tibiæ armed externally with fine short setæ.

Sent both from Auckland and Tairua by Mr. Lawson and Captain Broun.

Obs. This species departs somewhat from the European *Coxelus pictus*, by the more elongate antennal cavities and by the slightly concave front part of the surface of the undersides of the thorax; but its general structure seems to be so similar to that of the European species, that I think it would be premature to characterize it at present as a distinct genus.

Coxelus similis, n. sp.

C. oblongus, angustulus, parallelus, piceus, antennis pedibusque rufis, supra dense breviterque hispidulus, vix variegatus; tibiis extus breviter pubescentibus. Long. corp. $2\frac{1}{2}$ m.m.

This species is extremely closely allied to *C. dubius*, and only differs therefrom, so far as I can see, by the following characters:—The antennæ and legs are a little stouter; and the tibiæ, instead of bearing externally coarse setæ such as are seen on the elytra, bear only a few fine hairs; the base of the thorax is less depressed, so that the outline at the junction with the elytra seems less interrupted.

Sent from Auckland by Mr. Lawson.

SYNCALUS (nov. gen. Colydiidarum).

Corpus crassum, convexum, setosum. Antennæ 11-articulatæ, clava triarticulata; retractiles. Prothorax lateribus subtus impressis. Coxæ sat distantes. Tarsi 4-articulati, articulo basali sat elongato, subtus setoso. Facies generis *Tarphii*.

I propose this generic name for two species which have extremely the appearance of *Tarphius*, but differ therefrom by the 3-jointed antennal club and the more elongate basal joint of the tarsi. I have little doubt that these insects have the habits of *Tarphius*, and will require to be sought among the dead leaves and decaying vegetable matter of the New Zealand woods and forests. The two species before me, though they look extremely like one another at first sight, show, on examination, structural differences that leave me no doubt that numerous other species will be found in New Zealand. *Enarsus bakewellii*, Pascoe, is a very interesting allied form; but ts appearance indicates very different habits, its tarsi have the second and third joints much more developed, and I believe the trophi will show important differences.

Syncalus optatus, n sp.

S. oblongo-ovalis, convexus, piceus, antennis pedibusque rufis; setis elongatis, erectis adspersus, et cum pube depressa inæqualiter vestitus; tibiis setosis. Long. corp. 4½ m.m.

Antennæ short, red, with the basal joints pitchy; first joint elongate and exposed; third longer, but much more slender than second; fourth a good deal shorter than third, but longer than fifth; eighth small, but transverse; ninth and tenth abruptly broader; ninth not quite so broad as tenth, both of them strongly transverse; eleventh joint large, about as broad as tenth. Labrum large and exposed; last joint of maxillary palpi elongate and rather slender. Antennal cavities directed straight backwards along the inner margin of the eye. Eyes large, convex, without setæ. Head coarsely sculptured, so as to appear covered with flattened tubercles. Thorax with the sides a little rounded and narrowed towards the front; the anterior angles acute and prominent; the sides behind the middle almost straight, so that the well-marked hind angles are about rectangular; the base on each side much sinute; its surface is covered with an exudation which conceals the irregularly distributed tubercular sculpture; and it bears some erect setæ. Elytra very convex, without tubercles, sprinkled with numerous long upright setæ, and also bearing some fine, greyish, depressed setæ, which are distributed in irregular patches; the sculpture which apparently consists of rows of coarse punctures) is concealed by an exudation. Tibia bearing externally a row of long setæ. Tarsi with the basal joint about as long as the two following ones together; the second and third are small; the fourth is slender, and rather longer than the other three together.

A single mutilated individual sent by Mr. Lawson from Auckland.

Syncalus hystrix, n. sp.

S. breviter ovalis, convexus, piceus, antennis pedibusque rufis, setis elongatis erectis adspersus; tibiis sine setis exsertis. Long. corp. 3½ m.m.

At first sight this insect seems to be exactly similar to *S. optatus*, except that it is much shorter in form; on examination, however, some very important differences are seen. The ninth joint of the antennæ is here scarcely more than half as broad as the tenth, the eyes are much smaller, the last joint of the maxillary palpi is broader, and the tibiæ are without erect setæ. I think, if the surface were denuded, it would be seen that the punctures on the elytra of *S. hystrix* are much coarser than in *S. optatus*; for on a denuded spot I perceive one or two very coarse punctures.

A single individual has been sent to me by Captain Broun.

* EPISTRANUS (nov. gen. Colydiidarum).

Corpus transversim convexum, rugosum, prothorace magno, basi ad elytra haud applicata. Caput in thoracem receptum. Antennæ 11-articulatæ, clava biarticulata. Prothorax lateribus subtus valde excavatis. Tarsi subtus setosi, articulo basali quam secundus longiore. Tibiæ extus dense ciliatæ, pro tarsorum receptione subimpressæ. Coxæ posteriores sat distantes. Abdomen breve.

The extraordinary little creature for which I propose this name has, so far as I know, no near described ally; but it displays in some respects an affinity with the *Tarphii*, and it should, I think, be classed in their neighbourhood. The head, by a movement of nutation, is so placed as to be protected by the front of the prosternum (as in the *Histeridæ*); and the antennæ are then received into the two very large, deep, and abruptly defined excavations of the thorax. The tibiæ are also a good deal modified for the protection of the tarsi; these, when turned back, are applied along the upper face of the tibiæ; and the outer and lower edge of the tibia is very densely ciliated. The excessively coarse and peculiar sculpture is much concealed by a dense exudation, which forms a covering very difficult to remove.

Epistranus lawsoni, n. sp.

E. niger, antennis pedibusque rufis, tuberculato-rugosus, setis breviusculis parce adspersus. Long. corp. 2 m.m.

Antennæ with the basal joint stout, and only its extremity visible from above; second joint stout and rather long, cylindric; third joint small, but more elongate than the small following joints; ninth joint small, but yet a little produced inwardly; tenth joint broad, strongly transverse; eleventh

* Substituted for *Epistrophus*, "Ann. Mag. N.H.," Jan. 1877.

nearly as broad as tenth. Parts of the mouth small; maxillary palpi thick but very short. Eyes small, coarsely faceted. Antennal cavities not prolonged on underside of head. Thorax quite as long as broad, greatly narrowed behind, extremely convex transversely, especially in front; so sculptured as to appear covered with strongly elevated tubercles. Elytra narrowed towards the base, so that the shoulders are quite indistinct sculptured in a similar manner to the thorax. Under surface with deep pits and depressions, the ventral sutures very deep.

A single specimen sent from Auckland by Mr. T. Lawson, in whose honour I have named this little species, one of the most interesting of those he has discovered,

Ithris gracilis, n. sp.

I. subcylindrica, augustula, rufescens, opaca; prothorace minus distincte trisulcato; elytris costatis. Long. corp. vix 3 m.m., lat. $\frac{2}{3}$ m.m.

Antennæ yellowish; first joint in large part exposed from above, second short and stout, third to eighth small, ninth and tenth forming a large broad club, ninth and tenth each strongly transverse, eleventh large. Head with the sides greatly elevated; its surface rather densely but indistinctly punctured, so as to be almost opaque, Thorax longer than broad, the sides straight and parallel, along the middle with a broad but ill-defined groove; and on each side of this central depression there is also another, but very obsolete, depression; the surface is densely and indistinctly sculptured, and is quite dull. Elytra each with three or four longitudinal costæ, and the surface between them densely sculptured, so that they are quite dull. Legs reddish-yellow. Under surface dull, but only finely and indistinctly punctured, and with an extremely scanty and fine pubescence. All the pairs of coxæ are only slightly separated; the metasternum is elongate; the epipleuræ are narrow, and not accurately adjusted to the body; the tibiæ are considerably dilated at the extremity, and exhibit small but distinct spurs; the tarsi are slender, with the three basal joints rather short, and differing but little from one another in length; the first ventral segment, though not elongate, is distinctly longer than the second.

Auckland: a single individal, sent by Mr. Lawson.

Obs. This species is an undoubted member of the *Colydiidæ*; and as it displays pretty much the characters assigned by Mr. Pascoe to his genus *Ithris*, I have used that word as part of its name. In many respects it approaches *Colydium elongatum* rather closely, and probably, like that species, lives in burrows in wood.

Bothrideres mæstus, n. sp.

B. niger, subopacus, antennis, tarsisque rufescentibus; prothorace subquadrato, fortiter punctato; elytris apicem versus costatis. Long. corp. 4¼ m.m.

Nearly as large as *B. contractus.* Antennæ dark red; joints 3–9 small, 10 and 11 forming a broad club, the eleventh nearly as broad as the tenth. Head ratherly coarsely punctured. Thorax quite as long as broad, nearly straight at the sides, these not being rounded in front and only very slightly narrowed behind the middle; the surface is a little uneven, but has no distinct impression, it is rather coarsely punctured, the punctures about the middle being irregularly distributed. Elytra with the alternate interstices narrowed, and a little elevated towards the extremity, and bearing rather fine punctures. Underside rather coarsely punctured. Legs slender.

A single specimen has been sent me from Tairua by Captain Broun.

This species has the intermediate joints of the antennæ more slender and the club broader than in *B. contractus*, the legs more slender, and the thorax differently shaped.

Pycnomerus sophoræ, n. sp.

P. elongatus, parallelus, piceo-niger, subopacus; prothorace dorso impresso, impressione posterius minus distincte divisa; elytris sulcatis, sulcis punctatis, punctis distantibus. Long. corp. 3¼–4½ m.m.

Antennæ distinctly eleven-jointed, the eleventh joint a good deal narrower than the tenth. Head very coarsely punctured, with a very deep impression on each side in front, the outer margin of which is continued backwards close to the eye as an elevated fold. Thorax about as long as broad, slightly narrowed behind, coarsely and closely punctured, with a rather large impression on the middle, the posterior part of which is indistinctly divided into two. Elytra bearing deep broad striæ or grooves, at the bottom of which are deep punctures separated from one another by a long raised interval; the interstices between the striæ are narrow, elevated, and impunctate. Underside closely and very coarsely punctured.

Sent from Tairua by Captain Broun, and indicated as found in the wood *Sophora tetraptera.*

This species is variable in size; and the small individuals are often not so dark in colour as the larger ones. These smaller individuals therefore at first sight much resemble the following species, from which they can always be distinguished by the different impression on the thorax, and the more widely separated punctures of the striæ of the elytra.

Pycnomerus simulans, n. sp.

P. piceo-niger, parallelus; prothorace dorso longitudinaliter haud profunde biimpresso; elytris sulcatis, sulcis punctatis, punctis approximatis. Long. corp. 3¼ m.m.

This species is extremely similar to the preceding one; but the thorax has two not very distinct elongate impressions on the middle, the narrow space between which is without punctures; the grooves on the elytra are not so deep, and the punctures at the bottom of these are less widely separated from one another; the sculpture of the under surface is less coarse.

Also sent by Captain Broun from Tairua.

Pycnomerus minor, n. sp.

P. parallelus, ferrugineus, subnitidus; prothorace fere æquali; elytris punctato-striatis; antennis minus distincte 11-articulatis. Long. corp. 2¾ m.m.

Very similar in size, form and colour to a *Rhizophagus*. Very closely allied to *P. simulans*, but smaller and paler in colour. The head is rather short; the fold near the eye very obsolete; the suture between the tenth and eleventh joints of the antennæ is indistinct. The thorax is longer than broad, slightly narrowed behind, with extremely indistinct traces of two impressions on the middle. The elytra are striated, and the striæ are coarsely punctured. The under surface is quite shining, and moderately coarsely punctured.

Also sent by Captain Broun.

Obs. Pascoe and Leconte have proposed to distinguish the *Pycnomeri* with distinctly eleven-jointed antennæ by the name of *Penthelispa*. Erichson, who pointed out this character, considered it unnecessery to make distinct generic names for the two forms; and the present species indicates the correctness of his judgment; for the antennæ are just intermediate in structure between the two forms.

Bitoma vicina, n. sp.

B. fusca, capite, thoraceque brunneo-testaceis, elytris testaceis, antennis pedibusque rufis; prothorace inæquali, haud costato; elytris minus distincte costatis, lateribus apiceque fusco-signatis. Long. corp. 3¾ m.m.

Antennæ reddish, the ninth joint scarcely larger than the preceding one, the tenth very broad and transverse, eleventh large, nearly as broad as the tenth. Head of a brownish colour, rugose, without distinct impressions. Thorax a good deal narrower than the elytra, not quite so long as broad, nearly straight at the sides, the front angles prominent; the surface bears some irregular elevations, so that it appears to be occupied by large irregular depressions; in sculpture it is similar to the head. Elytra rather depressed, of a testaceous colour, with some ill-defined darker marks near the sides, and a larger and more distinct one just before the apex; each elytron bears three or four costæ, and between these is coarsely sculptured; but the sculpture is made indistinct by some short rigid setæ. Legs reddish; tarsi rather long and slender.

Tairua (Captain Broun).

Obs. Though this species at first sight is extremely similar to *Bitoma insularis*, White, yet it is readily distinguished therefrom by the absence of the distinct costæ of the thorax of that species.

Bitoma distans, n. sp.

B. nigro-fusca, opaca, griseo-setosa, elytris rufo-maculatis, pedibus fusco-rufis; prothorace fere æquali, haud costato, elytris duplo angustiore; his fortiter punctatis, haud costatis. Long. corp. 4 m.m.

Antennæ blackish-red, with two joints of the club black. Thorax rather longer than broad, greatly narrower than the elytra, slightly curved at the sides, the front angles acute but only slightly prominent; the surface very opaque and obsoletely sculptured, without distinct elevations or depressions, but with grey setæ arranged in an irregular manner, so as to give a good deal the appearance of depressions between them. Elytra elongate, less dull than the front parts, of a blackish colour, with numerous large but indistinct reddish marks, punctured with rows of crenate punctures, and with the alternate interstices very indistinctly elevated; the setæ rather long and distinct, though not abundant. Underside blackish, very dull. Legs infuscate red.

Also sent by Captain Broun from Tairua.

Bitoma rugosa, n. sp.

B. fusca, griseo et albido variegata, antennis pedibusque rufescentibus; prothorace subquadrato, basin versus angustato elytris fere duplo angustiore, inæquali; elytris rugosis. Long. corp. 2–2½ m.m.

Antennæ reddish; joints 3–9 slender, tenth abruptly larger, strongly transverse; eleventh large, quite as broad as the tenth. Head rather short, rather strongly constricted behind to form the neck, rugose. Thorax small, widest at the front angles, gradually narrowed towards the base, the front angles acute; the surface rugose, and occupied by several ill-defined large impressions. Elytra uneven, their sculpture coarse but indistinct, and their pubescence or setæ variegated, its most conspicuous parts being some small, white, slightly elevated tubercles. Legs reddish; underside nearly black.

Tairua (Captain Broun).

Obs. The facies of this little species is very different from the other species of the genus I know, owing, I think, chiefly to the form of the thorax; but the general points of structure seem to be those of the genus to which I have assigned the species. The European *Xylolæmus fasciculatus* is, I judge, according to Duval, similar in appearance to this species; and though *B. rugosa* does not possess the peculiarly slender basal antennal joints of *Xylolæmus*, yet it is probable that it may be ultimately considered to be as much allied to *Xylolæmus* as to *Bitoma crenata*.

Bitoma nana, n. sp.

B. fusco-testacea, supra testacea, elytris (præsertim in lateribus) fusco-maculatis; prothorace basin versus angustato, lateribus serratis; elytris æqualiter scabrosis. Long. corp. $1\frac{3}{4}$ m.m.

Antennæ with joints 3–9 small, tenth and eleventh large. Head short, yellowish, quite rough and dull. Thorax much narrower than the elytra, a good deal narrowed towards the base, the sides coarsely serrate, the front angles not acute; it is yellowish in colour, rough and dull, and with very indistinct large impressions. Elytra yellowish, with some indistinct dark marks on the middle, and a large one covering most of the side; their sculpture is very indefinite, but consists apparently of regular rows ot coarse punctures, the interstices between which are narrow and interrupted; and they are hispid with short erect setæ. The legs are yellowish, short and stout; the femora somewhat infuscate.

A single specimen, sent from Tairua by Captain Broun.

This minute species in size and form much suggests a *Latridius*. It appears, however, to be closely allied to *B. rugosa*, but is very readily distinguished by the pale colour and the more ragged sides of the thorax.

Philothermus nitidus, n. sp.

P. piceo-castaneus, angustulus, subdepressus, nitidus, fere nudus; prothorace parcius fortiter punctato; elytris punctato-striatis, striis apicem versus obsolescentibus. Long. corp. 2 m.m.

Antennæ about as long as the thorax, yellowish; the basal joint stout, second joint rather slender, but distinctly thicker than the following ones; 3–9 similar to one another in thickness, the ninth being only slightly broader than the eighth; tenth and eleventh joints large, very distinctly separated from one another. Head small, immersed in the thorax up to the convex eyes. Thorax about as long as broad, straight at the sides, which are a little rounded at the front, the hind angles rectangular; the surface bearing rather large but sparing punctures, and with a small and indistinct impression at the base on each side. Elytra with rows of distinct punctures, which become obsolete at the extremity. Legs reddish; front tibiæ rather strongly dilated towards the extremity.

Tairua: a single individual found by Captain Broun.

Obs. This species has exactly the appearance of our European species of *Cerylon*; but the two large and very distinct apical joints of the antennæ induce me to call it a *Philothermus*.

Aglycyderes wollastoni, n. sp.

A. corpore superne hispido, antennis pedibusque rufescentibus, subtus nigricante; antennis articulis duobus ultimis subclavatis. Long. corp. 2–3 m.m.

Antennæ reddish, short; the two basal joints stouter than the following ones, joints 3–8 small and bead-like, tenth joint subquadrate, both broader and longer than the preceding joints; eleventh joint almost oval, quite as broad and two or three times as long as the tenth. Head very variable in size, abruptly constricted at the neck, the forehead rather convex; it is of a reddish colour and rugose, but hispid, so that the sculpture is concealed. Thorax transversely quadrate, straight at the sides, a little narrower than the elytra, the surface rugose and hispid. Elytra rather elongate and parallel, similar in colour to the head and thorax; their sculpture very coarse but indistinct, and consisting of rows of coarse punctures separated by narrow interstices, hispid, being clothed with both long and short setæ. Underside pitchy black; the metasternum coarsely but sparingly punctured. Legs red, short, hispid.

Several specimens sent from Tairua by Captain Broun; one of them was sent amongst a lot of Coleoptera found on *Cyathea dealbata*, one of the tree ferns.

Obs. The structure of the antennæ, as well as their insertion, seems to justify the location of this insect in the *Colydiidæ*. The anterior coxæ are very small, and their cavities completely closed behind; and this is the only character, so far as I can see, which would throw any doubt on the propriety of the association mentioned. Mr. Wollaston, in calling attention to the peculiarities of this important genus, has already suggested its affinity with the *Colydiidæ*. The New Zealand insect I have here described approaches the *Aglycyderes setifer* closely in appearance; but it differs in the structure of the antennæ, as well as in its remarkably widely separated anterior coxæ. The *Colydiidæ* as a group is one of the less specialized of the Coleopterous groups; and it is not therefore surprising that we should find some of its members exhibiting wide and puzzling affinities. I am unable to see any close ralationship in *Aglycyderes* with *Bruchidæ* and *Anthribidæ;* and if the genus be not accepted as an aberrant member of the *Colydiidæ*, I think there is no other course but to do as Mr. Wollaston has suggested, viz., to regard it as representing a distinct family of Coleoptera.

Art. LII.—*Descriptions of New Genera and Species of New Zealand* Coleoptera. By Francis P. Pascoe, F.L.S.

[*From the "Annals and Magazine of Natural History," Sept., 1875, and Jan., 1876.*]

The following is a list of species described in this paper :—

Byrrhidæ.

Morychus coruscans.

Liochoria, n. g.

—— huttoni.

Tenebrionidæ.

Phycosecis, n. g.

—— discoidea.

—— atomaria.*

Actizeta, n. g.

—— ammobioides.

—— albata.

Syrphetodes, n. g.

—— marginatus.

Ectomida, n. g.

—— lacerata.

Adelium bullatum.

Cerambycidæ.

Stenopotes, n. g.

—— pallidus.

Ochrocydus, n. g.

Xuthodes, n. g.

Xuthodes punctipennis.

Xyloteles costatus.

Ochrocydus huttoni.

Curculionidæ.

Tysius, n. g.

—— amplipennis.

Inophlœus, n. g.

—— traversii.

—— inuus.

—— villaris.

—— rhesus.

—— vitiosus.

Phrynixus, n. g.

—— terreus.

Cecyropa, n. g.

—— tychioides.

Irenimus, n. g.

—— parilis.

Lyperobius, n. g.

—— huttoni.

Pædaretus, n. g.

—— hispidus.

Erirhinus acalyptoides.

Aneuma, n. g.

—— fulvipes.

Stephanorhynchus purus.

—— brevipennis.

Hoplocneme punctatissima.

Pactola, n. g.

—— variabilis.

Idotasia egena.

Coccinellidæ.

Cranophorus venustus.

Scaphidiidæ.

Scaphisoma tenellum.

Cucujidæ.

Dendrophagus capito.

ELATERIDÆ.

Amychus, n. g.
—— candezei.
Limonius collaris.

CLERIDÆ.

Phymatophæa, n. g.
—— electa.
Eumede, n. g.
Eumede æraria.
Eleale opiloides.

PYTHONIDÆ.

Salpingus bilunatus.

ŒDEMERIDÆ.

Sessinia pauperata.

MORDELLIDÆ.

Mordella funerea.
Mordella detracta.

ANTHRIBIDÆ.

Aræocerus paladis.

LAMIIDÆ.

Agapanthida scutellaris.

EROTYLIDÆ.

Triplax brounii.

CAPTAIN F. W. HUTTON, Director of the Museum at Otago, and author of several valuable papers on the geology and natural history of New Zealand, has had the kindness to remit to me from time to time collections of insects of nearly all orders from that country. To his friends also, especially Mr. Travers and Captain T. Broun, I am indebted for several interesting novelties. Some of these gentlemen's discoveries have been anticipated, as far as publication is concerned, by other collectors, and have been described by Messrs. H. and F. Bates, Dr. Sharp,* and Mr. Wollaston, more especially the former gentleman, and our knowledge of New Zealand entomology has been greatly increased; but doubtless much still remains to be done, inasmuch as insects in those islands are very scarce individually, and the species seem restricted to more than usually limited areas.

It is perhaps premature to generalize upon our present materials; but, so far as we have gone, the following is a summary of what I think may be said:—(1) That the insect-fauna is most nearly allied to that of Australia,

* I take this opportunity to mention that Dr. Sharp's genus *Lawsonia* "(Ent. Monthly Mag.," X., p. 30) is identical with *Exillis* (*antè*, ser. 3, V., p. 43). Two species are described from New Zealand, both distinct from the type *E. longicornis* from Borneo. Unfortunately Dr. Sharp has given the same specific name to one of his species. Lacordaire wrongly refers *Exillis* to his "Anthribides vrais;" it is nearer *Tropideres*, but, from its reniform eyes, it is perhaps best placed near *Proscoporhinus*, as Dr. Sharp has suggested.

if we exclude such "microtypal" forms as are common more or less to all temperate countries. Such well-marked genera as *Distypsidera*, *Promecoderus*, *Calonota*, *Cilibe*, *Rhadinosomus*, *Psepholax*, *Mitrastethus*, *Didymocantha*, *Phlyctænodes*, and others are common to both and are not known elsewhere; while genera found in Australia have in New Zealand comparatively numerous others closely allied. On the other hand, however, there is a singular absence, or only an exceedingly limited number, of large and characteristic Australian genera, and even of whole families having numerous exponents in Australia—as, for example, the *Buprestidæ*, with over 300 representatives in Australia, but only with one, and that very doubtful, in New Zealand; the *Scarabiædæ*, with 11 New Zealand species (no *Cetoniinæ)* has about 450 in Australia; the great group of *Phytophaga*, abundant almost everywhere, and some of them great pests to the agriculturist, with more than 200 Australian species, has only three or four in New Zealand, and those belonging to three microtypal genera. Of the entomology of the numerous islands north and north-east of New Zealand we know very little, except that it includes some isolated forms. (2) That out of about, in round numbers, 180 genera of Coleoptera, about 50 are peculiar to New Zealand, and about 50 are either almost cosmopolitan or also found in middle Europe [mostly British] ; the remainder have representatives in Australia, the Malayan archipelago, Japan, Madagascar, North and South America, Africa, etc., but not in Europe. In the other orders of insects European forms are mostly represented. No one genus, I believe, is peculiar to New Zealand, except amongst the Lepidoptera.* From these considerations, I think that the New Zealand fauna (for insects at least) cannot be regarded as belonging to the primary Australian region, but that it is a secondary or "satellite" region, having too many endemic forms and too many representatives (out of all proportion to the rest) of widely distributed genera, and yet subsidiary to a certain extent to the Australian, inasmuch as it approaches it in a very marked manner in possessing several peculiar forms, as we have already stated.†

* Mr. Butler, in the recently completed "Zoology of the Voyage of H.M.S. '*Erebus*' and '*Terror*'" [Janson], enumerates 318 species of Lepidoptera. A few genera, for the present at least, may be assumed to be peculiar.

† Mr. Murray, in his paper "On the Geographical Relations of the chief Coleopterous Faunæ" ("Journ. Linn. Soc.," XI., pp. 1 *et seq.*), seeks to establish three great "stirpes" to which all the Coleoptera in the world are referable, viz., I., the Indo-African; II., the Brazilian; and III., the "microtypal." To the first of these, *inter alia*, belongs the New Guinea group, and to the last Australia and New Zealand, including also the temperate regions of the globe as well as tropical Peru. While I agree with Mr. Murray in regarding the beetle-fauna of New Guinea as totally different in character from that of Australia, I look upon the latter as being peculiarly distinct and isolated. If we knew anything of the entomology of the southern part of New Guinea and more of the district of Cape York the gap which now exists might be somewhat lessened.

Some caution must be exercised in regard to introduced species. New Zealand, it has been observed, seems to have a slight hold on its animal and plant life; and, conversely, introduced species seem to do well. In that category I believe I may place the Australian *Cyttalia griseipila* (*ante*, XI., p. 195), or at least a form so closely allied that I hesitate to place it as a distinct species; it is found very commonly on a plant called the "Spaniard," whatever that may be. An *Onthophagus*, apparently identical with the Australian *O. fulvolineatus*, Bl., and an *Aphodius*, like *A. pusillus*, have also been received; but there could have been no pabulum for such insects formerly. Captain Hutton has likewise sent from Wellington numerous specimens of our *Otiorhynchus sulcatus*. I suspect, among others, a *Catops*, a *Scymnus*, a *Ptinus*, some wood-borers, etc.

Morychus coruscans.

M. ellipticus, valde convexus, nitidissime æneus, antennis pedibusque pallide ferrugineis; capite leviter subconfertim punctato; prothorace elytrisque coriaceis, subtilissime punctatis; scutello transversim triangulari, impunctato; corpore infra ferrugineo, leviter punctato; femoribus tibiisque sparse hirsutis. Long. 2 lin.

Hab.: Wellington.

Of this species I have seen only one specimen. It is very like the European *M. auratus*; but, *inter alia*, it is narrower, more minutely punctured, and the scutellum is transverse.

Liochoria.

Antennæ subelongatæ, articulis sex ultimis, ultimo excepto, perfoliatis, clavam angustatam formantibus. *Labrum* magnum, distinctum. *Palpi* maxillares articulo ultimo ovali. *Tibiæ* anticæ extus excavatæ.

I have only a single specimen of the species described below; but, so far as I have been able to examine it, it seems to differ from *Morychus* in the six-jointed, very narrow club of the antennæ. It is apparently perfectly free from any villosity; but under a strong lens very short, erect, hair-like bristles are seen to exist.

Liochoria huttoni.

L. elliptica, convexa, nigra, nitida, antennis pedibusque piceis; capite prothoraceque confertim subtiliter, elytris subtilissime punctatis; scutello æquilateraliter triangulari; corpore infra femoribusque subtiliter punctatis, sparse hirsutis; tibiis extus integris, intus ciliatis. Long. $3\frac{2}{3}$ lin.

Hab.: Otago.

Phycosecis.

Caput transverum, deflectum. *Antennæ* longiusculæ, 11-articulatæ,

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* In a note *Phycosecis algarum* and *P. litoralis*, from Australia.

articulo basali ampliato, secundo subelongato, tertio breviore, duobus ultimis conjunctim globosis, intermediis transversis. *Oculi* prominuli, liberi. *Palpi* maxillares articulo ultimo ovato. *Prothorax* antice productus, lateribus ciliatus, basi rotundatus. *Elytra* modice convexa, subrotundata. *Tibiæ* anticæ subtrigonatæ, apice inermes, omnes extus denticulato-ciliatæ; *tarsi* lineares, antici liberi, articulo ultimo majusculo.

In the rounded base of the prothorax, in contact only with the elytra in its middle portion, this genus agrees with *Hyocis:* but the globose two-jointed club of the antennæ, the last joint being very small, differentiates it from all the other genera of its sub-family. The genus contains four species, two only inhabiting New Zealand; the other two, from Australia, are described in the note. One of the species, and probably all, like many others of the *Phaleriinæ*, is found on the sea-shore under *Algæ*.

Phycosecis discoidea.

P. breviter ovata, nigra, elytris vel totis pallide ochraceis vel nigris, sæpissime in medio plus minusve nigris, squamulis minutis albis rare adspersa; fronte longitudinaliter sulcata; antennis fuscis; prothorace sparse punctato, antice leviter granulato; elytris sat rude seriatim punctatis, singulis in medio seriebus irregulariter dispositis; corpore infra fusco, sparse punctulato; pedibus subsetulosis, fermoribus tarsisque dilute fuscis, tibiis ochraceis. Long. 1¼ lin.

Hab.: Waikato.

A variable species in regard to the coloration of the elytra.

Phycosecis atomaria.

P. breviter ovata, nigra, squamulis albis sparse irrorata, antennis pedibusque piceis; fronte minus sulcata; prothorace pone medium latiore, punctis sparsis singulis squama repletis; elytris subrotundatis, haud seriatim punctatis, punctis singulis squamulam albam elongatam erectam gerentibus; corpore infra pedibusque sparse albosetosulis. Long. 1¼ lin.

Hab.: Great Barrier Island; Kaikarua.

The silvery white, small, erect scales dotting the elytra will, *inter alia*, readily distinguish this species from the preceding.*

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* *Phycosecis algarum.*

P. breviter ovata, supra pedibusque fulvo-testacea, squamulis minutissimis albidis dense tecta; capite castaneo vel subcastaneo; antennis pallide ferrugineis; prothorace subtransverso, marginibus lateralibus longe albo-ciliatis; elytris subrotundatis, punctis numerosis, singulis squama pallida repletis, sat confertim impressis; corpore infra pedibusque subtiliter sparse setosulis; tarsis articulo ultimo apice nigro. Long. 1⅔ lin.

Hab.: Melbourne.

ACTIZETA.

Caput transverum, antice rotundatum. *Antennæ* validiusculæ, 11-articulatæ, articulis duobus basalibus ampliatis, æqualibus, tertio minore, cæteris ad octavum valde transversis, gradatim incrassatis, tribus ultimis clavam oblongam formantibus. *Oculi* liberi. *Palpi* maxillares articulo ultimo breviter subcylindrico. *Prothorax* transversus, convexus, lateribus haud ciliatus, basi rotundatus, antice late emarginatus. *Elytra* breviter obovata, prothorace vix latiora. *Tibiæ* anticæ dilatatæ, extus profunde emarginatæ, lobo elongato terminatæ, angulo interiore spinis duabus instructo; *tarsi* lineares, antici liberi, intermedii et postici elongati.

There are two species of this genus: one, *A. ammobioides*, the type, is like *Ammobius rufus* and is about the same size, apparently scaleless; but I suspect when perfectly fresh it is otherwise; the second species, *A. albata* is a pretty little insect clothed with close-set white scales having a somewhat varnished gloss, but generally marked with a few dark more or less indistinct spots. All the tibiæ are armed at the interior angle of the apex with two long spines.

Actizeta ammobioides.

A. ovalis, castaneo-fusca, subtillissime crebre punctulata; antennis ferrugineis, clava articulis bene determinatis; prothorace transverso, basi in medio canaliculata et bifoveata; elytris striato-punctatis, striis secundo tertioque subflexuosis, interstitiis parum convexis; corpore infra sparse punctato: pedibus colore dilutiore; tibiis setulosis. Long. $1\frac{1}{3}$–$1\frac{1}{2}$ lin.

Hab: Great Barrier Island.

Actizeta albata.

A. ovata, nigra, squamis albis, aliquando maculatim nigrescentibus, dense tecta; antennis brevioribus; clava articulis arcte contiguis; capite prothoraceque rarissime punctatis, hoc fortiter transverso, basi in medio impressa; elytris striatis, striis subflexuosis, inter-

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Under a high power of the microscope the exceedingly minute scales are seen to radiate from a common base; the patches thus formed appear under an ordinary lens to look like simple scales closely imbricated.

Phycosecis litoralis.

P. ovata, fusca, supra squamulis minutissimis albis sat dense tecta; antennis, marginibus elytrorum pedibusque ochraceis, albo-setosulis, femoribus aliquando nigris; corpore infra dense albo-squamoso. Long. $1\frac{1}{3}$ lin.

Hab.: King George's Sound.

In this species the punctures are filled with very minute scales, and probably in a fresh state the intervals between the punctures are also covered with scales; beneath the scales appear to be massed together in profusion.

stitiis rarissime uniseriatim punctulatis; corpore infra pedibusque ferrugineis, squamis albis adspersis. Long. $1\frac{1}{2}$–$1\frac{2}{3}$lin.

Hab.: Waikato.

In most specimens there is a dark round blotch on the middle of each elytron, and vestiges of two or three smaller spots on the prothorax.

Syrphetodes.

Caput depressum; *clypeus* apice truncatus; *labrum* productum; *palpi* maxillares elongati, labiales brevissimi; *mentum* transversum; *oculi* rotundati. *Antennæ* tenues, articulis tribus ultimis clavam formantibus. *Prothorax* transversus, basi angustatus, apice profunde emarginatus. *Elytra* convexa, subcordata; *epipleuræ* latæ, integræ. *Pedes* tenuati; *tibiæ* cylindricæ, apice breviter bispinosæ. *Coxæ* posticæ subapproximatæ.

The head is slightly concave between the antennæ; the latter are nearly free at the base, owing to the small size of the antennary orbits; for the same reason the eyes preserve their rounded outline. The clypeus is rather narrowed anteriorly, and shows no trace of any line of separation from the front. The tarsi are filiform, and the claw-joint is nearly as long as the rest together, especially of the anterior pair. *Opatrum tuberculicostatum*, White, the type of a new genus, differs from *Syrphetodes* in the antennæ not being clavate, the eye partly divided by the antennary orbit, and by the non-approximation of the posterior coxæ; both genera agree with the "*Phylacides*" of Lacordaire in having the epipleuræ of the elytra entire behind. The exact habitat is unknown; my specimens I owe to the kindness of Major Parry.

Syrphetodes marginatus.

S. ovalis, fuscescens, squamis silaceis sat dense tectus; antennis articulo tertio quam secundo duplo longiore; clava tomentosa; prothorace inæquato, apice bifido, angulis anticis acute productis, lateribus explanatis; scutello valde transverso, fusco; elytris prothorace latioribus, punctis parvis in seriebus irregularibus impressis, dorso tuberculis plurimis instructis, marginibus explanatis, transversim sulcato-punctatis; pedibus albido variatim maculatis. Long. 5 lin.

Hab.: ——?

Stenopotes.

Caput elongatum, antice protensum, quadratum. *Oculi* reniformes, obliqui, grosse granulati. *Antennæ* corpore longiores, articulo basali elongato. *Prothorax* capite angustior, latitudine sesquilongior, lateribus inermis. *Elytra* elongata, subparallela, leviter costulata, epipleuris distinctis. *Pedes* tenuati; *femora* fusiformia; *tibiæ* rectæ. *Coxæ* anticæ subcontiguæ.

The strongly faceted eyes in this genus are an exceptional character in this and in a few others of the forty-eight "groupes" into which Lacordaire has divided his "Section B" of the Cerambycidæ. In other respects *Stenopotes* differs, in the form of the prothorax, in the presence of epipleuræ to the elytra, etc., from both *Rhagiomorpha* and *Tritocosmia*, the other two genera of the "groupe." These he differentiates by the one having a tuft of hairs on the third joint of the antennæ, which the other has not. At best this is a doubtful character; one objeetion to it is, that the tuft very often, apparently, belongs to the insect only in its earlier life.* *Rhagiomorpha* is at present confined to one species—*lepturoides*, Boisd. My *R. exilis*, from its prothorax slightly protuberant but not spined at the sides, will probably form the type of a new genus. *Stenoderus concolor*, McLeay ("King's Voyage," II., 452), with which Lacordaire identifies *R. lepturoides*, is a true *Stenoderus*.

Stenopotes pallidus.

S. elongatus, fulvescens, vix nitidus, capite prothoraceque saturatioribus, illo in medio canaliculato; rostro longitudine paulo latiore, planato-marginato; antennis leviter piloso-fimbriatis, articulo tertio quam sequentibus multo breviore; prothorace latitudine sesquilongiore, postice gradatim latiore, pone apicem parum incurvato, supra lineis duabus pilosis notato; scutello subrotundato; elytris prothorace quintuplo longioribus, supra plunatis, singulis costulis duabus longitudinalibus instructis; infra pedibusque pube tenuissime indutis. Long. 7 lin.

Hab.: Waikato.

Xuthodes.

Caput breve, inter oculos sulcatum. *Oculi* magni, supra distantes. *Antennæ* corpore longiores, tenuiter ciliatæ, articulo basali obconico, tertio fere æquali, quarto paulo breviore, quinto ad undecimum longioribus. *Prothorax* antice late truncatus, utrinque bituberculatus, tuberculo anteriore apicali, altero mediano, disco inæquali. *Elytra* oblonga, parallela. *Pedes* mediocres; *femora* fusiformia. *Prosternum* angustum, arcuatum.

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* In the case of *Tritocosmia digglesii* ("Tr. Ent. Soc." ser. 2, V., p. 58), one of my specimens has the tuft reduced to a small patch at one point of the apex of the joint; this is what I alluded to in saying that the tuft was "deciduous," an expression which M. Lacordaire has taken to mean a denial of its existence. In the same note (Gen. VIII., p. 408) he quotes me as giving "Nouvelle Bretagne" (from which island I have never seen an insect) instead of New South Wales, as the habitat of *T. rubea*. The antennæ of *T. paradoxa* are remarkable, but do not, in the absence of other characters, justify its generic separation as Lacordaire suggests.

In habit and colour the only representative of this genus is like the Chilian *Phymatioderus bizonatus;* but its characters ally it with *Grammicosum* and *Hesperophanes,* from both of which it differs in the prothorax and antennæ.

Xuthodes punctipennis,

X. capite prothoraceque fulvis, opacis; elytris nitide flavescentibus, nigro-punctatis, punctis apicem versus minutis, pone medium fascia angusta fusca ornatis; antennis, pedibus abdomineque luteis; prothorace impunctato, disco 5-tuberculato. Long. 7½ lin.

Hab.: Pitt Island.

Xyloteles costatus.

X. elongatus, fusco-metallicus, antennis pedibusque castaneis subtilissime tomentosis; illis articulis basi plerumque pallidioribus; capite prothoraceque lævigatis, hoc in medio tenuiter corrugato; scutello semicirculari, griseo-pubescenti; elytris oblongo-obovatis, apicibus rotundatis, singulis fortiter quinquecostatis, costis duabus exterioribus basi conjunctis, interstitiis sparsim impresso-punctatis; corpore infra subtiliter punctulato; abdomine segmentis quatuor basalibus utrinque macula grisea pilosa notatis. Long. 7½–9 lin.

Hab.: Pitt Island.

What, from its narrower abdomen, I take to be the male, has shorter elytra less drawn out at the apex than the female; the antennæ are about the same length—a little shorter than the body in both. This fine species, which at first sight might be taken to be generically distinct trom *Xyloteles,* was, like the last, found by Mr. Travers in Pitt Island, one of the Chatham group.

TYSIUS.

Caput elongatum; *rostrum* mediocre, subangulatum; *scrobes* subterminales, obliquæ, infra oculos currentes. *Scapus* tenuatus, gradatim incrassatus, ad marginem posticum oculi attingens; *funiculus* 7-articulatus, articulo basali elongato, ampliato, secundo breviter obconico, cæteris transversis; *clava* distincta, longe elliptica. *Oculi* subrotundati, grosse granulati, a prothorace distantes. *Prothorax* parvus, subcylindricus, antice paulo productus. *Scutellum* triangulare. *Elytra* ampliata, oblongo-cordata, humeris rotundatis. *Femora* antica et intermedia modice incrassata, illa mutica, postica valida, infra fortiter dentata; *tibiæ* subflexuosæ, apice inermes; *tarsi* mediocres, articulo tertio late bilobo. *Metasternum* modice elongatum. *Processus* intercoxalis latus, truncatus. *Abdomen* segmentis duobus basalibus ampliatis; *sutura* prima in medeo arcuata.

The only species of this genus is ferruginous in colour, with deciduous greyish scales, but always more scattered at the sides, which, to the naked eye present the appearance of being marked with a large brownish patch. I obtained my original specimen from an old collection in the possession of Mr. Stevens; but I have since received it from Capt. Broun, who finds it plentifully at Tairua, near Auckland.

Eugnomus, Schönh., with an undescribed New Zealand insect for its type, is unknown to me, but is apparently differentiated from the present genus in several particulars, *i. e.* in the eyes, antennæ, prothorax, elytra, etc.

Tysius amplipennis.

T. ferrugineus, squamalis grisescentibus inæqualitur vestitus, supra setulis paucis adspersus; capite confertim punctato, super oculos tuberculis duobus munito; rostro capite parum longiore; prothorace longitudine latitudini fere æquali, pone apicem fortiter constricto; elytris basi prothrace duplo latioribus, pone basin oblique excavatis, striato-punctatis, interstitiis latis, vix convexis, tertio quintoque interrupte elevatis, quarto quintoque versus apicem callosis; corpore infra sparse punctato. Long. $1\frac{3}{4}$ lin.

Hab.: Tairua.

INOPHLŒUS.

Rostrum modice elongatum robustum, apicem versus gradatim incrassatum, supra tricarinatum, plaga triangulari munitum; *scrobes* terminales, arcuatæ ad latera rostri cito desinentes. *Scapus* pone oculum superans; *funiculus* articulo basali elongato, cæteris obconicis vel pyriformibus; *clava* distincta. *Oculi* infra angulares, subfortiter granulati. *Prothorax* basi angustior, lobis ocularibus munitus. *Elytra* dorso planata vel subdepressa, apicem versus declivia. *Femora* in medio crassiora; tibiæ anticæ flexuosæ, intus haud dentatæ, reliquæ, rectæ, posticæ corbellis subapertis; *tarsi* normales. *Abdomen* segmentis duobus basalibus ampliatis.

The Chilian genus *Cylindrorhinus* is not capable of being strictly defined as it stands at present; but taking Lacordaire's characters, the more determinate seeems to be the close connection of the club to the funicle; in the genus before us the club is well limited. If, however, we had been dealing with Chilian instead of New Zealand insects I should have had little hesitation in placing, provisionally at least, the species described below with *Cylindrorhinus*, except that the latter is without any vestige of scales.

Inophlœus traversii.

I. fuscus, obscure griseo-squamosus, rostro prothorace paulo breviore, carina intermedia sat acute elevata; antennis piceis; funiculi articulo secundo quam primo paulo breviore; clava elongato-elliptica, griseo-tomentosa; prothorace parum longiore quam latiore, supra inæquali, subtilissime punctato, lobis ocularibus prominulis; scutello minuto, vix conspicuo; elytris postice gradatim latioribus, supra valde planatis, inæqualiter striato-punctatis, punctis nonnullis areolatis, humeris obliquis, singulis elytris utrinque angulatis, postice dentato-productis, apicibus acutis, parte declivi in medio paulo producta; pedibus sparse squamosis; tibiis sat elongatis. Long. 5–6 lin.

Hab.: Chatham Islands.

This species is remarkable for the perfectly flat disc of the elytra, the sides bent suddenly down forming a sharp angle with the disc. It is from Pitt Island, one of the Chatham group, where it was found by Mr. Travers.

Inophlœus inuus.

I. nigrescens, subtiliter squamosus, squamulisque piliformibus albis adspersus; rostro prothorace vix breviore, carina intermedia basi magis elevata; antennis piceis; funiculi articulo secundo quam primo breviore; clava elongato-elliptica, tomentosa; prothorace paulo latiore quam longiore, punctis flexuosis leviter impresso; scutello parvo, distincto; elytris sat anguste obovatis, supra paulo convexis, seriatim fortiter punctatis, interstitiis alternis paulo elevatis, tertio a sutura postice dentato-producto, parte declivi in medio modice convexa, apicibus paulo elongatis; tibiis sat elongatis. Long. 7 lin.

Hab.: Queenstown.

The punctures on the prothorax are so modified as to give the impression of a granulated surface rather than of punctuation. Nearly all the characters of this species are diagnostic.

Inophlœus villaris.

I. fuscus, griseo-squamosus; rostro prothorace multo breviore, apice sat subito deflecto; antennis brevioribus, funiculo articulis duobus basalibus æqualibus; prothorace fere in medio latiore, supra inequali, vage foveatim impresso; scutello inviso; elytris pone humeros latioribus, supra subplanatis, striato-punctatis, postice minus angulatis; apicibus acuminatis, vix productis; corpore infra pedibusque squamis elongatis aspersis; tibiis minus elongatis. Long. 3½ lin.

Hab.: Christchurch.

Has a somewhat different outline from that of *I. traversii*, but is perhaps more nearly allied to it than the preceding.

Inophlœus rhesus.

I. ovatus, fuscus, leviter griseo-squamosus, supra setulis adspersus; rostro prothorace breviore; antennis ferrugineis; funiculo articulis secundo, tertio, quarto subæqualibus, modice elongatis; clava minus elongata; prothorace rugoso, ante medium latiore; scutello parvo; elytris subcordatis, dorso ad suturam postice dentato-productis, versus apicem verticaliter declivibus, seriatim foveatis, singulis costis tribus munitis; tibiis minus elongatis. Long. $3\frac{1}{4}$ lin.

Hab.: Lake Guyon.

Allied to the preceding; but, *inter alia*, there is a small but very distinct scutellum.

Inophlœus vitiosus.

I. subangustus, niger, nitidus, squamis concoloribus adspersus; rostro prothorace fere duplo breviore, apice squamositate grisea tecto, costis lateralibus obsoletis; antennis piceis; funiculi articulo secundo quam primo longiore; prothorace æquato, latitudine longiore, ante medium latiore; scutello minuto; elytris elongato-cordatis basi depressis, postice singulis in mare acute productis, apicem versus ad suturam carinato-elevatis, supra striato-punctatis, punctus sat remotis, bene determinatis; tibiis posticis paulo flexuosis. Long. $3\frac{3}{4}$ lin.

Hab.: Lake Guyon.

A somewhat aberrant species. A specimen, apparently the female, has the elytra less produced and the apex more rounded.

PHRYNIXUS.

Rostrum mediocre, arcuatum, basi angustius; *scrobes* medianæ, foveiformes. *Oculi*, parvi, ovales, grosse granulati, a prothorace distantes. *Scapus* antennarum clavatus; *funiculus* 7-articulatus, articulis a secundo sensim crassioribus; *clava* distincta. *Prothorax* suboblongus, irregularis, lobis ocularibus obsoletis. *Scutellum* nullum. *Elytra* brevia, ovata, angulis anticis porrectis. *Pedes* breviusculi; *femora* in medio incrassata; *tibiæ* subflexuosæ, apice mucronatæ; *tarsi* articulis tribus basalibus transversis, penultimo integro, supra excavato, ultimo valido. *Abdomen* segmentis duobus basalibus connatis, ampliatis.

On the whole this genus may be considered as being most nearly allied to the European *Dichotrachelus:* but in four species of that genus, which I have examined, I do not find the penultimate tarsal joint entire, as stated by Lacordaire, but more or less bilobed. The foveiform scrobes and small eyes away from the prothorax are the most essential diagnostic characters of *Phrynixus*. My specimen is from an old collection, and was purchased from Mr. Stevens.

Phrynixus terreus.

P. ovatus, fuscus, supra squamositate dilutiore vestitus; rostro prothorace paulo breviore; funiculi articulo basali longiusculo, secundo breviore, quinque sequentibus transversis, ultimo crasso, obconico; clava brevi, obsolete articulata; prothorace supra sulcatim tuberculato; elytris irregularibus, seriatim punctatis, punctis approximatis, tuberculis plurimis conicis instructis; pedibus rude squamosis. Long. $2\frac{2}{3}$ lin.

Hab.: ——?

Cecyropa.

Rostrum breve, validum; *scrobes* subterminales, postice dilatatæ, longe ante oculos desinentes; *scapus* elongatus, gradatim incrassatus, pone oculum superans; *funiculus* breviusculus, 7-articulatus, articulo basali crassiore, secundo breviore, cæteris transversis; *clava* distincta. *Oculi* ovati, grosse granulati, prothoraci contigui. *Prothorax* ampliatus, paulo convexus, utrinque rotundatus, basi truncatus; lobis ocularibus fere obsoletis, fimbriatis. *Scutellum* invisum. *Elytra* cordiformia, prothorace latiora, humeris obliquis. *Femora* crassa; *tibiæ* versus apicem valde ampliatæ, posticæ corbellis cavernosis; *tarsi* articulis duobus basalibus triangularibus, secundo minore, tertio late bilobo; ultimo mediocre; *unguiculis* liberis; *coxæ* anticæ haud contiguæ. *Abdomen* segmentis duobus basalibus amplis, sutura prima arcuata.

It is not without hesitation that I place this genus with the *Rhyparosominæ*, the cavernous corbels of the posterior tibiæ being exceptional. It has, however, some analogy at least to *Dysostines* on account of its large prothorax and the non-contiguity of the anterior coxæ. At any rate there is no other place for it in "Section A" of the "Phanérognathes symmérides" of Lacordaire, to which the genus belongs. Of my two specimens, one has a few patches of dark-coloured scales on the middle of the elytra; in the other the dark predominates, the white forming dispersed spots on the upper surface.

Cecyropa tychioides.

C. sat late ovalis, fusca, squamulis griseo-albidis adpressis, supra plus minusve fuscis interjectis, omnino dense tecta; rostro antennisque squamulosis, his ferrugineis setulis adspersis; prothorace ante medium latiore, utrinque valde rotundato, apice quam basi duplo angustiore; elytris seriatim punctatis, punctis approximatis, juxta apicem sat subito deflexis; pedibus parce setulosis. Long. 2¾ lin.

Hab.: Pitt Island; Wellington.

Cranophorus venustus.

C. elliptico-ovatus, modice convexus, villosus, niger, supra sat confertim, punctulatus; prothorace utrinque late flavo-marginato; elytris singulis margine externo maculisque duabus magnis flavis. Long. 2¼ lin.

Hab.: Waikato.

Cranophorus, Muls., is easily recognised by the prolongation of the anterior part of the prothorax completely covering the head (not emarginate as in the generality of the *Coccinellidæ*). Two species only from the Cape were known hitherto. I have but a single specimen of the species before me; but a minuter examination might show structural peculiarities requiring its generic separation from the Cape species, which have certainly a somewhat different aspect. Only four members of the family are known from New Zealand, viz,, *Coccinella tasmanii, C. concinna, Lais antipodum*, and the above; Capt. Broun has sent two or three species of *Scymnus*, not yet determined, and possibly introduced.

Scaphisoma tenellum.

S. nitidum, nigrum, pygidio pedibusque piceis; antennis pallidis, articulis quinque, ultimis, basi apiceque exceptis, fuscis; capite prothoraceque impunctatis, hoc lobo scutellari scuttellum obtegente; elytris impunctatis, stria suturali distincta; pygidio conico; corpore infra nigro; abdomine segmentis sex. Long. 1¾ lin.

Hab.: Auckland (Tairua).

Longer than our *S. boleti*, and the elytra, except in the sutural stria, impunctate; in my specimen the eighth joint of the antennæ is much narrower than the seventh or following joints. This character is found in other members of the genus, but it does not seem to be invariable even in the same species.

Dendrophagus capito.

D. parallelus depressus, fulvus, parcim pilosus; capite prothoraci latitudine æquali, inter oculos plicato-rugoso; antennis corpori longitudine fere æqualibus, articulis secundo tertioque simul quarto paullo brevioribus, prothorace antice utrinque tuberculato producto, lateribus dentibus tribus parvis instructis; elytris pallidioribus, confertim fortiter lineatim punctatis, plagis fuscis obscuris notatis; pedibus pallidis, tarsis anticis articulo basali cordato-ampliatis, secundo minore, tarsis intermediis et posticis elongatis, linearibus. Long. 2½–3 lin.

Hab.: Otago; Lake Guyon.

Dendrophagus brevicornis, Wh., is a *Cryptamorpha*, a genus first discovered in Madeira by Mr. Wollaston ("Ins. Mad.," p. 156). *D. suturalis* and *D. umbrinus*, also from New Zealand, and each represented by a single specimen in bad condition in the *British Museum*, appear to me to be scarcely more than varieties. A species of the nearly allied genus *Prostomis* from New Zealand was sent to me many years ago by the late Dr. Howitt; but, excepting its larger size, I am unable to separate it from the European *P. mandibularis*.

Amychus.

Caput parvum, inter oculos planatum. *Antennæ* breves, articulo primo valido, secundo quam tertio paulo breviore, cæteris, ultimo elliptico excepto, triangularibus, quam secundo haud longioribus. *Sulci* pectorales obsoleti. *Characteres* alii fere ut in *Lacone*.

The habit of the species described below is unmistakably that of *Lacon*; but it has only a very slight trace of the lateral prosternal groove destined for the reception of the antenna in repose. It was discovered in the Chatham Islands by Mr. Travers. I have dedicated it to Dr. Candéze, who has so elaborately monographed the insects of the family.

Amychus candezei.

A. validus, modice convexus, fusco-tomentosus, pilis aurulentis parce adspersus; antennis fuscis, extus, magis pubescentibus; prothorace amplo, subtransverso, basi fortiter trisinuato, angulis posticis productis; scutello scutiformi; elytris striatis, lateribus valde rotundatis, griseo subfasciatis vel plagiatis, punctis nitidis adspersis; corpore infra indumento fusco, verisimiliter sæpe detrito, induto. Long. 7–9 lin.

Hab.: Pitt Island.

Limonius collaris.

L. gracilis, nitide fuscus, prothorace pedibusque, fulvescentibus; antennis luteis, corporis dimidia longitudine, articulis secundo tertioque breviusculis, cæteris longiusculis, serratis; capite prothoraceque sat vage punctatis; elytris elongato-cuneiformibus, striato-punctatis; meso-metathoraceque nitide fuscis.

Hab.: Auckland.

An elegant species, not agreeing well with *Limonius*, and probably belonging to a new genus.

Phymatophæa.

Caput antice modice productum. *Oculi* reniformes, transversi. *Antennæ* articulo basali elongato, valido, tertio ad octavum gradatim brevioribus; *clava* magna, laxe triarticulata, articulis duobus basalibus triangularibus, ultimo rotundato. *Palpi* articulo ultimo triangulari. *Prothorax* utrinque tuberculato-productus. *Elytra* supra inæqualia, basi prothoracis duplo latiora. *Pedes* modice elongati; *femora* fusiformia anteriora crassiora; *tarsi* articulo basali obtecto; *unguiculi* basi dente instructi.

There is nothing in the sterna or abdomen different from *Scrobiger*, Spin., near which this genus may be placed. Its distinctive peculiarity is the large, loosely three-jointed club, but there is much to remind us of the West African genus *Erymanthus*.

Phymatophæa electa.

P. modice elongata, fusca, subnitida, plagis succineis ornata, pilis concoloribus adspersa; capite inter oculos nudo, bituberculato; prothorace antice tuberculis duobus succineis instructo; elytris inæqualiter rude impresso-punctatis, humeris tuberculisque succineis sex, *scil.* duobus subbasalibus, duobus ante medium, duobus sub apice positis, pone medium fascia obliqua elevata notatis; pedibus fusco variegatis; corpore infra nitide fusco. Long. 4–4½ lin.

Hab.: Auckland.

Eumede.

Caput antice brevissimum. *Oculi* magni, leviter emarginati, tenuiter granulati. *Antennæ* breviusculæ, 11-articulatæ, articulis tribus ultimis clavam formantibus. *Palpi* maxillares articulo ultimo ovoideo, labiales securiformi. *Prothorax* capite angustior, basi modice latus. *Elytra* oblonga. *Pedes* graciles; *tarsi* articulo primo brevissimo.

The only exponent of this genus has somewhat the habit of *Lemidia*, from which it differs, *inter alia*, in its emarginate eye; while *Aulicus*, to which it slightly approximates, has all the palpi securiform.

Eumede æraria.

E. fusco-ænea, nitida, antennis, palpis pedibusque, femoribus exceptis, testaceis, pilis volitantibus aliisque albis subadpressis vestita; antennis prothorace vix longioribus, articulis duobus basalibus validis, secundo dimidio breviore; prothorace paulo longiore quam latiore, lateribus rotundatis; elytris postice paulo gradatim latioribus. Long. 2½ lin.

Hab.: Christchurch.

Eleale opiloides.

E. elongata, æneo-fusca, fulvo-varia, vage breviter pilosa; antennis modice elongatis, clava laxe articulata; capite prothoracque confertim punctatis, hoc capite angustiore, basi angusto, in medio fulvo; scutello cordiformi; elytris fortiter punctatis, apicem versus paulo gradatim latioribus, fasciis duabus apiceque fulvis notatis; pedibus fulvis. Long. $2\frac{1}{4}$ lin.

Hab.: Christchurch; Auckland.

Not unlike a small individual of *Opilus mollis*. The genus is somewhat doubtful.

Ectomida.

Characteres generici fere ut in *Pristodero*, sed tarsis tibiisque aliis, *scil.* articulis duobus basalibus conjunctis triangulum breviusculum formantibus, tertio, parvo, angusto; tibiis extus compressis, margine exteriore denticulatis.

Dermestes scaber, Fab.,* is congeneric with *Pristoderus antarcticus*, White; Erichson's *Ulonotus* is probably founded on one of these two (he does not describe any species); Lacordaire, indeed, suggested the identity of these genera. In *Pristoderus* the tarsi are simply linear, and the tibiæ filiform, not denticulate externally. The species here described is remarkable on account of the dilatation, deeply divided into lobes, of the sides of the prothorax; the insect varies in colour from uniform yellowish testaceous to brownish or with brownish patches.

Ectomida lacerata.

E. oblonga, depressa, subtestacea, aliquando infuscata vel fusco variegata, subtiliter tomentosa; capite tuberculis parvis instructo; antennis articulis duobus basalibus crassis, tertio ad octavum gradadatim brevioribus, clava fusca, articulis duobus basalibus valde transversis, ultimo rotundato; prothorace rugoso, lateribus foliaceis, trilobis, lobo anteriore tripartito, lobis duobus posticis multo minoribus; scutello parvo; elytris striato-punctatis, seriatim tuberculatis, tuberculis interioribus quatuor, quorum tribus majoribus, marginibus externis serratis, apicibus divergentibus. Long. $1\frac{1}{2}$–2 lin.

Hab.: Auckland (Tairua).

Adelium bullatum.

A. nitide nigrum, vel subnigrum; capite prothoraceque subtiliter punctatis, hoc transverso, in medio leviter canaliculato, lateribus rotundato, basi sat lato, angulis posticis subacutis; scutello parvo, transverso; elytris elongato-cordatis, leviter irregulariter punctatis,

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* "*Nova Hollandia*" is given as the *habitat*; but the type in the British Museum is the only individual I have seen. *Dermestes limbatus*, Fab. "Enter Syst." I., p. 234), is either my *Phycosecis discoidea* or *P. atomaria* (*ante*, Vol. XVI., pp. 213, 214). I incline to the former; but Mr. C. O. Waterhouse, who has carefully compared them, thinks it is the latter; the two specimens in the British Museum are barely recognizable. Fabricius must have been labouring under difficulties when, in describing these two species from the Banksian collection, he referred them to *Dermestes*, with which, it is almost needless to say, they have no affinity.

spatiis inter puncta lævibus ovatis, plurimis oblongis vel linearibus; pedibus lævigatis, nitidis; corpore infra nitido, abdomine reticulato-punctulato. Long. 7 lin.

Hab.: Otago.

Adelium is a common Australian genus; but it has not previously been found in New Zealand. This species may be placed after *A. proximum*, although it is not closely allied. The sculpture of the elytra is very distinctive (lines of fine punctures embracing oval, oblong, and a few linear spaces, all of a very irregular character). *Seirotrana*, to which *A. proximum* was referred, should, I think, be united to *Adelium*, its principal character (the "contiguity" of the prothorax to the elytra) being in some species rather difficult to determine, although Lacordaire lays great stress on it. *Amarosoma*, Redt., is the same as my *Pheloneis* ("Journ. of Entom.," Vol. II., p. 483); his species, *A. simulans*, is or was known to Australian entomologists as *Adelium harpaloides*, White; but White's species is much less convex, with more parallel sides, and larger. The two species should therefore stand as *P. harpaloides*, Wh., and *P. simulans*, Redt.

Salpingus bilunatus.

S. fuscus, subnitidus; antennis articulis quatuor ultimis perfoliatis, fuscis; capite prothoraceque fortiter punctatis, hoc utrinque rotundato, basin versus multo angustiore; scutello transverso; elytris confertim striato-punctatis, macula magna semilunari, ad suturam contigua, ornatis; corpore infra pedibusque fulvescentibus, vel aliquando infuscatis. Long. 1–1¼ lin.

Hab.: Auckland.

This species has quite the outline of our *S. æreus;* but it is scarcely half the length (*i.e.*, eight times less in bulk), and well marked by the large semilunar patch on the elytra extending from the shoulder to near the apex and meeting its fellow at the suture.

Sessinia pauperata.

S. testacea, parce pubescens; antennis articulo tertio quam quarto paulo, breviore; capite prothoraceque subtiliter et confertim punctatis; scutello majusculo, transverso; elytris brevibus, subpunctato-striatis, interstitiis alternis multo latioribus. Long. 4 lin.

Hab.: Christchurch.

This very distinct species may at once be known by its short elytra. The genus *Sessinia* was published by me in January, 1863 ("Journ. of Entom." II., p. 45, note). *Ananca*, Fairm. et Germ. ("Ann. Soc. Ent. de Fr." 4ᵉ sér. III., p. 267, 1863), must have been published some months later, as a subsequent paper (p. 293) was read at the "séance" of the 10th June in the same year. *Dryops lineata*, Fab. ("Ent. Syst.," I., pt. 2, p. 76), and *Dryops strigipennis*, Wh. ("Ereb. and Terror," p. 12), belong to *Sessinia*. The genus is differentiated from *Nacerdes* by its two-spurred tibiæ. *Selenopalpus chalybæus* and *subviridis* are probably only varieties of *S. cyaneus*, Fab. (*Dryops*).

Mordella funerea.

M. nigra, subtillissime squamulosa, elytris in medio maculis duabus fasciaque flexuosa postica, ad suturam interrupta, albo-pubescentibus, sed in certa luce evanescentibus; antennis, articulis quatuor basalibus exceptis, serratis; capitis fronte subtillissime punctata; tibiis fere ecalcaratis; tarsis quatuor anterioribus breviusculis; aculeo paulo recurvo; corpore infra nitido nigro. Long. 7 lin.

Hab.: Waikato.

About the size and general appearance of the Australian *M. 10-maculata*, Fab., but, *inter alia*, minutely scaly, except the white spots and band, not pubescent, and the tibial spurs nearly obsolete.

Mordella detracta.

M. nigra, pube, in certa luce grisea, subtiliter vestita; elytris fascia flexuosa ante medium maculisque duabus posticis albis ornatis; antennis minus serratis; capite antice valde convexo; tarsis quatuor anterioribus valde elongatis; aculeo recto, breviusculo; corpore infra griseo-sericante. Long. 4 lin.

Hab.: Waikato.

About the size and general appearance of our *M. fasciata*, but the elytra narrowing much more posteriorly and differently marked.

Irenimus.

Rostrum parum elongatum, modice robustum, versus apicem manifeste crassius, apice triangulariter emarginato; *scrobes* breves apicales. *Antennæ* graciles; *scapus* prothoracem attingens; *funiculus* articulo primo vix incrassato; *clava* distincta. *Oculi* subtenuiter granulati. *Prothorax* subcylindricus, basi rotundatus, lobis ocularibus parum prominulis. *Elytra* elongato-cordata, basi prothorace manifeste latiora, humeris obliquis. *Femora* crassa; *tibiæ* flexuosæ, posticæ corbellis subcavernosis. *Abdomen* segmentis duobus basalibus ampliatis. *Corpus* squamosum.

Allied to the Australian genus *Perperus*, differing principally in the base of the elytra exceeding the width of the prothorax at the base. This is a character on which Lacordaire lays great stress; but in many genera it really seems to be only of specific importance.

Irenimus parillis.

I. oblongus, niger, squamis obscure cervinis omnino dense tectus, setulisque nigris adsperus; rostro capite duplo longiore, antice carinato;

antennis ferrugineis; scapo squamoso; funiculo articulis tribus basalibus sensim brevioribus, cæteris obconicis; prothorace parum longiore quam latiore, lateribus rotundatis, pone medium subparallelis; scutello inviso; elytris seriatim punctatis, interstitiis vix convexis, tibiis subbisinuatis, apice subacuminatis. Long. 3¼ lin.

Hab.: Chrischurch.

LYPEROBIUS.

Molyti affinis. *Rostrum* validum, rotundum; *mandibulæ* lamelliformes; *scrobes* obliquæ, oculos vix attingentes; *clava* distincta. *Prothorax* lobis ocularibus paulo prominulis. *Elytra* ovalia. *Femora* incrassata; *tibiæ* apice haud laminatæ. *Abdomen* segmento secundo quam tertio paulo longiore.

With nearly all the characters of the European *Molytes*, this genus is principally distinguished by the tibiæ being without that peculiar external prolongation of the lamina which normally forms the floor of the hollow (corbel) above which the tarsus is inserted, and also by the club of the antennæ deing distinctly marked off from the funicle. The fine species constituting the only exponent of the genus at present has been recently discovered by Capt. Hutton, at Tarndale, near the head of the Wairau River, Nelson. "It lives on the spear-grass *(Aciphylla colensoi)*, and sucks its turpentiny juices. The plant only grows on the mountains from 2,000 to 5,500 feet elevation." The insect is entirely black; but some of the specimens are sprinkled with a few fine straw-coloured hairs.

Lyperobius huttoni.

L. ovalis, niger, nitidus; capite antice convexo; rostro tenuiter punctato, basi fovea profunda impresso; oculis valde angustis; antennis piceis; scapo apice sensim incrassato; funiculo articulis duobus basalibus æqualibus, reliquis submoniliformibus; clava breviter ovata, tomentosa; prothorace inæqualiter convexo, leviter vage punctato; elytris striato-punctatis, punctis approximatis, interstitiis planatis, tertio quintoque multo latioribus; corpore infra nitido, subtiliter punctato; pedibus tenuiter vage setulosis. Long. 9–11 lin.

Hab.: Tarndale.

PÆDARETUS.

Caput parvum; *rostrum* modice elongatum, apicem versus crassius; *scrobes* præmedianæ, obliquæ, ante medium oculorum desinentes. *Oculi* ovales, grosse granulati. *Scapus* oculum vix attingens; *funiculus* 7-articulatus, articulo primo magno, cæteris, transversis. *Prothorax* amplus, utrinque rotundatus, basi leviter bisinuatus. *Scutellum* invisum. *Elytra* breviter cylindrica, basi prothoracis

latiora. *Coxæ* anticæ haud contiguæ; *femora* mutica; *tibiæ* cylindricæ, unco valido armatæ; *tarsi* breves; *unguiculi* liberi. *Propectus* haud excavatum. *Abdomen* segmentis duobus basalibus ampliatis.

I can only compare this genus to the Australian *Psaldus*, from which it is at once differentiated, *inter alia*, by its normal scrobes and propectus (the latter without the slightest trace of a canal). *Syagrius* has a different rostrum and the tibiæ not armed with a hook.

Pædaretus hispidus.

P. breviter cylindricus, fuscus, squamulis erectis piliformibus, rostro incluso, vestitus; antennis nitide subferrugineis, clava ovata; prothorace latitudine longitudini æquali, lateribus valde rotundatis supra confertim fortiter punctato; elytris fortiter striatis striis punctis remotis impressis, corpore infra fortiter punctato; tarsis fulvis. Long. $1\frac{3}{4}$ lin.

Hab.: Auckland.

Erirhinus acalyptoides.

E. ovatus, fulvus, parce sericeo-pilosus, prothorace fusco; rostro gracili, prothoraci longitudine æquali, modice arcuato, basi striato; antennis fere in medio rostri insertis, clava majuscula, fusca; prothorace transverso, utrinque valde rotundato, sat vage punctato; scutello rotundato; elytris prothorce multo latioribus, striato-punctatis, apice rotundatis; pedibus fulvis; corpore infra infuscato. Long. $1\frac{2}{3}$ lin.

Hab.: Otago.

I can see nothing to differentiate this pretty little species generically from *Erirhinus.* It is very similar in appearance to our *Acalyptus carpini.*

ANEUMA.

Rostrum cylindricum, tenue arcuatum; *scrobes* antemedianæ, laterales. *Scapus* oculum attingens; *funiculus* articulo primo elongato, crasso; *clava* distincta. *Oculi* rotundati, fortiter granulati. *Prothorax* transversus, basi truncatus, lobis ocularibus nullis. *Elytra* elongato-cordata, prothorace multo latiora. *Pectus* antice emarginato-canaliculatum. *Coxæ* anticæ contiguæ, intermediæ modice approximatæ; *femora* incrassata, infra dente minuto instructa; *tibiæ* breviusculæ, rectæ; *tarsi* normales. *Abdomen* segmento secundo haud ampliato, duobus sequentibus conjunctim longiore. *Corpus* pilosum.

In this genus the head is deeply inserted into the prothorax, and, although it is much bent inward, the rostrum is not received in the pectoral canal, the latter being bounded behind by the anterior coxæ. The presence of this canal prevents the genus being associated with *Erirhinus*, to which otherwise it might have been referred.

Aneuma fulvipes.

A. ovalis, supra subtestacea, nigrescenti-nebulosa, pilis griseis sat sparse vestita; rostro prothorace breviore, basi lineis elevatis instructo; antennis subtestaceis, apicem versus infuscatis; funiculo articulis secundo, tertio quartoque gradatim brevioribus, tribus ultimis transversis; prothorace utrinque rotundato, leviter punctulato; elytris confertim striato-punctatis interstitiis convexis; corpore infra piceo-testaceo: pedibus fulvescentibus, sparse pilosis. Long. 1¼ lin.

Hab.: Christchurch.

Stephanorhynchus purus.

S. fere omnino griseo squamulosus; rostro vix compresso, antice haud cristato, fronte super oculos leviter bituberculata, tuberculis haud setosis clava antennarum elongato-ovato, tomentosa, arcte articulata; prothorace nonnihil subquadrato, sed antice subito constricto, supra vix tuberculato; scutello parvo, transverso; elytris elongato-subcordatis, supra subplanatis, leviter tuberculatis, striatis interstitiis alternis elevatis, lateribus subito deflexis, apicibus divergentibus; femoribus posticis dente minus prominente; abdomine segmentis tribus ultimis esquamosis, infuscatis; tarsis articulo penultimo nigro. Long. 3½ lin.

Hab.: Pitt Island.

In *S. attelaboides*, Fab., the only species hitherto described, the upper surface is very irregular, the rostrum with a sharply raised longitudinal crest, the prothorax conical, etc. It varies in colour, being sometimes uniformly grey, as in the species before us; but its normal state is well represented in Mr. White's ("*Erebus*" and "*Terror*," tab. 3, fig. 11).

Stephanorhynchus brevipennis.

S. squamulis filiformibus brevibus fere omnio tectus; rostro capite paulo longiore, antice gibboso, fronte super oculos leviter bituberculata, tuberculis haud setosis; occipite longitudinaliter excavato; clava antennarum elongato-ovata arcte articulata; prothorace capite minore, conico, pone apicem strangulato; elytris brevibus leviter striatis, singulis quadrituberculatis, tuberculo juxta suturam pone medium majore, vel cristam triangularem formante, apicibus rotundatis; tibiis fulvis, posticis valde curvatis. Long. 2½ lin.

Hab.: Christchurch.

Well differentiated, *inter alia*, by its short elytra, rounded at the apices.

Hoplocneme punctatissima.

H. nigra, vel purpureo-nigra, vix nitida, femoribus apice, tibiis tarsisque, subferrugineis, supra confertim punctata; capite inter oculos haud excavato, collo valde constricto; clava antennarum majuscula; prothorace subcylindrico, angulis anticis rotundatis; scutello parvo; elytris sat ampliatis, haud striatis. Long. 1¾ lin.

Hab.: Otago.

Smaller than *H. hookeri*, Wh., from which it may be at once known by the irregularly crowded punctures on the elytra without any trace of striæ, instead of being in regular lines. Mr. White refers *Hoplocneme* to the neighbourhood of *Orchestes*, with which it has nothing to do; it is one of the *Erirhininæ*, and applied to the same writer's *Stephanorhynchus*. The funicle in *Hoplocneme* is six-jointed, and the club is four-jointed.

PACTOLA.

Rostrum capite brevius, cylindricum; *scrobes* obliquæ, infra oculos desinentes. *Antennæ* subterminales *scapus* elongatus, pone oculos superans; *funiculus* 7-articulatus, articulo primo majusculo, quatuor ultimis transversis; *clava* magna, ovata, concreta. *Oculi* prominuli, laterales, rotundati, grosse granulati. *Prothorax* angustus. *Elytra* ampliata, supra irregularia, humeris callosis. *pedes* quatuor anteriores mediocres, femoribus simplicibus, *tibiis* subrectis; *pedes* posteriores majores, *femoribus* fortiter clavatis, infra dente magno armatis, *tibiis* arcuatis, haud compressis, omnibus apice muticis; *tarsis* articulo tertio late bilobo: *unguiculi* subdentati; *coxæ* anticæ contiguæ, intermediæ et posticæ lato dis tantes. *Abdomen* segmentis duobus basalibus valde ampliatis.

It is with some doubt that I refer this genus to the *Erirhininæ*. In the form of the hind legs it approaches the two preceding genera; but the head, not constricted behind to form a neck, would seem to indicate a different type. *Ixalma*, another anomalous genus, with somewhat similar legs, but having a free pygidium, I refer to the neighbourhood of *Tachygonus*. M. Roelofs ("Ann. Soc. Ent. Belg.," XVII., p. 126) places his genus *Celia**, apparently identical with *Ixalma*, among the "Eugnomides," *i. e.* with the *Erirhininæ*. These are all isolated forms; but I think the pygidium offers a more important character than the separation or the contiguity of the anterior coxæ. The species described below differs considerably in coloration, some individuals being of an almost uniform dark brown, others pale brown on the disk of the elytra; some have the elytron prettily variegated—a central dark triangular spot with a light semicircular line behind, and other variations.

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* *Celia* has long been used for a genus of *Carabidiæ*.

Pactola variabilis.

P. oblongo, fusco- vel brunneo-squamosa, aliquando variegata: antennis fulvis, apicem versus infuscatis; prothorace subcylindrico, in medio bituberculato; elytris basi prothorace fere triplo latioribus, supra tuberculatis, antice subdepressis, late striato-punctatis; corpore infra sparse punctato. Long. $1\frac{3}{4}$ lin.

Hab.: Auckland.

Idotasia egena.

I. elliptica, nitide nigra; rostro pone basin fortiter arcuato, dimidio basali antice punctis magnis oblongis approximatis impresso; oculis grosse granulatis; antennis fulvo-ferrugineis; clava oblongo-ovata; prothorace sat vage punctato; elytris vage leviter punctulatis; pedibus piceis. Long. $1\frac{2}{3}$ lin

Hab.: Waikato.

This species is more nearly allied to the Batchin *I. scaphioides* than to either of the Australian members of the genus; it is, however, broader and less convex, the posterior portion of the elytra less attenuated, the intervals of the punctures on the rostrum less decidedly elevated or cariniform, etc. *Idotasia* now contains nine species—five from New Guinea and the neighbouring islands, two from Queensland, one from New Caledonia, and the above. They are very homogeneous, except the one from New Caledonia, but are differentiated by well-marked characters.

Aræocerus pardalis.

A. dense pubescens, fuscus, albido maculatus; antennis breviusculis nitide fulvis, articulis tertio ad quartum paulo elongatis; clava infuscata, articulis perfoliatis, duobus basalibus valde transversis, ultimo rotundato; prothorace transverso, basi quam apice fere duplo latiore; scutello minuto; elytris oblique striato-punctatis, humeris paulo callosis; pedibus pallidis, tibiis apicem versus leviter incrassatis, tarsis articulo basali modice elongato. Long. $1\frac{1}{2}$ lin.

Hab.: Auckland.

Probably introduced, as this species has also been found in Ceylon; but it has not, I think, been described. It is like *A. Coffeæ*, but smaller, with shorter antennæ, the club stouter and more compact, the tarsi not nearly so long, etc.

OCHROCYDUS.

Caput breve. *Oculi* permagni, subtenuiter granulati; *epistoma* distincta; *labrum* parvum; *labium* membranaceum, bifidum; *maxillæ* lobo interiore triangulari. *Palpi* elongati, omnes fere æquales. *Antennæ* (male) corpore longiores, 12-articulatæ, articulo basali mediocri, obconico, tertio paulo breviore, cæteris (ultimo excepto breviusculo) parum longioribus, subæqualibus, unilateraliter dilatatis; (female) corpore breviores, 11-articulatæ. *Prothorax* transversus, depressus, muticus. *Elytra* prothorace latiora, elongata, subparallela. *Pedes* tenuati, elongati; *femora* linearia; *tibiæ*, posticæ flexuosæ exceptæ, rectæ, apice bispinosæ; *coxæ* anticæ transversæ. *Prosternum* elevatum, postice rotundatum. *Abdomen* molle, lævigatum.

The only exponent of this genus retains the name of *Aphanasium australe*, Boisd., in the British Museum,* and as such was referred by Mr. White to the *Prionidæ*. It is probable that Lacordaire, had he known it, would have placed it in his "Monodesmides." I do so now with some hesitation in consequence of the absence of the lateral ridges separating the pronotum from the sides of the prothorax, and the presence of the inner maxillary lobe.

Ochrocydus huttoni,

O. fulvescens, elytris nitide testaceis; capite prothoraceque sat sparsim, pectore dense, villosis; prothorace angulo antico rotundato, lateribus subparallelis; elytris sat confertim punctatis, apicibus ad suturam spinosis; pedibus tenuiter pilosis; tarsis intermediis et posticis articulo primo quam secundo longiore; segmento ultimis abdominis in fæmina solum detecto. Long. (male) 12 lin., (female) 15 lin.

Hab.: Waikato; Wellington.

Agapanthida scutellaris.

A. oblonga, depressa, rufo-castanea, antennis pedibusque dilutioribus, supra confertim punctato, griseo variegata; scutello nigro, subscutiformi, in medio excavato; elytris apice, paulo dehiscentibus, sutura canaliculata. Long. 4 lin.

Hab.: Waikato.

Judging from Mr. White's figure of *A. pulchella* ("Voyage of the '*Erebus*' and '*Terror*,'" Entom., tab. 4, fig. 10), this species differs, it might be thought almost generically, in its shorter and much thicker femora. The derm in my unique example (apparently a female) seems to be covered with a membranous sort of integument, peeling off in patches; but, from the regularity on both sides, the variegation does not seem to be due solely to that cause. The slight intervals between the punctures on the elytra have a granulated appearance. *Agapanthida* differs from *Phlyctænodes* in its finely faceted eyes, an exceptional character in its own and allied groups.

Triplax brounii.

T. obovata, fusco-castanea, nitida, antennis pedibusque ferrugineis, illis

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* It was this that led me to describe the true *Aphanasium australe* as a new species under the name of *Solimnia sublineata*, a mistake which I afterwards corrected ("Journ. Linn. Soc.," IX., p. 134).

articulo ultimo apice obliquo, palpis maxillaribus articulo ultimo valde transverso ; capite prothoraceque subtiliter, elytris fere obsolete punctatis ; tibiis modice triangularibus ; prosterno postice paulo bilobo. Long. 1¾ lin.

Hab.: Auckland.

Rather narrower than *T. ænea,* and the elytra more cuneate. The nearly allied Australian genus *Thallis,* Er., has filiform palpi. I have named this interesting species after Captain Broun, whose numerous discoveries are adding so much to our knowledge of the insect-fauna of New Zealand.

EXPLANATION OF PLATE.

Fig. 1. *Tysius amplipennis:* 1 *a,* head.

Fig. 2. *Phrynixus terreus;* 2 *a,* head (the eye is much too small)

Fig. 3. *Cecyropa tychioides.*

Fig. 4. *Inophlæus traversii.*

Fig. 5. *Actizeta albata.*

Fig. 6. *Phycosecis discoidea ;* 6 *a,* antenna ; 6 *b,* fore tibia and tarsus ; 6 *c,* maxilla with its palpus , 6 *d,* mentum with the lower lip and its palpi.

Fig. 7. *Stenopotes pallidus.*

Fig. 8. *Xyloteles costatus.*

Fig. 9. *Xuthodes punctipennis.*

Fig. 10. *Syrphetodes marginatus.*

Fig. 11. Right fore tibia and tarsus of *Actizeta albata* (the artist has placed it in a position to represent the left). 11 *a,* antenna ; but the basal joint has been unaccountably omitted.

Fig. 12. Head of *Cyttalia griseipila.*

ART. LIII.—*Notes on the occurrence of a Curlew, probably* Numenius cyanopus,* *Vieillot, in New Zealand.* By JULIUS VON HAAST, Ph.D., F.R.S.

[Read before the Philosophical Institute of Canterbury, May 4th, 1876.]

FOR years past I have repeatedly been informed by several sportsmen in this Province, that they had observed specimens of a large Curlew in the estuaries of some of our rivers, and although every attempt was made to secure a specimen for the Canterbury Museum, for a long time it proved unsuccessful. Thus Mr. Alexander Barnes, of Saltwater Creek, told me that he had seen about six years ago as many as five together, which were so shy that he could never get near enough to fire at them. In the last four years he has seen, however, only one solitary bird, the others having disappeared. Similar accounts have reached me from the South.

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* See *ante*, p. 333.

Mr. Robert Day at last obtained one on the Kaiapoi Bar on the 2nd of April of this year, where it was found by him together with a mob of *Limosa uropygialis*, the Godwit, usually called the New Zealand Snipe.

On examination it proved to be a very fine male bird, which as to size agrees more with the Australian than the European species. Mr. Gould has already pointed out * that the Australian Curlew, although in many respects resembling the common Curlew of Europe, is distinguished from it, amongst several differences in the plumage, by a much longer bill. As it will be seen by the following measurements, taken from a specimen in the Canterbury Museum, the New Zealand bird is the largest of the whole series :—

—	From Gape to point of Bill, in a straight Line. Inches.	Length of Metatarsus. Inches.
Numenius arquatus, Silesia, North Germany, male, (1870, no further date)	4·82	3·11
Numenius arquatus, Silesia, North Germany, female, (1870, no further date)	4·65	3·32
Numenius arquatus, Bremen, Germany, female (April 13*th*, 1875)	5·96	3·19
Numenius cyanopus, Australia, no sex, no date	7·0	3·20
Numenius cyanopus (?), Canterbury, N.Z., male, (April 2*nd*, 1876)	7·62	3·48

From these measurements it will be seen that, whilst the bill of the only Australian specimen in the Canterbury Museum is considerably longer than those of the three European specimens, the New Zealand bird exceeds the former by more than half an inch in length. The length of the metatarsus is, however, no criterion, the European specimen with the shortest bill having the longest metatarsus of the whole series, except the New Zealand specimen. I am not aware how far variations may occur in the plumage of these Curlews in different seasons or during different ages, which might be important, but I find that the Australian specimen in the Canterbury Museum agrees entirely with Gould's description, so that if the New Zealand bird belongs to the same species the latter is in a different state of plumage, as it is usually found in Australia.

Thus I find what is pale buff in the Australian specimen is nearly white in the New Zealand bird, which is very striking on the side of the face, on the throat, and the lower part of the breast, also the greater wing covers and the first primary quill feathers are nearly black in the New Zealand specimen, in which both features it resembles the European species. The New Zealand specimen has, however, the rump and tail covers also barred with brown, instead of being uniform white as *N. arquatus* exhibits, so that

* "Birds of Australia," Vol. II., p. 278.

in this peculiarity of plumage, as well as in the length of the bill, the New Zealand bird agrees with *N. cyanopus* of Vieillot.

The back of the Australian specimen is described as blackish-brown, each feather irregularly blotched with reddish buff on the margin, whilst in the New Zealand specimen the feathers do not exhibit these reddish buff blotches.

In the two specimens, male and female, from Silesia (1870), but no date when they were obtained, there is also no sign of reddish buff on the back, the feathers being here more irregularly blotched with dark brown all over than in the New Zealand bird, where this tint is more confined to the central line of the feathers, and from which the brown bars run more regularly towards the edges than in the former. On the other hand the female bird, shot April 13th, 1875, near Bremen in Germany, exhibits the reddish buff blotches well, but in all other respects agrees with the two other European specimens. If it were not too hasty to draw a conclusion from two single specimens, of which the data of one of them are not known, we might infer that the reddish buff blotches on the back appear in both the European and Australian species before and at the breeding season. It is also impossible to say at present, if this specimen (like those before observed in New Zealand) is only a straggler from Australia, or if it is a distinct species which breeds in New Zealand and has some constant characteristic features of its own, and we have therefore to wait until more material is collected before we can settle that question.

P.S.—Since these notes were written, another male specimen of the Curlew was obtained on the estuary of the Ashley River by Mr. Robert Haylett, who shot it on June 27th, when flying past alone. My informant believes that it was the specimen which had been seen at Saltwater Creek and the neighbourhood for some years past, and to which I have alluded in my first paper. The bill of this specimen is only 5·71 inches, and the metatarsus 3·35 inches long, it being thus of smaller dimensions than the first one obtained on the Kaiapoi Bar.

With this latter it also agrees in the plumage, with the exception that its back is also irregularly blotched with reddish buff.

As this bird was shot at the end of June, when the Curlew would already assume the vernal dress in New Zealand, my former inference in that respect might prove correct. At the same time it appears that the Curlew, of which two specimens were obtained in New Zealand, is intermediate in plumage between the European and Australian species, and might thus rank as a variety, although I think it would be premature to designate it by a new specific term, until we shall know something more about it.

ART. LIV.—*Notes on the Skeleton of* Epiodon novæ zealandiæ. By JULIUS VON HAAST, Ph.D., F.R.S., Director of the Canterbury Museum.

[*Read before the Philosophical Institute of Canterbury, 4th May, 1876.*]

Plates.

AT the end of July, 1872, the report reached me that a Whale had been stranded on a reef in Lyttelton Harbour, Banks' Peninsula, and that the carcass had been towed into one of the small bays by several fishermen for securing the oil.

Being myself prevented by indisposition, Mr. Fuller, the taxidermist of the Museum, proceeded to that locality with instructions to secure the skeleton, and to make the necessary observations as to dimensions, form, sex, and age of the animal.

When he arrived where the fishermen were at work, he found that the blubber had nearly all been taken off, so that he could only partially obtain the required measurements.

The animal, which on dissection proved to be an aged female, had a total length of 26 feet; and Mr. Fuller described the body as being rather thick in the middle, tapering to a slender tail, without showing the least trace of any dorsal fin. Colour, bluish-black on the upper portion of the body; white beneath, the upper portion being marked with numerous oval spots, two to three inches across, like the skin of a leopard. The head was much swollen. The whole skeleton, with the exception of a few bones, was secured to the Canterbury Museum, where it now stands articulated in one of its rooms. Plate XXV. shows its general characteristics more fully than a mere description can convey.

Before, however, entering into a description of the principal portions of the skeleton, I wish to draw attention to the fact, that our specimen did not possess a dorsal fin, nor did a careful examination by Mr. Fuller of the central line of the back reveal the least fragment of one, or even the indication that it ever had existed.

However, this absence cannot be claimed as a generic character, as Raffinesque stated, when first establishing that genus, because the *Epiodon australe* of Burmeister* by that distinguished veteran naturalist) possesses a well-developed dorsal fin.

Moreover, the forehead of the New Zealand species is much swollen, whilst the head of the South American species previously alluded to, is tapering. Thus in the enumeration of the principal characteristics of the

* See the excellent Memoir on that South American species in "Anales del Museo Publico de Buenos Aires," Part V.

genus *Epiodon* (see, amongst others, Gray's "Catalogue of Seals and Whales," page 340) this feature also must lose generic value.

Skull.

Dr. Hector* has given a short description of the skull of a specimen, under the name of *Epiodon chathamiensis*, which, if not belonging to the same species, is closely allied to the animal of the New Zealand coasts. That skull was obtained on the Chatham Islands.

However, as amongst minor differences the form of the teeth is different, I have thought it more expedient to describe the New Zealand specimen under the specific name of *Epiodon novæ zealandiæ*, leaving it to the future, when more material has been collected, to determine if there are two distinct species or not.

The skull has the following dimensions :—

	Ft.	In.
Extreme length with lower jaw	3	3·12
Extreme length of cranium, point of rostrum, which is broken off, restored	3	1·50
Length of rostrum, from the apex of the præ-maxillæ to the middle of the line drawn between the ante-orbital notches	1	7·89
Greatest height from top of nasals to lower border of pterygoids	1	5·52
Greatest breadth across post-orbital processes of frontals	1	10·75
Breadth of occipital condyles	0	6·30
,, foramen magnum	0	2·40
Height ,, ,, ...	0	2·22
Breadth of base of rostrum between bottom of ante-orbital notches	1	0·91
Breadth of rostrum in the middle	0	4·83
Anterior nares, greatest width of the two	0	3·20
Height of crest above occipital foramen	1	2·93
Width of occiput	1	4·60
Mandible.		
Length of ramus	2	8·50
,, symphysis	0	7·46
Vertical height of ramus at coronoid process	0	6·40
Apex of mandible projecting beyond apex of rostrum (restored)	0	1·62

* "Trans. N.Z. Inst.," Vol. V., p. 165, Pl. IV. and V.

	Ft.	In.
Mandibular tooth, right, length	0	2·12
,, ,, ,, greatest breadth	0	0·72
,, ,, ,, weight, 184 grains.		

It will be seen in comparing its dimensions with those of the skull from the Chatham Islands, figured and described by Dr. Hector,* that it is larger and more developed, with the exception of the two mandibular teeth, which are much smaller in the Chatham Island specimen, and evidently are designed for other purposes. The rostrum, of which the point is broken off, is of small dimensions when compared with the posterior portions of the cranium, its point being slightly turned to the right. This point was shattered into such a number of small pieces, so that after maceration it was impossible to secure them all. The same was the case with the lower jaw, so as to suggest that the animal had struck the reef, and thus injured so considerably that portion of its frame.

The premaxillaries are two thin bones, which run parallel in their anterior portion. They here curve inwards, so as to form a semi-cylindrical excavation, running along the whole rostrum as far as the septum narium.

Before reaching this, however, they alter somewhat their general form, the rounded edge disappearing, the bones now showing a plane, rather concave surface, and gradually rising near the posterior end of the nares, unite here with the nasal bones, by which a high crest is formed.

For about one-third from the point both sides of the premaxillaries are alike, after which the right one becomes much broader than the left one, and passing over the median line of the skull to the left, the skull now becomes very unsymmetrical in its central portion, so that the opening of the nares is displaced to the left. Moreover the uppermost portion of the right premaxillary, besides being broader, is much higher than the left one—a peculiarity to which also the nasal bones conform, the right one being considerably higher than the left one.

The prefrontals (of Owen) begin 6·50 inches from the anterior point of the rostrum, gradually widening to one inch, being slightly concave in the centre for a length of eight inches. They then gradually flatten for a distance of one inch, after which they become convex, until they rise and form the thin ridge of the septum narium. The latter is wedged in its anterior portion against the left premaxillary, and then continuing its direction to the left joins then obliquely the nasal bones. In the centre of the nares the septum narium is excavated for a depth of nearly two inches and a width of 1·20 inches, the bone having here a very sharp edge. Shortly

* *Loc. cit.*

before the septum narium is formed the premaxillaries coalesce for a short space.* The maxillaries, which begin with a narrow point, having a downward sloping surface, gradually widen, and after having in about the centre of the rostrum a plane surface the outer side rises to the orbital notch, after which they expand greatly with a deeply concave surface, rising posteriorly to the highest part of the crest, uniting with the frontals through their whole extent.

The high maxillary crest of *Hyperoodon* is represented only by a small elevation at the beginning of the broad concave surface, similar to *Epiodon australe*, as pointed out by Professor H. Burmeister in his exhaustive description of that South American species.

A deep and narrow furrow begins on the lower side of both premaxillaries near the point, continuing after their junction with the maxillaries along the latter bones, where it runs below their lateral edge to about the middle of the rostrum, gradually getting shallower and narrower.

In these grooves small vascular cavities are observable, as if they had once served for rudimentary teeth, of which, however, not the least remnant could be observed, all without doubt having been absorbed.

The vomer begins 5·50 inches from the point of the rostrum, between the premaxillaries, forming for 8·75 inches a narrow convex ridge, which in its broadest or central portion is only 0·25 inch broad. The palatal surface of the rostrum is slightly bent upwards near the point.

The united periotic and tympanic bones are of considerably less size than those of *Berardius arnuxii.*

The tympanic bone, of which a figure is given (Pl. XXIV., Fig. 1, A. upper surface, A′. lower surface), is shorter, the anterior end not being so much prolonged, and thus resembling more in form the same bone in *Hyperoodon*. The same can be said of the periotic bone, which is also not only shorter but has the notches between the lobes much shallower than *Berardius.*

The lower mandible, which projects about two inches beyond the point of the rostrum, consists of two thin callous rami, which gradually become narrower till their termination at the point, the bony substance of which they are composed getting more spongy towards the beginning of the symphysis. From this beginning the united bones curve upwards. At the point two small teeth are embedded in sockets, the tips rising only a few lines above them. They are covered with rugose cement to the very point, which in their lower part forms wart-like prominences.

* I have given these details because in another skull of the same species which the Canterbury Museum possesses, and of which I shall give the measurements with some notes in an appendix, besides some minor points, a very marked difference occurs in the form of the prefrontals.

As there is scarcely any difference between the two teeth, I give only the figure of one of them (Pl. XXIV., Fig. 3, C. front, C′. back, C″. section), the left one, which is 2·12 inches long, with the greatest breadth about the centre of 0·72 inch. It weighs 184 grains, and runs out at both ends to a constricted rounded point, that of the apex being the narrowest. It will thus be seen that the weight of this tooth, although it belongs to a skull of larger dimensions than the one obtained from the Chatham Islands, described by Dr. Hector, is scarcely the fourth of the weight which the teeth of the latter have. It is, moreover, evident that the teeth of the Chatham Island specimen must have been used, as, according to the description, "they are worn down into two lateral facets, divided by an acute ridge,* whilst in the New Zealand specimens the tips are as rough as the sides and roots, and do not show the least sign of wear. We know that the two skulls of the New Zealand specimens belong to female skeletons, whilst the skull of the Chatham Island specimen may possibly have been that of a male, but as we have not the least evidence in that respect, this point can only be settled by future researches into the anatomical characteristics of this interesting genus.

Returning to the skeleton under consideration, I wish to state that the teeth were only visible after maceration, and appear to be altogether functionless, because the lower jaw projects so much beyond the rostrum, unless we assume that the Whale had an upper lip of a somewhat prehensile character. On the upper margin, all along the anterior half of each ramus, a well-defined groove extends to the dental canal at the anterior extremity where it is broadest. A considerable number of small vascular canals open into this groove, without, however, showing the least rudiment of teeth. The coronoid process is marked very feebly, but the condyle is well developed, and forms the most posterior portion of the bone.

I may here observe that the skull of *Epiodon novæ zealandiæ* resembles in some respects that of *Epiodon australe* of South America, notwithstanding the difference in the form of the head, the former having a swollen and the latter a tapering forehead. In many instances, Professor Burmeister's excellent description of some of its osteological characters could be applied quite well to the New Zealand species.

Hyoid Bones.

The basihyal and the thyrohyals are still unanchylosed, notwithstanding the great age of the animal. The former has a somewhat trapezoidal form, thus resembling in that respect the same bone in *Epiodon australe*, but it is more pointed in its anterior portion, and has a deep notch in the centre,

* See "Trans. N.Z. Inst.," Vol. V., p. 165.

whilst in the South American species the anterior border is only slightly concave.

Breadth, 4·60 inches, antero-posterior length on both sides of the notch, 4·10 inches.

The thyrohyals have a length of 6·80 inches, with their greatest breadth of 2·55 inches, one-third from their posterior end.

The stylohyals are 10·80 inches long, and in their middle portion 2·10 inches broad; they are straighter than the same bone in *Epiodon australe*, which they resemble, however otherwise in form. The whole apparatus is more slender than in the Buenos Aires species.

Vertebral Column.

The following are the numbers of vertebræ:—

Cervical	7
Thoracic	9
Lumbar	11
Caudal	19
Total	46

In comparing this number with that observed in *Epiodon australe*, it will be seen that the New Zealand species has three less, viz., 9 thoracic instead of 10, and 19 caudal instead of 21; thus showing also some difference in the osteological structure of the two species. I may here observe, that all the plates of the vertebræ are so thoroughly coalesced with the rest of the body, that the line of juncture is not visible—a proof that the animal must have been not only adult, but aged.

Cervical Vertebræ.

Of these, the four first are entirely anchylosed, whilst the fifth, sixth, and seventh are free; thus having one free vertebra less than *Epiodon australe*, in which only the first three vertebræ are united. However, as this skeleton was derived from a young animal, this difference cannot be claimed as of a permanent character until we know the skeleton of the same animal in a full-grown state. The atlas, which is 11·40 inches broad by 8·15 inches high, forms, with the next two vertebræ, one solid bone with a high crest. It is the largest of all the cervical vertebræ. The parapophyses (lower process) in each of the coalesced bones, of which that of the atlas is the largest, are, with the exception of that belonging to the the fourth, well developed. They decrease, however, gradually in size to the third, that of the fourth being of such small dimensions, that it is an inch shorter than the same process in the preceding one, with which it is anchylosed at the upper and lower extremities, but not with the body.

The fifth cervical vertebra is very narrow, 0·55 inch; it has, moreover, no spinous process above the arch, the summit of which stands two inches below the point of the spinous process of the four anchylosed vertebræ. The parapophyses, although much larger than those of the fourth cervical vertebra, stand on the same line with them.

The sixth cervical vertebra is a little broader than the preceding one. There is only an indication of a spinous process above the arch; the parapophyses are well developed, and advance half an inch beyond those of the former vertebra.

The seventh vertebra is slightly broader than the preceding one. It has a distinct spinous crest standing two inches above the arch. The lower process, or parapophyses, on each side, has dwindled to a narrow tubercle, sloping upwards; the body of the bone has a well-marked articular surface for the head of the first rib on both sides, which is situated between the well-marked upper transverse process (diapophysis) and the small tubercle representing the lower transverse process (parapophysis). These seven vertebræ have a length of 7·15 inches, measured along the lower side of their main body.

Thoracic Vertebræ.

Their number, as before stated, is nine, consequently one less than *Epiodon australe* possesses. In this respect the New Zealand species resembles *Hyperoodon*, which, as far as I am aware, is the only other known Ziphioid Whale having such a small number of thoracic vertebræ. Each vertebra has a spine standing backwards at an angle of 60° to the body of the vertebra. That of the first one is pointed, 6·40 inches high and 2·58 inches broad at the base. Gradually these spinous processes rise higher, and become broader at the same time, that of the ninth or last thoracic vertebra being the highest, 11·62 inches and 3·46 inches broad at the base. They are all laterally compressed, thinning out at the top to a mere blade.

The first two vertebræ possess on both sides of the arch a rounded apophysis on which the articular extremity for the tubercle is placed. This apophysis gradually enlarges, being laterally compressed and showing one well marked process pointing upwards and forward, as well as the articulation for the tubercle for the rib, which is situated more backwards.

On the seventh vertebra this separation of the apophysis is still more conspicuous, whilst in the eighth vertebra a separation of that apophysis in two distinct portions has taken place, the forward or superior process now appearing as the metapophysis, whilst its lower or posterior portion forms now a lower transverse process, on which the articular surface for the eighth rib is situated directed obliquely backwards. This lower transverse process is already situated in front on the body of the vertebra, but on its upper portion.

This division is still more conspicuous in the ninth or last thoracic vertebra, where the metapophysis has nearly the same form as that on the first lumbar vertebra, with the exception that its upper surface has a rounded instead of a horizontal edge. The lower transverse process has a more depressed, flattened form, moreover it is situated not only in the centre of the body of the vertebra, but also lower down and nearly on the same level as the same process in the first lumbar vertebra.

The bodies of the vertebræ gradually increase in size, the first having an antero-posterior length of 1·65 inches, and the ninth or last of 4·10 inches.

The inferior surface of the first thoracic vertebra is rough and rounded. The second, third, and a small portion of the anterior part of the fourth, have a shallow concave groove, after which on the fourth a median keel appears, which continues to run along the rest, gradually becoming more pronounced.

Lumbar Vertebræ.

The nine thoracic vertebræ are succeeded by eleven lumbar vertebræ, which possess nearly all the same form, getting of larger dimensions as they follow each other, so that the body of the last is the largest, viz., 5·48 inches for the first, and 7·58 inches for the last lumbar vertebra. The spines are of considerable size, the first being 13·25 inches high along its posterior margin. They then gradually rise to the eighth, which is 15·52 inches high, after which they diminish again slightly. They are compressed as usually and broader at the apex, which has a truncate form as if they were cut off.

The metapophysis on the anterior end of the arch is similar in form to that of the last thoracic vertebra, but a little larger in the first four vertebræ, its apex having moreover a still more truncated edge. Beginning with the fifth vertebra, this process gets gradually smaller, assuming at the same time a more rounded form.

They all possess on their inferior surface a median keel, which is most pronounced on the fifth, sixth, and seventh vertebræ, after which getting shallower by degrees it nearly runs out on the last. The lower transverse process is throughout of the same form and size, having a horizontal and little forward direction.

The caudal vertebræ are nineteen in number, of which the first ten have chevron bones attached to them on the posterior border of the lower surface, thus forming as usual two distinct classes. The bodies of the caudal vertebræ shorten from 7·51 inches to the tenth, which is only 3·78 inches long, although their height is the same. From the first to the thirteenth a broad shallow groove runs along their lower surface, after which they have a deep lateral excavation. The spines are also gradually reduced in height to the tenth, in which the same is only 1·50 inch high. They continue, however, to possess the same truncated apex with a downward slope from front to back, getting at their starting point from the arch gradually larger, that on the fourth caudal vertebra being here the largest of the whole series of vertebræ. The metapophyses also gradually diminish and assume, instead of the former flattened form, now a stouter appearance with a more outward direction of the point. The same diminution in size is observable in the lower transverse proccess, which on the eighth caudal vertebra forms only a very small ridge, but has entirely disappeared on the ninth.

The tenth vertebra is very much laterally compressed. The eleventh assumes a rounded form, which becomes more squared in the 12th, after which the rest have a nearly quadrangular form to the last. The last caudal vertebræ, beginning with the tenth, have a well excavated channel running along both sides of the vertebræ. I may here observe that the last chevron bone, as well as the seventeenth and nineteenth vertebræ, are missing in this skeleton.

Ribs.

There are nine ribs on each side, of which seven possess two articulating processes. The first, which is the shortest of the whole series, is also the broadest. It is thick and flattened throughout. It articulates by a distinct capitular process with the body of the seventh cervical vertebræ, and above by an excavated articular surface, with the transverse process of the first thoracic vertebra.

From the second to the sixth the ribs gradually lengthen, the sixth being the longest, after which they decrease again. The second has still the flattened appearance of the first, but in a lesser degree, after which they assume all nearly the same shape, the upper portions below the articulations or articulator having a prismoid form, which is most pronounced in the middle of the ribs, where they are also the most constricted, the edge being on the inner side. They then widen and flatten to their lower extremity.

The second to the seventh ribs inclusive have, like the first, two articulations—a distinct capitular process for articulation with the vertebra in front, and an excavated articular surface slightly raised round the edges, into which the transverse process fits.

The eighth and ninth ribs have only one excavated surface, articulating with the end of the transverse process.

The greatest length of each rib, measured in a straight line, is :—

	Ft.	In.
First	1	9½
Second	2	6¼

	Ft.	In.
Third	2	10¼
Fourth	3	0½
Fifth	3	2
Sixth	3	3¼
Seventh	3	2¾
Eighth	2	11¼
Ninth	2	5½

Sternum.

In the form of the sternum, and of which I add a drawing (Pl. XXIV., Fig.) *Epiodon novæ zealandiæ* shows a well-marked difference from *Epiodon australe* of Buenos Aires.

It consists of five distinct segments, of which the first is the largest, having a greatest length of 14¼ inches, with a greatest breadth of 12½ inches. The second, third, and fourth generally diminish in both dimensions until the fifth, which is the narrowest, but longer than the three preceding ones. The dimensions of the fifth are 7¾ inches in length, with a breadth of 6 inches. The first, which possesses a shallow keel in its upper portion, has a deep notch above it, and another in the centre of its basal portion. Similar fossæ exist in each of the succeeding segments, by which four median fenestræ are formed, gradually diminishing in size, having their largest diameter in a vertical direction.

There are six articular surfaces on each side for the sternal ribs; the first near the upper portion of the first segment, the second at the junction of the first and second, the third at the junction of the second and third, the fourth at the junction of the third and fourth, the fifth at the junction of the fourth and fifth segments, and the last at the posterior ends of the two narrow processes, by which the fifth segment terminates. The entire length of the sternum, in a straight line, is 3 feet 1 inch.

A comparison with the sternum of *Epiodon australe* shows a great difference in the form of the segments and of the fenestræ, and, as it appears to me when mature, this species would only have four segments instead of five, thus agreeing with *Berardius arnuxii.*

Professor Flower figures, in his excellent memoir on *Berardius arnuxii*, the sternum as consisting of five pieces; but it is evident that the fourth and fifth segments are portions of the same bone, although they, from some cause, have not yet anchylosed.

In a skeleton belonging to the same species, which stands articulated in the Canterbury Museum, and which has been taken from a full-grown but not aged male, the discs on both sides of the vertebræ being not yet anchylosed, the sternum consists of only four segments. The fourth and fifth pieces of the skeleton in the Hunterian Museum appears as one bone without any suture visible between them ; the two last articular facets standing close to each other on the side of the fourth segment.

Pectoral Limb.

The scapula has the usual form, peculiar to the Ziphioid Whales; the acromion is, however, narrower and thinner than in *Epiodon australe,* in which that bone corresponds more with *Berardius arnuxii.* The coracoid is also shorter and stouter. The humerus to which the head is thoroughly anchylosed, has a well-defined tuberosity for articulation, with the strongly excavated glenoid fossa of the scapula, and on its lower posterior side a groove for the articulation of the ulna. Both ulna and radius have their articular surfaces well anchylosed, and do not call for any further remark.

The carpus differs considerably from that of *Berardius arnuxii,* of which Professor Flower gives a figure in his paper on that Whale in the "Transactions of the Zoological Society," and with which the carpus of another specimen articulated in the Canterbury Museum fully agrees. Instead of being united in pairs, the scaphoid and lunar and the cuneiform and unoiform are all distinct, and only the magnum and trapezoid are united into one bone.

They agree in this respect with the same elements in the carpus of *Mesoplodon sowerbiensis* of the Northern Hemisphere, whilst in the skeleton of *Epiodon australe* the magnum and trapezoid are also still separate bones. However, as this skeleton is derived from a very young animal, it may be possible that they unite in more aged individuals.

APPENDIX.

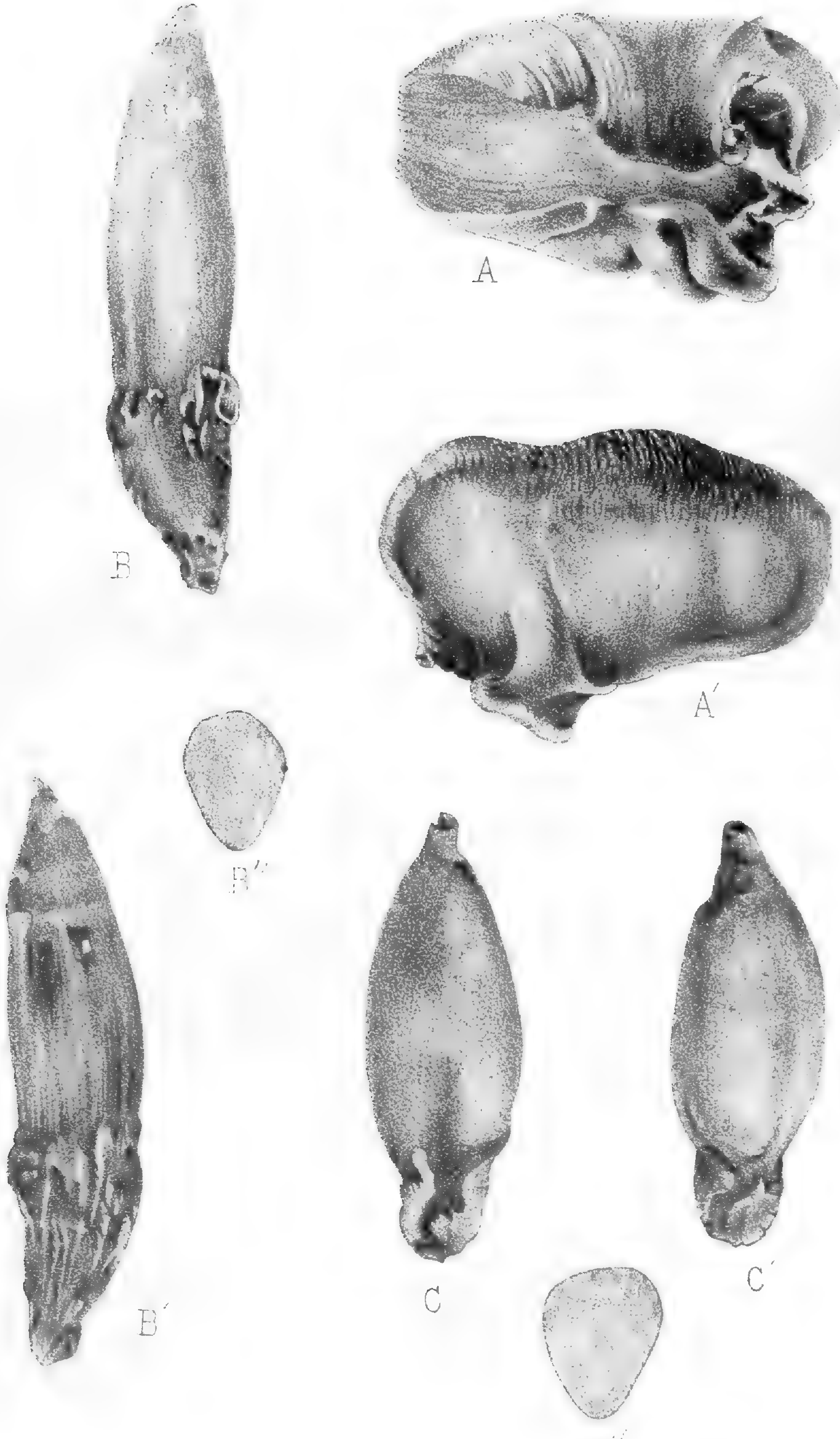
Notes on Skull B.

A female Whale of somewhat larger dimensions, belonging to the same species, was stranded about the middle of July, 1873, in Akaroa Harbour. According to Mr. Gorham Lambert, my informant, the animal was suckling a calf at the time. The latter was, however, thought not worth preserving by the finder. The skull of the mother Whale was secured for the Canterbury Museum. Pl. XXVI., fig 1.

From the following table of measurements it will appear that the skull is a little larger in all its dimensions than the one described previously belonging to the skeleton in the Canterbury Museum.

Although the point of the rostrum is quite entire, the point of the lower jaw was considerably broken, which proves that the animal made considerable struggles to regain deep water, during which, without doubt, it injured itself in the same manner as the Lyttelton Harbour specimen did. The skull under review is also derived from an aged individual, and with the exception that its rostrum is rather narrower than that of the Lyttelton Harbour specimen, it has otherwise somewhat larger proportions.

The most marked difference, however, is in the form of the prefrontals. In this skull the premaxillaries are much more excavated, and stand 1·53 inches apart in the centre of the rostrum.



Haast. del. J.B. lith.

The prefrontals, like in the former skull, begin 6·50 inches from the point of the rostrum, forming at the beginning a ridge, which continues for about eleven inches, constituting the central portion of these bones, and only gradually disappearing. For the last five inches they have a concave form. The premaxillaries here approach each other as in the Port Lyttelton specimen, but stand always half an inch apart. Here the beginning of the septum narium rises to within the eighth of an inch of the surface of the premaxillaries, gradually getting thinner and turning obliquely to the left, resting against the left of these latter bones.

The excavation in the septum narium is, however, much deeper and wider than in the first described skull, being three inches wide and two and a half inches deep. There is also considerable difference in the teeth of the two skulls, as a comparison of these figures will testify. I add two drawings of the right tooth. Pl. XXIV., fig. 2.

The tooth of this skull is 2·85 inches long and 0·61 inches broad. It is covered everywhere with a rough cement, which forms, principally near the lower extremity, wart-like protuberances, taking near the root-end ridgy forms.

It is consequently longer than the tooth of the Lyttelton Harbour specimen, and although the tenth of an inch thinner, is a little heavier, 198 grains.

A portion of the pterygoid has been cut away when taking out the skull. Otherwise it is in a fine state of preservation.

TABLE OF MEASUREMENTS.

	Ft.	In.
Extreme length of the skull with lower jaw ..	3	4·90
,, ,, ,, cranium ..	3	3·15
Length of rostrum from the apex of the premaxillaries to the middle of the line drawn between the ante-orbital notches ..	1	10·50
Greatest height from top of nasals to lower border of pterygoids ..	1	5·85
Greatest breadth across post-orbital processes of frontals ..	1	9·12
Breadth of occipital condyles ..	0	7·20
,, ,, foramen magnum ..	0	2·62
Height ,, ,, ,, ..	0	2·31
Breadth of base of rostrum (between bottom of ante-orbital notches) ..	1	0·50
Breadth of rostrum in the middle ..	0	5·
Anterior nares, greatest width of the two ..	0	3·05
Height of crest above occipital foramen ..	1	3·20
Width of occiput ..	1	5·05
Mandible.		
Length of ramus ..	2	9·75
,, ,, symphysis ..	0	7·25
Vertical height of ramus at coronoid process ..	0	6·83
Apex of mandible projecting beyond apex of rostrum ..	0	1·75
Mandibular tooth, length ..	0	2·85
,, breadth, greatest ..	0	0·61
,, weight, 198 grains.		

DESCRIPTION OF ILLUSTRATIONS AND PHOTOGRAPHS EXHIBITED.

No. 1.

Skeleton of *Epiodon novæ zealandiæ* (Haast), female, 1-16th of the natural size, obtained in Lyttleton Harbour. (Pl. XXV.)

No. 2.

Skull of same. Side view.

No. 3.

Skull of same. Upper view.

No. 4.

Skull of same. Lower view.

No. 5.

Left mandibular tooth of same. (Pl. XXIV., fig. 3.)

A. Front view.
B. Back view.
C. Section.

No. 6.

Left tympanic bone of same. (Pl. XXIV., fig 1.)

A. Lower surface.
B. Upper „

No. 7.

Sternum of same. (Pl. XXVI.)

No. 8.

Skull of *Epiodon novæ zealandiæ*, female, obtained in Akaroa Harbour. Side view. (Pl. XXVI.)

No. 9.

Skull of same. Upper view.

No. 10.

Skull of same. Lower view.

No. 11.

Mandibular right tooth of the same. (Pl. XXIV., fig. 2.)

A. Left side.
B. Right side.
C. Section.

Art. LV.—*Notes on* Mesoplodon floweri. By Julius von Haast, Ph.D., F.R.S., Director of the Canterbury Museum, New Zealand.

[Read before the Philosophical Institute of Canterbury, 6th September, 1876.]

Plate.

In the beginning of April, 1874, the information reached me that a Whale about eighteen feet long had been stranded on the sea beach near Saltwater Creek, about thirty miles north of Banks Peninsula, and although I did not lose any time in securing the skeleton for the Canterbury Museum, I was too late to obtain the necessary information as to form, colour, position of fins, etc., the animal having in the meantime been stripped in order to obtain the blubber. Fortunately, however, no bone was lost, and on examination the animal proved to be a *Mesoplodon*, closely allied to a specimen obtained at the Cape of Good Hope, of which the skull has been described by Professor R. Owen, and figured Vol. XXIII. of the Palæontographical

Fig. 1.

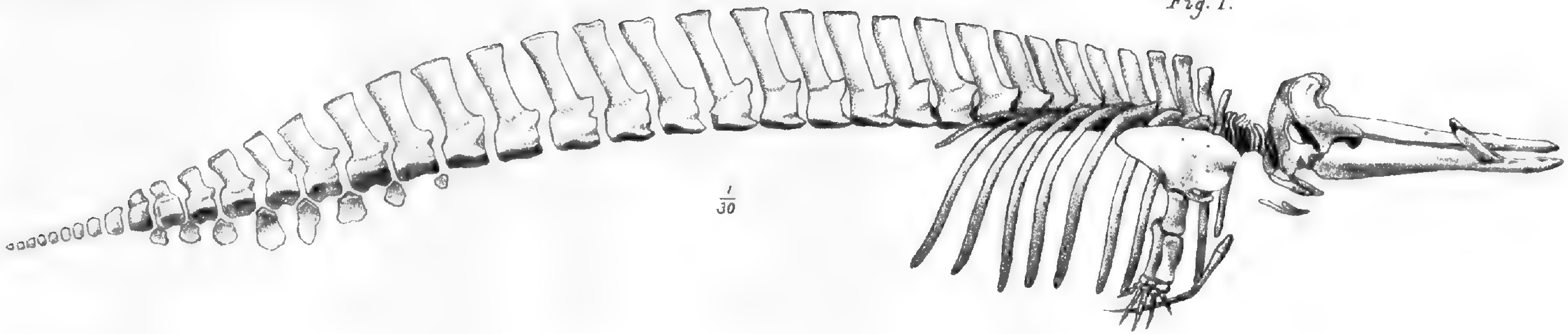


Fig 2.

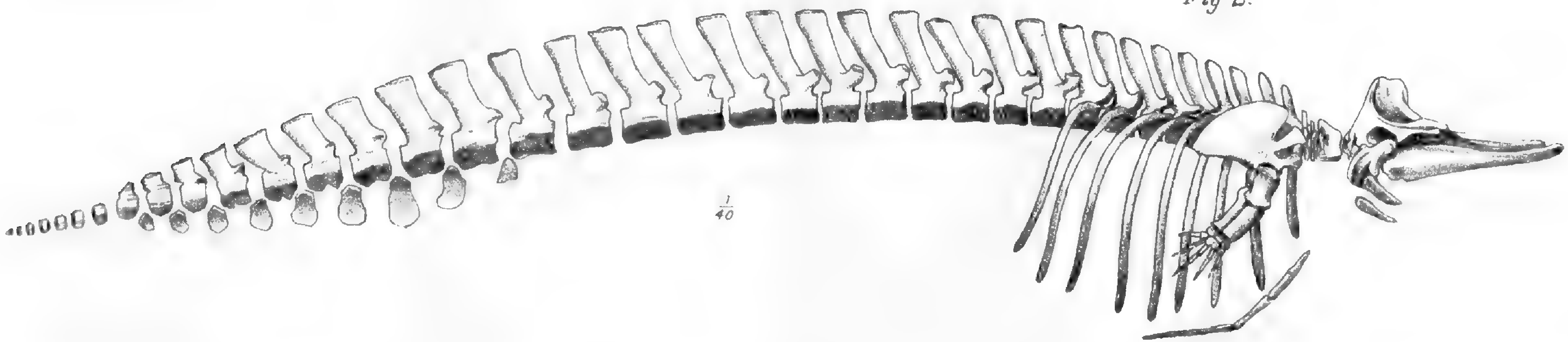


Fig. 1. MESOPLODON FLOWERI.
Fig. 2. EPIODON NOVÆ ZEALANDIÆ.

Society of London, under the title of *Ziphius (Dolichodon layardi)* *, Gray,

As far as I am aware, nothing is known of that interesting animal, except the skull, with the lower jaw, between which and the New Zealand specimen under review, there exist some points of difference, as I shall point out further on; moreover, as I believe that the same species of Ziphioid Whale would scarcely exist in two regions so far distant from each other, I have thought it more expedient to designate the New Zealand species by the specific distinction of *M. floweri*, in honour of the accomplished anatomist, Professor W. H. Flower, F.R.S., to whom the New Zealand naturalists owe a great debt of gratitude for his excellent memoir on *Berardius arnuxii.*

The animal proved on dissection to be a full-grown male, and of mature age, the terminal epiphyses of the body of the vertebræ being so thoroughly anchylosed, that the line of junction could not be detected, and we can draw the conclusion, from its osteological characteristics, that it must have combined considerable strength with great swiftness, whilst at the same time the large and remarkable strap-like teeth must have given it a peculiar appearance. The skeleton (Pl. XXV., Fig. 2) as now mounted has a total length of 17 feet 9 inches, which closely corresponds with the measurement given to me, and taken before the flesh was removed from the skeleton.

The skull (Pl. XXVI., Fig. 2) resembles in all its general features so closely the skull of *M. layardi*, as described by Professor Owen, that it would be superfluous to offer any detailed account of it. Amongst other peculiarities, the prefrontals have also the rami well defined form, and appear as a dense convex ridge between the premaxillaries, as in the Cape specimen. Notwithstanding this general likeness, if we compare closely the figures of both skulls, it is nevertheless apparent that there exist some differences between them, of which I wish to point out the following :—

The frontals in the Cape specimen rise higher above the maxillaries than in the New Zealand specimen, and the occipital portion of the skull is far more rounded in the former than in the latter, in which the supra-occipital stands nearly vertical, whilst in the Cape specimen this portion of the skull has a considerable slope towards the foramen magnum. At the junction of the basi-occipital with the temporal, the former enters the latter with a sharp angular projection, whilst in the New Zealand specimen it has a rounded edge.

The inter-parietal in the New Zealand specimen runs up to the crest as a much narrower bone than in the Cape one, in which it has a rounded form near its junction with the frontals. Besides the difference in the mandibu-

* Pro. Zool. Soc., 1865, p. 353.

lar teeth, to be pointed out hereafter, I find that the lower jaw is far deeper in proportion to its length in the New Zealand specimen. Measured on the drawing of that bone on Plate 1, Vol. XXIII. of the Palæontographical Society of London the total length of the lower jaw of *M. layardi* from the point to angle is to the greatest depth as 8⅕ to 1, whilst in the New Zealand specimen it is as 6½ to 1. In *M. layardi* the lower jaw is much slenderer, the upper and lower border being very slightly inclined to one another, whereas in *M. floweri* the two borders form a much opener angle with one another, the upper border being very convex near the coronoid process. If both skulls were available for comparison side by side, I have no doubt that other differences would be detected, especially by a comparative anatomist of more experience than I possess.

There is an important difference in the amount of curvature of the large tooth on each side of the lower jaw, which in the Cape specimen is so much arched that the apices of both teeth actually meet above the rostrum—a peculiarity which the late Dr. Gray thought could scarcely be a malformation.

In the New Zealand specimen that curvature, although existing, is not so pronounced, the point of the tooth standing in a vertical line above the centre of the root. Its form and position agree entirely with those of the tooth of the lower jaw brought from the Chatham Islands by Mr. H. Travers, and described and figured by Dr. Hector as *Dolichodon* (*Mesoplodon*) *layardi.** Behind this mandibular tooth there is no partial hollow on the upper margin of the lower jaw, as if it were the cavity of an old tooth that had fallen out, as is the case in the Cape specimen, and which was first pointed out by Dr. Gray in his "Catalogue of Seals and Whales in the British Museum." The New Zealand specimen under review thus conforms also in this respect to the lower jaw obtained in the Chatham Islands.

The anterior edge of both teeth are, however, perfectly intact, and not worn away like those in the Cape and Chatham Islands specimen—a peculiarity which might be traced to individual habits, and is, I suppose, not of any specific character.

There is no doubt that the New Zealand and Chatham Islands specimens would open their mouth, as there is sufficient space for the rostrum to pass between the apices of the teeth. However, there has evidently been some abrasion on the inner side of both teeth, near the crown, as they are here somewhat worn down and polished.

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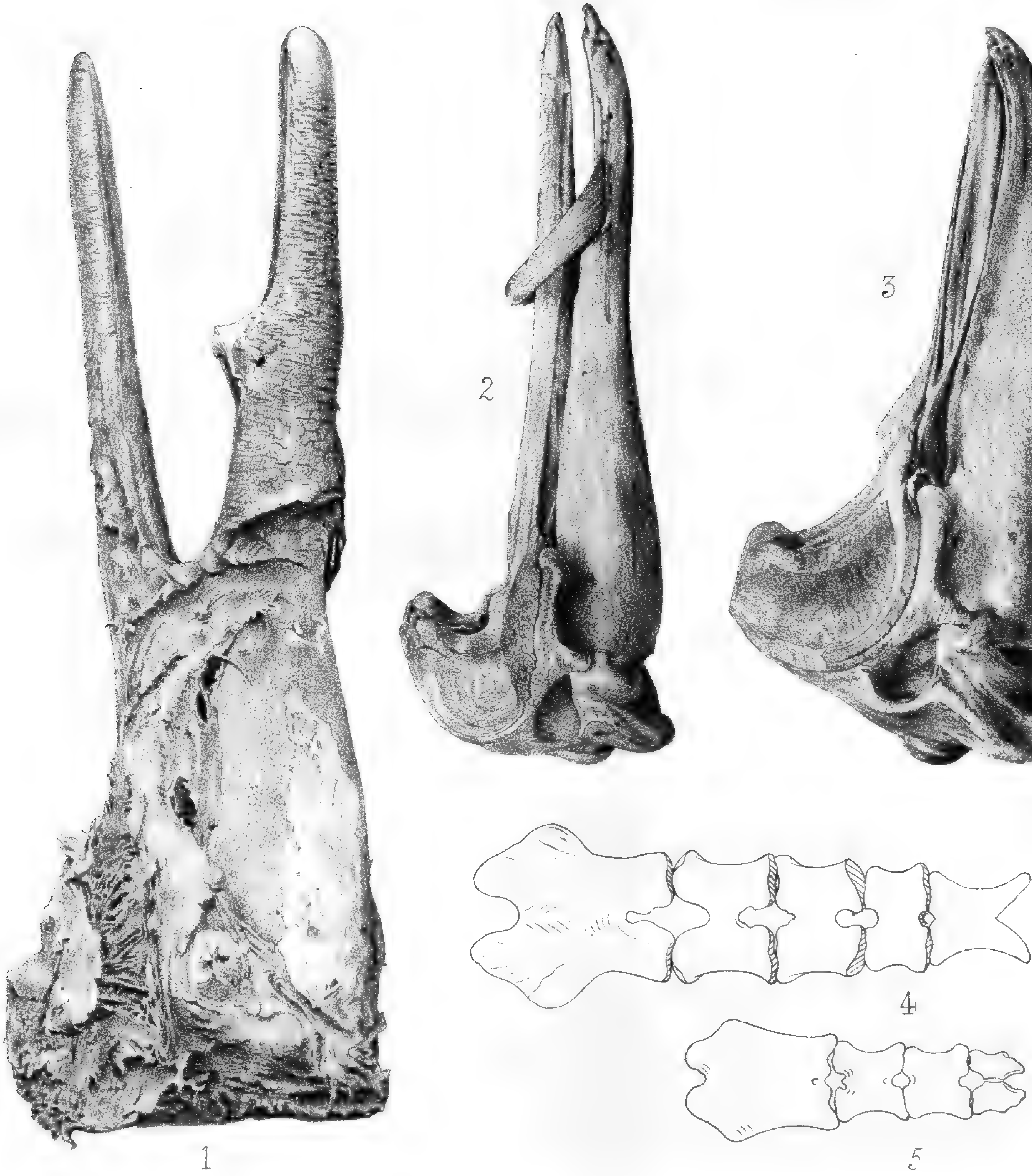
* "Trans. N.Z. Inst.," Vol V., p. 166, Pl. III., 1-5. [Gray has distinguished the New Zealand species as *D. traversii.* "Trans. N.Z. Inst.," Vol. VI., p. 96.—Ed.]



J.B. lith.

The small enamelled portion rising on the anterior edge of the apex is not quite so large as in the Cape specimen.

The lower jaw from the Chatham Islands is 1·75 inches shorter than that of the specimen under review, in which latter the mandibular tooth is also much longer, which may be regarded as an individual difference only.

The following table of measurements will also supply further material for comparison :—

Dimensions of the Skull.

	Ft.	In.
Extreme length of cranium	3	5·75
Length of rostrum from the apex of the pre-maxillæ to a line drawn between the ante-orbital notches ...	2	3·48
Greatest height from top of nasals to lower border of pterygoids	1	3·80
Greatest breadth across post-orbital process of frontals..	1	3·22
Breadth of base of rostrum between bottom of ante-orbital notches	0	5·90
Breadth of rostrum in the middle	0	2·71
Greatest width of the two nares	0	2·15
Height of crest above occipital foramen	0	8·75
Distance from point of rostrum to crest over blowers in a straight line	2	8·48
Mandible.		
Length of ramus	2	10·75
,, ,, symphysis	0	8·05
Vertical height of ramus at coronoid process	0	4·82
Distance from the condyle to the hinder edge of the base of the mandibular tooth	1	9·53
Breadth of exposed part of mandibular tooth along upper margin of ramus	0	4·51
Length of mandibular tooth measured along anterior edge from upper margin of ramus to crown ...	0	8·74

Hyoid Bones.

The basihyal and thyrohyals are united into one bone; the two latter are each 4·5 inches long and 2·1 inches broad at their junction with the basihyal. The anterior edge of this bone is formed by two processes advancing considerably beyond its general outline, and being separated in the centre by a deep notch, in which respect the bone resembles that of *Epiodon novæ zealandiæ.*

The two posterior points of the thyrohyals stand 7·2 inches apart. The stylohyals are 7·5 inches long; they possess a distinct head for their articulation with the skull, and have afterwards for some distance still a roundish form, then gradually flattening, till, about 2·5 inches from their anterior end, they are 1·71 inches broad and 0·5 inch thick, the upper side having a sharp ridge and the lower side being flattened.

Vertebral Column.

The number of vertebræ is as follows :—

Cervical	7
Thoracic	10
Lumbar	10
Caudal	19
	46

Mesoplodon floweri thus agreeing in that respect with *Mesoplodon sowerbiensis.*

Cervical Vertebræ.

Measured along the lower side of their main bodies, the seven cervical vertebræ have a total length of 5·75 inches.

Of these the atlas, second and third vertebræ, are united to one large triangular bone, 8 inches broad and 6·10 inches high. Only their lower processes, of which those of the second are the largest, are free.

The third vertebræ has two distinct transverse processes, on each side of which the higher one (diapophysis) is a thin bone with its termination pointing downwards. The next four vertebræ are all free, and if we take into consideration that the skeleton under review belonged to a fully adult animal, there is no doubt that no further change in their relation to each other would have taken place.

The upper as well as the inferior transverse processes become gradually smaller as we advance towards the thoracic region. In the fourth vertebræ the inferior transverse process has still a horizontal direction. In the fifth it assumes a downward slope, which is continued to the seventh, where it consists only of a small tubercle. Above it on the side of the body of this vertebra is the articular surface for the head of the first rib. The fourth vertebra had evidently a small spinous process, which doubtless was broken off in cleaning it. In the fifth the spinous process is 1·05 inches ; in the sixth, 1·53 inches ; and in the seventh, 2 inches high, all leaning a little forwards.

The bodies of the four last vertebræ are broader than they are high. *Mesoplodon floweri* therefore stands so far alone in regard to the arrangement of the cervical vertebræ ; as no other Ziphioid Whale, as far as I am aware, has the three first cervical vertebræ anchylosed and each of the next four perfectly free.

Thoracic vertebræ.

The species under review possesses ten, of which the bodies are all flattened from top to bottom, and getting gradually of larger dimensions, the body of the first being 1·12 inches, and the tenth 4·20 inches postero-anterior length. The spinous process of the first is pointed, and stands slightly forward. That of the second stands nearly vertical, after which in the remaining eight vertebræ it gradually slopes more and more backward, and becomes higher and broader. This process in the second and third has rather a rounded apex, after which it becomes more truncated in the rest. Height of spine of first thoracic verebra, 4·25 inches; tenth, 9 inches. The articulation for the head of the second rib is situated at the posterior end of the first vertebra, low at the base of the arch; it rises gradually in the two next, so that in the third vertebra this articulation is placed some distance above that base—a position which it maintains in the fourth, fifth, and sixth, after which it disappears, the following ribs having only one articulation. The transverse process which springs from both sides of the arch is, in the three first vertebræ, a rounded apophysis; in the next four vetebræ it gradually enlarges, becoming, like in *Epiodon novæ zealandiæ*, laterally compressed, showing one strongly marked process pointing upwards and forwards, as well as a well-indicated and posteriorly-situated articulation for the tubercle of the ribs.

A separation into two distinct processes takes place in the eighth, the forward or anterior process of the apophysis now appearing as the metapophysis, and its lower or posterior process forming a lower transverse process, starting as a small rounded prominence from the anterior border of the upper portion of the body, and on which the articular surface for the eighth rib is situated, directed obliquely backwards.

In the ninth vertebra this separation is still more accomplished, the metapophysis being well developed, and the transverse process, which springs now from near the centre of the body, although thicker and more rounded than those of the succeeding vertebræ, takes already their usual form. It has an articular surface for the ninth rib on its posterior end, with the same direction as the preceding one.

The tenth vetebra, which is the largest of the series, has a very large transverse process, depressed and broad, on the edge of which the tenth small rib obliquely articulates. This transverse process is the broadest and longest of the whole series of vertebræ, those of the lumbar region beginning with the first, getting by degrees shorter and narrower.

The transverse process of the ninth thoracic vertebra has a horizontal and somewhat backward direction; that of the tenth stands straight, whilst the same process in the lumbar and the first series of the caudal vertebræ have, beside, a slightly downward, also a forward direction.

The bodies of the thoracic vertebræ up to the seventh have a flattened lower surface, after which a keel starts on the eighth, which is well pronounced on the ninth and tenth.

Lumbar vertebræ.

The ten lumbar vertebræ resemble each other very much in form. Gradually they become more elongated, the first having an antero-posterior length of 4·55 inches, and the eighth of 6·30 inches, after which they shorten again a little. They possess all a median keel, and are compressed in the centre below the transverse process. The spinous processes are large and high, increasing to the eighth, which is 11·50 inches high, after which they slightly decrease. The arches arise from the centre of the bodies, thus differing from *Berardius* and *Epiodon*, where they have a more anterior position.

Caudal vertebræ.

There are nineteen caudal vertebræ, of which the first ten have a deep channel running along their lower surface. The spinous processes gradually lose in height, that of the tenth vertebra consisting only of a slight excrescence.

The lower transverse processes also shorten by degrees, so that in the sixth they are represented by a small horizontal ridge, which is only faintly indicated in the seventh. In the eighth, ninth, and tenth vertebræ, all signs of such processes are missing, but they are also strongly laterally compressed. There are nine chevron bones, of which the last is missing. With the eleventh vertebra the second series of the caudal vertebræ begins, which in form greatly resemble those of the New Zealand *Epiodon*.

Ribs.

There are ten ribs on each side, of which seven have two articulations, and the three last only one. The first is the shortest of the whole series, with the exception of the last; it is also the broadest. There is scarcely a sign of an articular process for its articulation with the seventh cervical vertebra, and only a very slightly marked articular surface for the transverse process, both being indicated by a small indentation on the edge of the head of the rib.

The second rib has the same flattened form as the first; it is longer, and both articulating processes are better defined.

From the second to the sixth rib they gradually lengthen, after which they diminish again a little until we reach the tenth, which is the shortest of the whole series. The third, fourth, fifth, sixth, and seventh ribs have all well defined articulating processes, and nearly the same form, flattened at and near their head, after which, for nearly one-third of their total length, they become more constricted, and assume a prismoid shape, after which they flatten and gain again in breadth, their terminal end being, however, narrower.

The eighth and ninth ribs, which have only one articulating surface for their junction with the transverse process, have the same form as the foregoing, if we imagine their heads and necks removed.

The tenth rib is flattened throughout; it has also only one articulating surface, and, at its posterior end, runs out to a point.

The greatest length of each rib, measured in a straight line, is :—

	Ft.	In.
First	1	2·75
Second	1	9·50
Third	2	1·60
Fourth	2	4·10
Fifth	2	4·25
Sixth	2	4·80
Seventh	2	4·60
Eighth	2	3·50
Ninth	2	3·00
Tenth	0	10·25

Sternum (Pl. XXVI., Fig. 5).

The sternum consists of four principal segments, of which the fourth and smallest is separated into a left and right portion by a division in the centre, and which apparently would not have disappeared by anchylosis in a still more aged state of the skeleton. The first segment is the largest and broadest; it is without a keel, but is well rounded towards the central line. There is a deep excavation on its upper, and a shallower one on its lower portion. Similar excavations exist in the three other segments, by which three fenestræ of a rounded shape are formed. There are five articulating surfaces on each side for the sternal ribs: the first near the upper portion of the first segment, the second at the junction of the first and second segments, the third at the junction of the second and third segments, the fourth at the junction of the third and fourth segments, and the fifth at each side of the fourth segment on its lower portion.

Pectoral Limb.

The scapula is remarkably flat and without prominent ridges, so that there is scarcely any sign of the post-scapular fossa. In form it resembles that of *Mesoplodon sowerbiensis*. The acromium is broad, and has an upward slope in its anterior portion; the coracoid is flat and narrow, but widens considerably at its extremity, where it assumes a prismoid form.

The humerus, ulna, and radius resemble also considerably those of *M. sowerbiensis*. The epiphyses on both extremities are so well anchylosed, that scarcely the line of junction can be traced. The elements of the carpus are, with the exception of the magnum and trapezoid (which are united to one bone), all separate, thus resembling also the *M. sowerbiensis* and the New Zealand *Epiodon*. The same appears to be the case with the digits, which, however, have somewhat suffered, as the pectoral fins had been much lacerated before the skeleton was secured.

Pelvic Bone.

The pelvic bone for the attachment of the crura of the penis is of small size, and of rather irregular form. It is 4 inches long, 0·37 inches broad near both extremities, and 0·25 inches in the middle portion. It is rounded osteriorly, and flat anteriorly, getting gradually flatter as we reach the lower end of the bone. It is very light and spongy.

ILLUSTRATIONS EXHIBITED.

No. 12.	Skeleton of *Mesoplodon floweri.*		Pl. XXV., Fig. 2.
„ *13.*	Skull „ „ „	Side view.	Pl. XXVI., Fig. 2.
„ *14.*	„ „ „ „	Upper „	
„ *15.*	„ „ „ „	Lower „	
„ *16.*	Cavity of the trunk	As seen from the point.	
„ *17.*	Sternum.		Pl. XXVI., Fig. 5.

Art. LVI.—*On* Oulodon: *a new genus of Ziphioid Whales.*

By Julius von Haast, P.H.D., F.R.S.

[*Read before the Philosophical Institute of Canterbury, 6th September, 1876.*]

In the month of May of last year (1875) the Canterbury Museum received from W. Hood, Esq., of the Chatham Islands, three skulls of Ziphioid Whales, taken from specimens stranded with about 25 others during the summer of last year on the Waitangi beach of the main island of that group. They were described as "black fish," all belonging to the same shoal, by my informant, who moreover believes that the whole series belonged to the same species. Unfortunately the skulls were so badly separated from the body that the occipital portion has been cut off, so as to lay the brain cavity open, but as they were brought over with the greater portion of the skin still attached, some hitherto unknown and as I think peculiar characteristic features in the dentition of a ziphioid genus have fortunately been preserved.

These three skulls accord in many respects with the genus *Mesoplodon* of Gervais, of which I will point out only one, viz., that they possess one tooth in each ramus of the lower jaw opposite the posterior edge of the symphysis, and of varying size and shape, either hidden below the gums or rising conspicuously above them, according to age and sex. They differ, however, from this and other ziphioid genera by possessing in the upper jaw, starting in a vertical line above the posterior border of that mandibular tooth, a series of small conical teeth, slightly incurved, which extends to near the gape of the mouth.

I may here at once observe that these teeth are neither rudimentary nor are they confined to young animals, because as I shall show in the sequel, these three skulls are derived from individuals of different ages, of which one is an aged (male ?) animal, in which the row of teeth is best developed. It is thus evident that this series of teeth is a functional portion of the animal, is constant and necessary for its proper nourishment, some of them being broken off, others evidently worn down from use. That these small teeth, of which the largest stands nearly half an inch above the gums, are only rooted in the latter, does not lessen their value as a specific character of some importance.

Of the species of Ziphioid Whales inhabiting the New Zealand seas I have obtained three, namely, *Berardius arnuxii*, three specimens, *Epiodon novæ zealandiæ*, and *Mesoplodon floweri*, none of which show the least sign or rudiment of teeth in the upper jaw. Moreover several others have been secured in New Zealand and Australia, but nowhere can I find that, except the teeth in the lower jaw, they possessed any, and I have looked carefully over all the different papers on the Ziphioid Whales of the Northern Hemisphere to which I had access without finding the slightest mention made of the occurrence of such a peculiar feature in their dentition.

On the contrary, Professor Flower, in his excellent paper on the recent Ziphioid Whales *, when enumerating their principal structural characters, begins by stating that they have no functional teeth in the upper jaw. I believe that this term functional is rather ambiguous when applied to their gums, and can scarcely be applied to the gums under consideration, as we are totally unacquainted with the food on which it subsists, or the manner in which the same is obtained. It is true these teeth do not grow from alveolar grooves in the premaxillaries, but only from a groove in the gums, and have their roots implanted therein, but nevertheless I have no doubt that they are always present and do perform as distinct and important functions as those of *Euphysetes*, or any of the Dolphins, which possess teeth of similar forms.

The first of the accompanying photographs shows the three skulls in comparison with each other; the second, the middle portion of the second skull belonging to an aged (male ?) individual; whilst the following list

* "Trans. Zool. Soc.," Vol. VIII., Part 3.

gives the principal dimensions of these three skulls, with the soft parts attached and as far as they could be ascertained; but, as soon as they are macerated, I shall offer some further observations on their anatomical structure:—

TABLE of Measurements of Three Skulls of *Oulodon grayi*, with the greater portion of soft parts adhering.

—	SKULL I. Probably Female, full grown.		SKULL II. Probably Male, aged.		SKULL III. Probably Male, young.	
	FT.	IN.	FT.	IN.	FT.	IN.
Height of skull from top of nasals (skin preserved) to lower border of pterygoids, the latter lying exposed	0	11·13	0	11·38	0	9·12
Greatest breadth of skull across post-orbital processes of frontals	1	0·48	1	0·88	0	9·51
Length of skull from crest of nasal bones to anterior border of rostrum in a straight line	2	5·46	2	3·47	1	5·07
Length of ramus of lower jaw, soft parts preserved, on anterior border	2	7·52	2	6·03	1	7·75
From gape* of mouth to anterior border of lower jaw	1	6·50	1	4·87	0	10·05
From anterior border of lower jaw to centre of tooth	0	10·75	0	10·12	0	5·
From centre of tooth to gape of mouth	0	7·75	0	6·75	0	5·05
Breadth of lower jaw to centre of tooth	0	2·31	0	2·69	0	1·75
Distance from extremity of rostrum to first anterior tooth	0	11·06	0	10·75	0	5·62
Distance from gape to end of teeth	0	1·02	0	1·37	0	1·40
Eye, perpendicular diameter, about	0	2·25	0	2·27		—
Opening of blower, the two extremities slightly directed backwards, about	0	4·50	0	4·50	0	3·25
Number of teeth in upper jaw		19		17		17

I should have liked to give also in this list the breadth of the rostrum at the ante-orbital notches, as it would have given another important point for comparison; but the coverings prevented this. Also I was not able to give the total length of each skull, owing to the occipital portion being cut off, but the length of the skulls from crest of nasals to anterior border of the rostrum, as well as the length of the ramus of each mandible, will supply this deficiency, and offer us sufficient material for comparison. Examining the skulls separately we find that the one marked No. 1 is longer but narrower than No. 2. This is still more striking when we compare the two rostrums with each other, that of skull No. 1 being considerably narrower than that of skull No. 2. The same observation applies to the mandibles, which in No. 1 only widen very gradually, and are much narrower all along than those of skull No. 2. In fact, if both skulls had been obtained separately, I believe that they would probably have been assigned to two distinct species. When the skull of No. 1 was first examined by me

* The drying of the skin has been so unequal in the different specimens, and even on both sides of the same skull, that the position of the gape cannot be fixed with precision.

the sharp point of a tooth in each ramus of the lower jaw, when passing the finger over the gums, was discernible, but I doubt if this was to be felt before the gums were dried up.

In cutting a portion of the gums away the apex of a very flat tooth, rather acutely triangular as far as visible, was exposed, which stands about one-eighth of an inch above the upper surface of the ramus. This tooth is embedded in a very narrow alveolar cavity, situated near the posterior edge of the symphysis, the ramus here scarcely bulging out. This is still more obvious if we compare that portion of the ramus with that of skulls Nos. 2 and 3.

Above the posterior edge of the small tooth in the lower jaw, and which without doubt has to perform some function, notwithstanding it is covered by the gums, a row of small conical teeth, the apices slightly incurved, begins on each side of the upper jaw, reaching within an inch of the gape of the mouth, which, however, may have somewhat retreated by the drying of the skin. These small teeth are situated in a well-defined dental groove in the gums. There were nineteen teeth on each side, of which, however, several are broken off. They are from 0·20 to 0·40 inch long, and extend along a line 6·12 inches in length, standing nearly the eighth of an inch apart. Of the whole series the first anterior tooth is the smallest, the succeeding ones gradually getting larger till the eighth, and then maintaining the same size to nearly their termination.

The crowns of the teeth stand on about the same level with the central line of the palate. The opening along the upper surface of the rostrum is still unclosed, thus showing that the animal is not so aged as the next specimen, No. 2, and I may here add that the rostrum in all three skulls is half an inch shorter than the mandible, and that it lies in a well-defined groove in the latter.

Skull No. 2. (Pl. XXVI., Fig. 3.)

The measures of this skull, as far as I was able to obtain them, show that, as previously stated, it was not so elongate as the former, but somewhat broader and more massive in all its proportions. The rami of the mandible widen much sooner than those of the former. About seven inches from their anterior extremity they expand considerably, in order to form the alveolar cavity for a large tooth, which is here rising conspicuously on both sides, having a vertical position. This tooth has a compressed triangular shape, is $2\frac{7}{8}$ inches broad at its base on the line of the gums, and $1\frac{3}{4}$ inches above them.

On the inner side near the top it is slightly abraded, and on the outside broken considerably, so as to suggest that the animal used it for the purpose of attack or defence. This injury has taken place on both teeth, so that they have lost their point, and show a rugged horizontal apex, with a width of nearly a quarter of an inch. From behind the tooth the rami expand very little as far as the gape.

A similar row of small teeth, as described as occuring in the first specimen, exists also in the second skull, but there are apparently only seventeen of them. Their position is exactly the same as that in the foregoing, the first anterior tooth standing exactly above the posterior base of the large tooth in the lower jaw. The teeth have the same form as those previously described, except that they are generally thicker. This becomes conspicuous with the seventh tooth, after which they gradually increase to the thirteenth, which is one-eighth of an inch thick at its base, and stands 0·45 inch above the gums. They then keep nearly the same size to their posterior end. As the space on which these seventeen teeth stand is only 4·25 inches long, besides their greater stoutness, they are far more crowded than in the first described skull.

Owing to the fact that the gums have dried more effectually in this than in the two other skulls, in both of which the teeth stand erect with the curve of the apex directed inwards, the teeth in this skull are no longer in their normal position, but lie somewhat backward on the palate.

The groove on the upper surface of the rostrum between the premaxillaries, is filled by a convex ridge of dense bone with a small channel on each side. That this is only caused by age, and that it is neither a sexual nor a specific character, is proved by the fact that the next skull, No. 3, which is doubtless a half-grown specimen of the same sex as the one under review, has this groove on the top of the rostrum still open, and thus resembles the skull No. 1, although, in the latter, that groove is narrower and more shallow.

Photograph No. 2 has been added in order to show the relative position and size of the teeth in the upper and lower jaws of the specimen No. 2 (aged male ?)

The whole skull, when compared with the former, strikes us by its massiveness and stronger and stouter proportions. This will be still more conspicuous when the soft parts have been removed, so that its anatomical structure can be studied in detail.

Skull No. 3.

Assuming that the last-described skull belongs to an aged male, the measurement of the third skull under consideration must lead us to the conclusion that it is that of a young half-grown male. Beginning with the lower jaw, the same form as in the foregoing is observable, the rami expanding considerably as soon as we reach the neighbourhood of the alveolar cavity; and although the tooth in the same is only small, and stands only

0·25 inch above the edge of the ramus, that alveolar cavity is much more bulged out, and has a different form from the first (or female ?) skull described. The apex of the tooth was distinctly visible, and seemed to have already pierced the gums when the animal was alive.

The row of teeth in the upper jaw, which have the same form as in the skull No. 2, are, however, smaller and somewhat slenderer. They begin likewise above the posterior end of the alveolar cavity. There are, as in the preceding skull, seventeen teeth on each side, occupying a length of 2·48 inches. They stand more closely together than in the supposed female skull, No. 1, thus also agreeing with the second skull in that respect.

In Vol. VI., p. 86, of the "Transactions of the New Zealand Institute," Dr. Hector describes the lower jaw of *Oulodon* under the title, "Notice of a variation in the dentition of *Mesoplodon hectori* (Gray)."

It is difficult for me to conceive by what process the tooth in the lower jaw, which in *Mesoplodon hectori* stands at the anterior end of the ramus, could have travelled as far backwards as to stand now opposite the posterior edge of the symphysis. Hitherto I have believed that the position of the mandibular teeth was constant and a valuable specific character—an opinion which, as far as I am aware, is held by the most eminent Cetologists, and which the observations I was able to make on the three skulls under review amply confirms. Mereover, I wish to add that a comparison of these three skulls of *Oulodon* with the skull of *Mesoplodon hectori* (Gray), in the Canterbury Museum, and which is derived from an aged specimen, shows at a glance the distinct specific character, besides being much smaller in all its proportious.

We are only at the beginning of the study of our Ziphioid Whales, and I have no doubt that, year by year, new material will come to hand, so that by the lumping of two distinct species into one, as attempted by Dr. Hector, and for which no tangible reason can be assigned, only confusion will be created.

Finally, I wish to propose to add to this new cetacean the specific name of *Grayi*, in memory of the late Dr. J. E. Gray, to whom New Zealand is so much indebted for his contributions towards the better knowledge of its natural history.

Conclusion.

In summing up the evidence which these three skulls under review presents to us the following points may be accepted as fully established :—

1. That there exists a genus of Ziphioid Whales in the New Zealand seas, which possesses a mandibular tooth at the posterior edge of the symphysis, either hidden below the gums or standing conspicuously above them, according to age or sex.

2. That the skull of one of the sexes (probably the female) is longer but narrower and lower than that of the opposite (probably the male) sex, which latter possesses also a large triangular compressed tooth rising above the gums, which in the latter (probably the female) sex is much smaller and always hidden below the gums.

3. That both sexes of this genus possess permanently in the upper jaw a row of small conical teeth with the apex slightly incurved inwards, which although only rooted in the gums have to perform important functions in the nourishing process of the animal.

Further notes on Oulodon grayi.

In continuation of my former paper on the interesting genus *Oulodon*, it will be seen from the following notes that the presence of a row of small teeth in the upper jaw is of a constant character in this new genus, and unless it is shown by further researches that other species belonging to the genus *Mesoplodon* have similar rows of small teeth, and of a permanent character in the upper jaw, I think that the genus *Oulodon* ought to be maintained in the nomenclature of the Ziphioid Whales, as being distinguished by that peculiar feature, which as far as I am aware no other Ziphioid Whale possesses.

Since I had the pleasure to lay the description of the three skulls obtained on the Chatham Islands before the Society, four specimens belonging to the same ziphioid genus, and which with our local fishermen goes under the name of Cowfish, have been stranded on the coast near Saltwater Creek, about 30 miles north of Banks Peninsula. One of them, a small male (A), about 13 feet long, was washed ashore on the 15th December, 1876. On the 29th December another male, 12 feet 9 inches long, was stranded, together with a female (D) 17 feet 6 inches long, on the beach a short distance north of the entrance of Saltwater Creek estuary, whilst another male (C) 13 feet 8 inches long, ran the same day into that small estuary, and was left high and dry by the receding tides. As I was fortunate enough to obtain two of these skeletons complete, I shall be able to send one of them to my friend Professor H. J. Flower, as a type specimen, and for description, and therefore leave any osteological details to that distinguished anatomist. Although the bones are not yet quite macerated, I may, however, state that the female, exceeding by nearly four feet the largest male obtained, is a full grown animal, whilst the three males are all immature specimens. I measured the length of its lower jaw, and find that it is 2 feet 8·50 inches long, consequently nearly one inch longer than the lower jaw of the dried skull, No. 1, which I assigned to a full-grown female, and with which it bears a close resemblance.

The mandibular tooth could scarcely be felt when passing the finger over the gums, and its existence could scarcely have been proved in that way had I not known its exact position.

On the other hand, the point of that mandibular tooth in all the three male skulls protruded already, even in the smallest, through the gums and the more laterally extended size of that portion of the lower jaw was at once discernible.

I measured also the lower jaw of the male skull (B), and found it to be 1 foot 11·85 inches long. Consequently its size is intermediate between the two Chatham Island skulls, No. 2, of which the lower jaw measures 2 feet 6·03 inches, and of the immature, No. 3, which is only 1 foot 7·75 inches long.

All the four skulls possess seventeen to nineteen teeth on both sides of the roof of the mouth, so that now this character can be claimed as being constant and specific.

As to the external features of this species, its form may be described as being rather elegant. The head is tapering and the beak-like rostrum runs out to a point, so that it was not unappropriately compared by one of the workmen to the beak of a bird.

Colour of back black, getting a little lighter near the tail, where it assumes a dark slate tint, lower side reddish-brown, near the tail assuming on both sides a more blackish hue.

The blowhole is situated in the centre. It is about six inches in diameter, and the corners are directed forward.

It possesses a large falcate dorsal fin, situated rather backwards, and the pectoral fins are small and somewhat pointed.

The following measurements were taken from the immature male (C):—Total length, 13 feet 8 inches; girth round the body, 18 inches beyond the pectoral fin, where the animal is of the largest size, 9 feet; from point of rostrum to anterior border of pectoral fin, 3 feet 5 inches; from posterior end of dorsal fin to centre of tail lobes, 4 feet 3 inches.

ART. LVII.—*Description of a species of* Catocala, *new to Science.*

By R. W. FEREDAY, C.M.E.S.L.

[*Read before the Canterbury Philosophical Institute, 15th December, 1876.*]

CATOCALA TRAVERSII.

Proboscis, stout. *Antennæ*, moderately long, setaceous. *Labial palpi*, stout, pilose, moderately long, obliquely ascending; third joint, short, avellanate. *Body*, robust, greyish-dove colour. *Thorax*, thickly pilose.

Abdomen, not extending beyond the hind wings, attenuated towards the tip, slightly tufted on the back.

Legs, long, stout, densely pilose, hind tibiæ with long spurs.

Wings, ample, marginal denticulation obsolete.

Fore wings: Upper-side slightly concave along the middle of the costa, convex towards the tip and base, greyish-dove colour, slightly shot with a faint purplish tint, irrorated and clouded with ferruginous and purplish-brown scales; transverse lines and central shade purplish-brown; half-line angulated; inner and elbow-lines slightly sinuous and indented, and with pale outer margins; the pale margin of the inner-line rather broad, of the elbow-line narrow and vanishing towards the costa; indentations of elbow-line from the costa to the middle forming a profile of a human face; the space between the central shade and the elbow-line forming a band darker than the ground colour of the wing, but lighter than the transverse lines; the area between the elbow-line and the rather indistinct sub-terminal line clouded with ferruginous, interrupted by a purplish-brown shade crossing it below the costal area, and forming the upper part into a sub-costal patch, the part towards the apex of the angle formed by the costa and elbow-line being paler and but slightly suffused with ferruginous; the space between the inner-line and central shade (especially the part beyond the middle) paler than the general ground colour; stigmata obsolete, with two dusky specks, one on the upper end and the other on the inner side of the lower end of the reniform stigma; hind margin with a narrow dusky border and a row of dusky dots. Under-side, basal, third and sub-marginal and costal parts pale brownish-grey; intermediate space dark purplish-brown, with a central broad white band extending from the sub-costal nervure to the anal angle, and deeply indented at the sub-internomedial nervure.

Hind wings: Upper-side dark purplish-brown, with a median white band slightly shaded with pale violet; two white patches on the hind margin, the one being sub-quadrate and situated towards the posterior angle, the other triangular and situated near the anal angle; also a narrow white border extending from the anal angle to near the triangular patch; the white patches extending into the cilia, and slightly tinted with pale violet; clothed at the base with long greyish-dove coloured hairs. Under-side pale brownish-grey, a dark purplish-brown patch, with whitish outer margin at the anal angle; a transverse narrow dusky fascia crossing the middle of the wing, and another beyond the middle, and a very indistinct sub-terminal one; an indistinct dusky hunule or spot in the centre of the area between the first line and the base of the wing; two pale patches on the hind margin representing the white patches on the upper-side.

Expanse of wings, 2″ 6‴.

Habitat: Wellington, New Zealand.

I have named the insect after Mr. W. T. L. Travers, by whom it was presented to me, and who captured it in his greenhouse, at Wellington, in the autumn of 1870.

I am not aware of any other representative of the *Catocalidæ* family having been taken or seen in New Zealand.

ART. LVIII.—*On the occurrence in New Zealand of a Species of* Lepidoptera *belonging to the* Cossidæ *family.* By R. W. FEREDAY, C.M.E.S.L.

[*Read before the Philosophical Institute of Canterbury, 1st June, 1876.*]

IN the month of February last, Mr. W. T. L. Travers kindly forwarded to me a specimen of a very large moth, recently captured by Mr. H. E. Liardet, at Wellington.

The insect is, unfortunately, in a very dilapidated condition, being almost denuded of scales, and having little more than half its wings remaining. It has, however, sufficient characters to identify it as belonging to the *Cossidæ* family; but as to species, or even genus, it does not appear to me to be clearly identical with any of those described in the "British Museum Catalogue," the only descriptive catalogue available to me for reference. At the same time I imagine it must be a species comprised in that catalogue, as Mr. Fuller, the Taxidermist of the Canterbury Museum, informs me that he has seen hundreds of a similar moth about the gum trees in Australia, and therefore it must be very common, and its existence and description has doubtless been long ago recorded.

The length of the specimen, from the front of the head to the anal extremity, is 40 lines, and the breadth of the thorax 12 lines, the head being extremely small in comparison—not more than 4 lines in breadth. The expanse of the wings (if perfect) would be about 90 lines. The few scales remaining on the insect indicate its general colour to have been somewhat similar to that of *Cossus ligniperda*, but rather more hoary.

A similar specimen was taken in the pupa state by Mr. D. O'Brien, from a log of jarrah (*Eucalyptus marginata*), at Lyttelton, a year or two ago, and is now in the Museum at Christchurch; and, at the time of its capture, large logs of jarrah and other timber imported for the harbour works were lying there. On that occasion I went to Lyttelton purposely to see if there were any indications of the timber having been bored by larvæ, and found several perforations in size and character such as would be made by a *Cossus* larva.

That in both cases these insects have been introduced in timber imported from Australia there can be little doubt; and it shows the importance of instituting a careful supervision of all the timber brought into the colony from other countries.

The moth which I received from Mr. Travers was a female, and contained thousands of eggs ; in fact, her abdomen was crammed with a mass of ova, which, had she been permitted to deposit, a new agent of destruction might have commenced its ravages in our forests. That other individuals of the same species have escaped from the imported timber is more than probable, and already the work of destruction may have begun.

I am not acquainted with the extent of injury done to the timber of Australia by this moth, but trees affected by *Cossidæ* larvæ are generally riddled with their perforations.

We are already suffering from other introduced pests of this description, *e.g.*, *Ægeria tipuliformis*, a moth whose larvæ are committing great destruction amongst our currant trees by perforating the branches and rendering them pithless and hollow.

Government inspectors should be appointed, whose duty it should be to carefully examine all imported articles subject to the attack of insect pests, for the purpose of ascertaining if any such pests are present, and of adopting means to effect their destruction.

There are probably many gentlemen in this colony who have resided in Australia, and been acquainted with the species of moth in question, and who might furnish information that would be a valuable supplement to this paper.

Art. LIX.—*Brief observations on the genus* Chrysophanus, *as represented in New Zealand.* By R. W. Fereday, C.M.E.S.L.

[Read before the Philosophical Institute of Canterbury, December 5th, 1876.]

In a paper read before this Institute on the 11th of October, 1871, * I took occasion to state that there were three, if not four, distinct species of *Chrysophanus* found amongst the butterflies of New Zealand ; and, in making such statement, the species *Boldenarum*, which has since been placed by Mr. A. G. Butler under the genus *Chrysophanus*,† was not taken into account, as it then stood recorded, on the authority of Mr White, by whom it was named and described, as of the genus *Lycæna*.

* "Trans. N.Z. Inst.," Vol. IV., p. 214.

† "Cat. Lep. N.Z.," p. 3.

Subsequent observations convince me that my conclusions were correct; and that there are five, or at least four, distinct species of *Chrysophanus* inhabiting New Zealand, if characters which have hitherto been generally allowed to constitute distinct species are to continue to be accepted as such, and not as constituting mere varieties.

Mr. Butler * quotes me as thinking there may be three species, but appears rather to doubt the distinctness of *C. feredayi*, which Mr. Bates named and described as a distinct species.† Mr. Butler, however, admits that he had not seen the insect so named, and I have no doubt his opinion will be changed when he has had an opportunity of comparing *C. feredayi* with *Lycæna edna* of Doubleday, which he identifies as *Hesperia R. salustius* of Fabricius, and places in this genus.

At present I propose to point out a few of the differences which mark the several species or varieties, reserving for a future paper a full description, to be accompanied by drawings, illustrating the distinctive characters of each form.

The several forms may, for convenience, be indicated respectively by the letters A B C D E F and G, A being represented in Mr. Butler's "Cat. Lep. N.Z.," p. 3. Tab. 1, Figs 1 and 2, as *C. salustius*, female, which he believes to have been described by Mr. Doubleday as *edna*, and by Fabricus as *salustius*; C being represented as *C. salustius*, male.‡ The sexes are not distinguished in the catalogue, but Mr. Butler has informed me that Figs. 1 and 2 represent the female, and Figs. 3 the male of *C. salustius*, and G being represented as *C. boldenarum*.§

A (female). That this is the female of the same species or form as that of which C is the male I cannot believe. In fact there is fair proof to the contrary, unless I am in error in the identity, which appears to me very clear, of A with the insect figured 1 and 2 in Mr. Butler's catalogue, for I have repeatedly found A in company with B—the strongest evidence of A and B being respectively the female and male of one species or variety. The nervures of the wings of this form are margined and irrorated with the same colour as the dark markings; pale violet pupils more or less present in the marginal macular band; the under side of the secondary wings saffron yellow.

B (male). Differs very little from A, the dusky basal shade being extended further over the wings in A than in B.

C (male). Very distinct in shape and contour of wings, which are

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* *Loc. cit.*

† "Ent. Mon. Mag.," Vol. IV. p. 53.

‡ *Loc. cit.*, Fig. 3.

§ *Loc. cit.*, Figs. 8 and 9.

broader, in comparison with their length, than in the other forms; the copper colour is more brilliant and lustrous; the dark markings are fewer and smaller; the nervures are only margined with the colour of the dark markings, and there are no violet pupils in the marginal macular bands. I have never met with this form but in one locality—at Wellington, where I took about a dozen specimens, which were unaccompanied by any of the other forms. They and two other specimens received from Hawke Bay are all that I have seen.

D (*C. feredayi*). I have both male and female of this form. In shape, colour, and markings of the wings the sexes do not appear to differ, the shape resembling that of A, the ground colour being pale fulvous; the dark markings much broader than in any of the other forms; secondaries below clouded with brown. With the exception of a few scattered specimens I have found this insect only in two localities, namely, Kaiapoi Bush, near Christchurch, and a bush near Mount Torlesse, both of which bushes are situated on the Canterbury Plains, and their vegetation is similar in character. The former bush, which afforded excellent entomological collecting ground, has, alas! disappeared, and cultivated fields now occupy the place where but a few years ago stood a dense forest.

E (male). Ground colour of wings copper, but duller than that of C; hind margin of primaries considerably more oblique and less rounded than in any of the other forms; costa somewhat concave beyond the middle; dark markings larger than in C, but smaller than in the other forms; nervures same colour as dark markings; no violet pupils in the marginal macular bands; under side of secondaries fuscous.

F (female). Basal shade rather darker, and dark markings rather larger than in E, but in other respects similar to that form. I have only seen two specimens—one I took at Kaiapoi Bush at the same time as the specimen of E, and the other in a lane near Christchurch, fourteen miles from Kaiapoi Bush.

G (*C. boldernarum*). There is no question as to this being a distinct species. See Mr. Butler's description.*

In conclusion, I would call attention to the fact that I have found forms A and B common in almost all parts of New Zealand that I have visited, but the other forms (excepting G) extremely local and by no means abundant.

Relying upon the ultimate establishment of the above forms as distinct species, or permanent varieties, I propose to give to C the name of *Maui*, after the celebrity who, according to Maori mythology, fished up the islands of New Zealand; and to E the name of *Rauparaha*, after the Maori chief

* *Loc. cit.*

Te Rauparaha, of the history of whose life the siege and capture of Kaiapoi Pa occupies a prominent part.

ART. LX.—*On the occurrence in New Zealand of* Diadema bolina, *Linn.* By R. W. FEREDAY, C.M.E.S.L.

[Read before the Philosophical Institute of Canterbury, 1876.]

ON the authority of my friend Mr. T. H. Meinertzhagen, of Waimarama, Hawke Bay, I am able to record the capture, in New Zealand, of a female specimen of this large and handsome Butterfly.

It is now in my possession, having been kindly presented to me by that gentleman, who informs that it was taken by a son of Mr. Thomas Turner, of Riverslea, Napier, where the boy caught it with his hat about the end of December or beginning of January last. Unfortunately the insect is in a rather dilapidated condition, otherwise it would be a very fine specimen, being 4 inches and 5 lines (9 lines more than the Australian specimens in the Canterbury Museum) in the expanse of the wings.

From all I can learn, it appears that, of the male of this species, there have been seven reputed captures in New Zealand, including two specimens now in the Auckland Museum; but that this is the first recorded capture of a female, and that, previously to this capture, there had not been a specimen, either male or female, seen in New Zealand for the last two or three years.

In the "Synonymic catalogue of Diurnal *Lepidoptera*," by Mr. W. F. Kirby, the habitat of *D. bolina* is described as India, Otaheite, and the Moluccas; and, in the "Encyclopèdie D'Histoire Naturelle," par Le Dr. Chenu, as America, Africa, and Asia.

The occurrence of the species in New Zealand appears to me to strengthen the opinion I ventured to express, in my paper "On the ocurrence of a Butterfly, new to New Zealand, of the genus *Danais*,"* as to New Zealand and Australia having been, at some distant period, connected, or nearly connected, with the Continent of Asia.

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* "Trans. N.Z. Institute," Vol. VI., p. 183.

ART. LXI.—*Notes on the Antarctic Petrel* (Priocella antarctica). By JAMES HECTOR, M.D., F.R.S.

[*Read before the Wellington Philosophical Society, 25th November, 1876.*]

THIS Petrel has been seldom met with, and the specimen I have now to describe was lately presented to the Museum by Mr. J. J. Buckrell, as a rare bird shot by him in Lat. 46° S., Long. 118° 9″ E., or about 1,000 miles west of Tasmania and in the latitude of Otago. It has not yet been recorded as a New Zealand bird, except that, in the "Zool. of the Voyage of the 'Erebus' and 'Terror,'" a figure of it is given among those from our colony. It is on this figure that I have to rely for the identification of the species, not being able to find any published description, although the name has been frequently quoted, as shewn in the following synonymy :—

Procellaria antarctica, Gmelin, "Syst. Nat.," I., 565, taken from Forster's "Icon.," ined., t. 95; *Id.*, "List, *Grallæ*, etc., B.M." 163; *Id.*, "Zool. 'Err.' and 'Terr.,'" Pl. 33.

Thelassoica (lege *Thelassœca antarctica)*, Rich. (1853), "Coues. P. Phil. Acad, 1866," 31.

Fulmarus antarcticus, Gray, "Hand List," B. iii., 105.

Priocella antarctica, Sharpe, "App. Zool. 'Err.' and 'Terr.,'" 1875, 37.

Description.—Head, neck, back, rump, scapularies, and small wing-coverts, dark brownish-grey, shaded off to brown on the side of the neck and on the throat; outer webs and tips of inner webs of the primaries dark brown; quills white; wing-coverts white; inner secondaries, secondaries, and coverts white, forming a distinct alar bar; tail white, with a terminal bar of brownish-black; underparts white; bill, brownish-black; legs and feet, pale brownish-grey, with brown claws.

Length, 14·4 inches; wing from flexure, 11·8 inches; tail, 4·9 inches; bill following curvature, 1·5 inches; lower mandible, from tip to gape, 1·8 inches; tarsus, 1·5 inch; mandible, toe, and claw, 2·3 inches; hind-claw, ·25 inch.

This elegant Petrel should be easily recognized by the drab colour of its surface, broken only by the marked white band across the tail and wings. I am under the impression that I have seen it after heavy weather in Foveaux Straits.

The species was founded on Forster's drawing taken on Cook's second voyage; but there are five specimens in the British Museum obtained during Ross's Antarctic Expedition, and I presume it is from one of them that the published figure was taken.

ART. LXII.—*Notes on New Zealand Ichthyology.* By JAMES HECTOR, F.L.S.

[*Read before the Wellington Philosophical Society, 9th December, 1876.*]

BRAMA SQUAMOSA.

Pl. IX.

D. 3–35, A. 2·29.

Toxotes squamosus, Hutton, "Trans. N.Z. Inst.," Vol. VIII., p. 210.

THE type of the above was presented to the Colonial Museum by Mr. W. T. L. Travers, F.L.S., but the second fresh specimen now figured shows that it must be referred to the genus *Brama*, on account of its general oval form and blunt profile; its subulate acute teeth, with a stronger second row in the lower jaw; long dorsal fin extending forwards to over vertical of the pectorals and ventrals, with three short feeble spines confluant with the soft dorsal, which, as also the canal, is enveloped in dense scutæ; its moderate very oblique, almost vertical, gape, and dilated maxillary; deeply-excised caudal fin, with elongate accuminate lobes. The genus *Brama* has been transfered in Dr. Günther's work from the Order *Squamipennes* to the *Scomberidæ*, on account of the number of vertebral segments. As a species this fish differs very little from Ray's Bream (*Brama rayi*, Cuv.)

(*a*) Dried specimen, Cook Strait, 1875 (Tylor).

(*b*) Fresh specimen, stuffed, Wellington Harbour, 1875.

Total length, 19 inches.

CYTTUS ABBREVIATUS.

This small fish from the "*Challenger*" collection, ascribed by me in error to the genus *Platystethus*,* should be referred to the genus *Cyttus*, although it differs from the other species of that genus in the possession of bony and spinous plates along the base of the dorsal and anal fins, as in *Zeus*, and in its non-protractile mouth. It will probably form the type of a new genus, but I provisionally place it with *Cyttus* until the "*Challenger*" collection has been published.

UPENEICHTHYS VALMINGII. Cuv. and Vul. C.M.

Upenoides valmingii, Cuv. Günth., I., 400.

Pl. IX., Fig. 5.

Red Mullet.

D. 1/7–9; A. 1/6; L.L. 29; L.T. 2/6.

Length, $3\frac{2}{3}$ times the height, which equals the length of head. Scales twice the vertical diameter of the eye, which is one-third the length of snout. First dorsal less in length of base than the second by the diameter of the eye. Base of second dorsal, length of pectoral and ventral, all equal to

* "Trans. N.Z. Inst.," Vol. VII., p. 247, Pl. XI., Fig. 31c.

length of head. First dorsal spine less than the diameter of the eye; second equal to length of head. Barbels reach nearly to the vertical from the extremity of the operculum.

Upper part of body dusky dull violet, variegated with yellow and azure blue blending into pale crimson, with golden and azure blue streaks on lower parts of body. Head with blue streaks descending on the snout. Fins brownish-purple, with waved markings of pink, yellow, and azure blue, the latter being distinct and the two former blending into the ground colour. Each scale with a violet patch in the centre. Iris golden yellow. Two silvery streaks and a granulated patch below the eye. No black bands on the side of the body.

Teeth on jaws minute, in a double row, with some slightly stronger teeth in front of upper jaw. No palatine teeth. Vomer with three teeth on each side in distinct patches. (See Fig. 2 *a.*)

In the colouration, general form, and divided vomerine teeth, this fish is very similar to *Upenoides vlamingii*, but the absence of teeth on the palatine bones places it in Blecker's genus *Upeneichthys.*

Distinguished from *U. porosus*, of the Australian seas, by the absence of a black lateral streak, which is always present in that species according to Count Castleneau ("Icthyology of Australia," p. 65.)

Specimen in spirit. Outside Wellington Harbour.

Total length, 16 inches.

BERYX AFFINIS. C.M.

Günther, I., 13 A.

Pl. IX., Fig. 1.**

D. 7/12; A. 3/12; V. 1/7; L.L. 44; L.T. 6/12.

Height equal to length of head and one-third total length. Operculum with two spines. Pectoral is one-fifth the total length. Eye situated high, its diameter being one-fifth the length of the head, and exceeding that of the snout. Snout with two nasal apertures close in front, the posterior being the larger. Intermaxillaries carry five teeth on the sides, and a group of large teeth on each side of a mesial notch, into which a projecting group of large teeth on the lower jaw fit.

Colour crimson-pink, paler beneath.

A dried specimen. Collected by Mr. Robson at Cape Campbell.

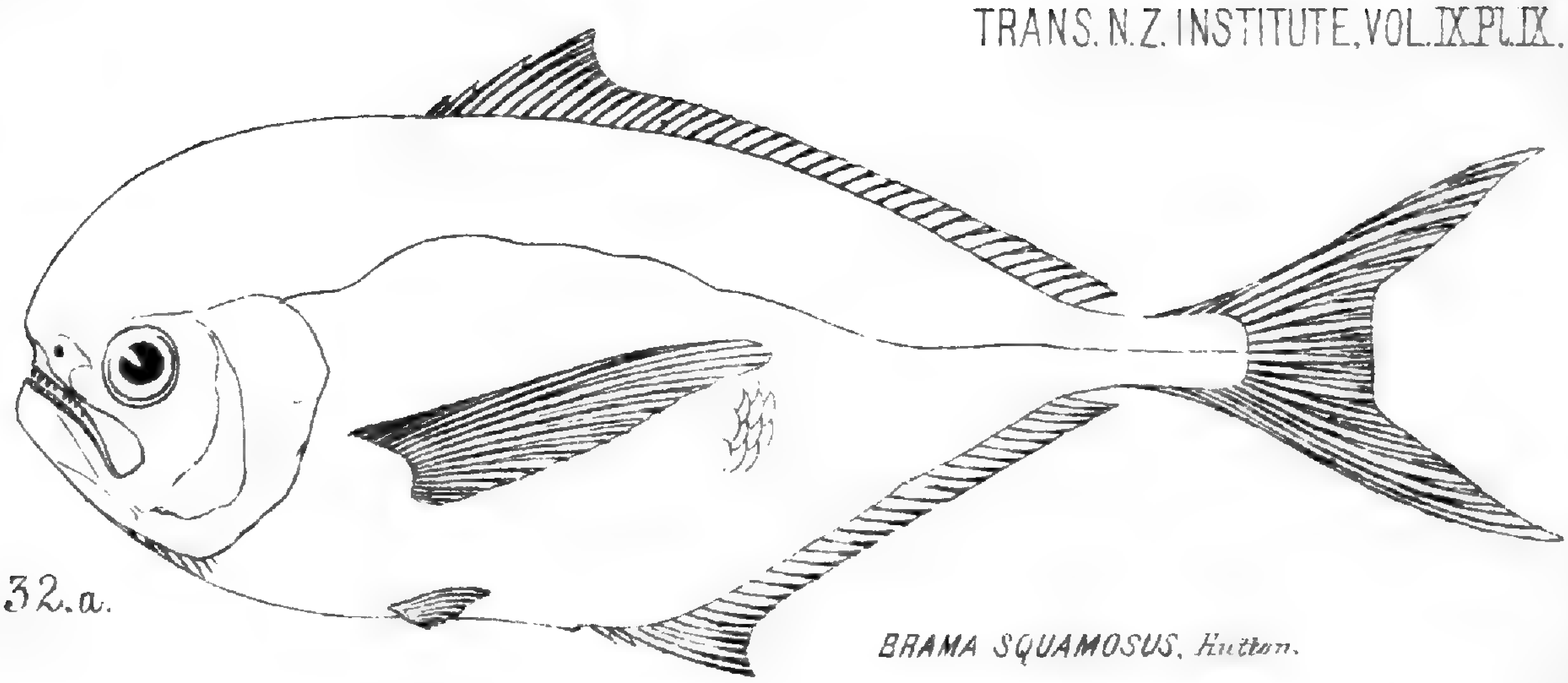
Total length, 18 inches.

This fish agrees with Dr. Günther's species, of which he gives a very minute description in the work above quoted. It inhabits the coast of Australia.

DINEMATICHTHYS CONSOBRINUS, Hutton.

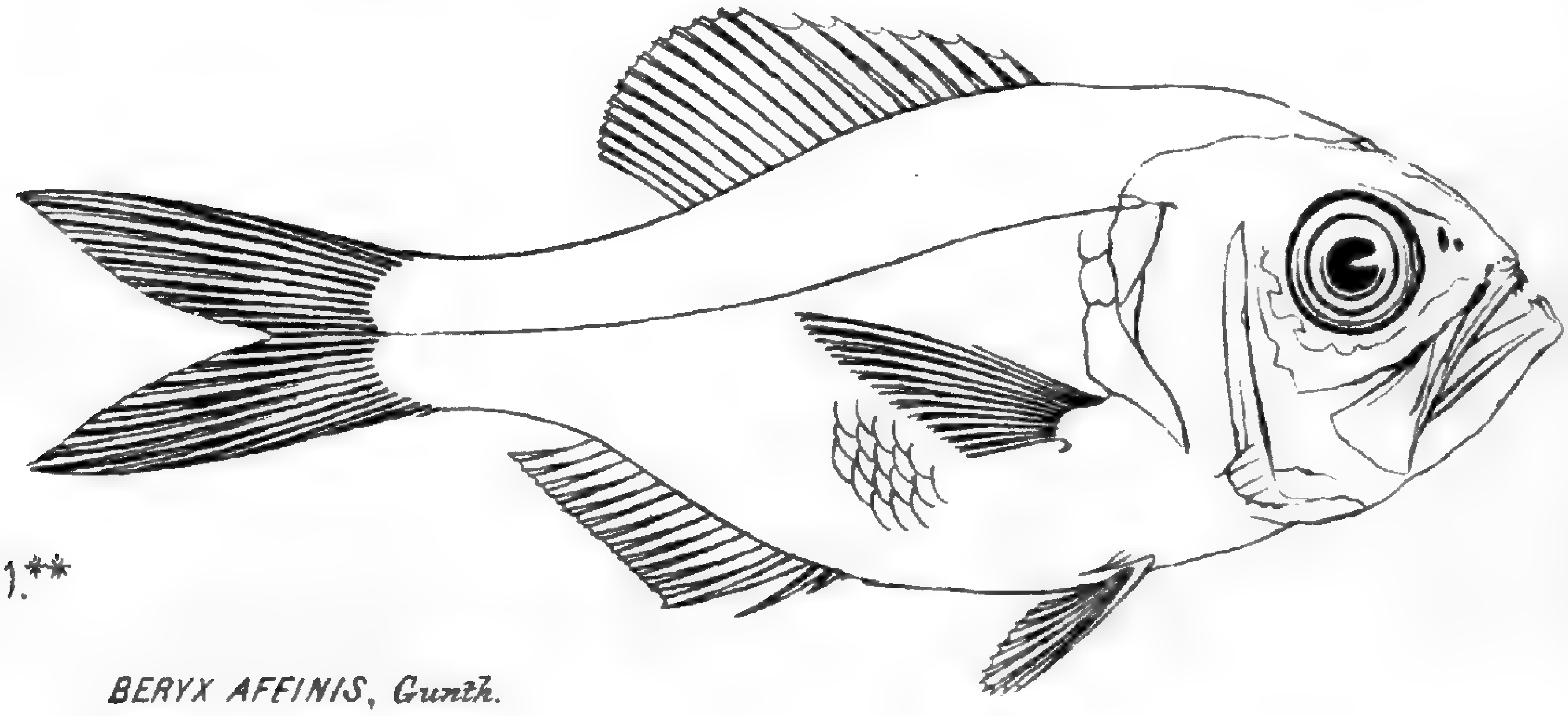
Pl. IX., Fig. 77a.

Captain Hutton's type, being in the Colonial Museum, is figured. He



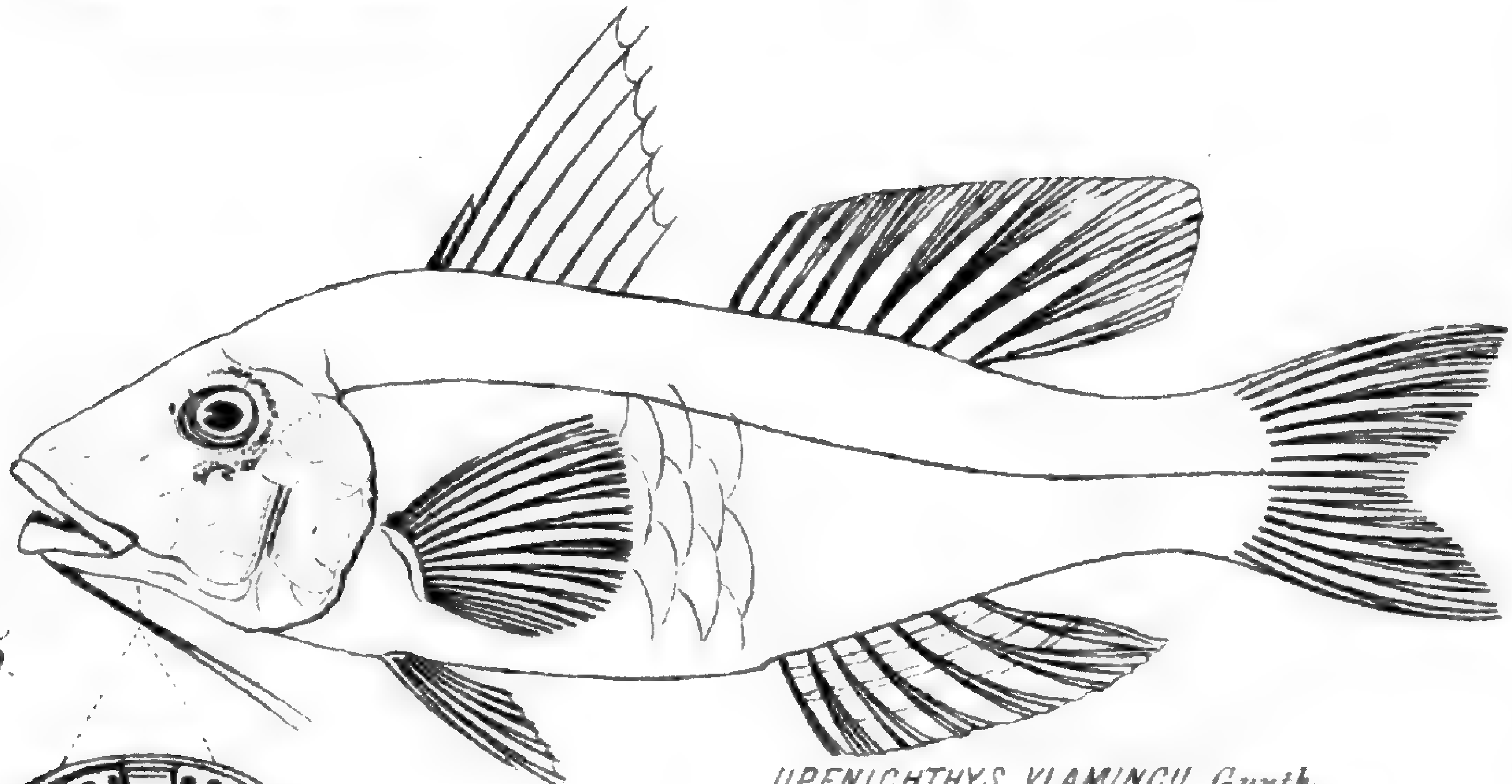
32.a.

BRAMA SQUAMOSUS, Hutton.



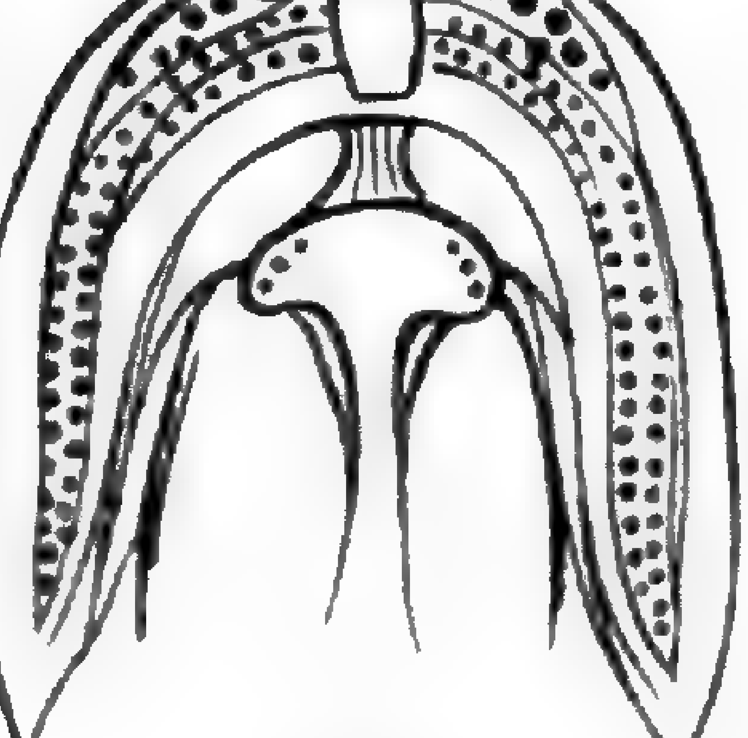
1.**

BERYX AFFINIS, Gunth.

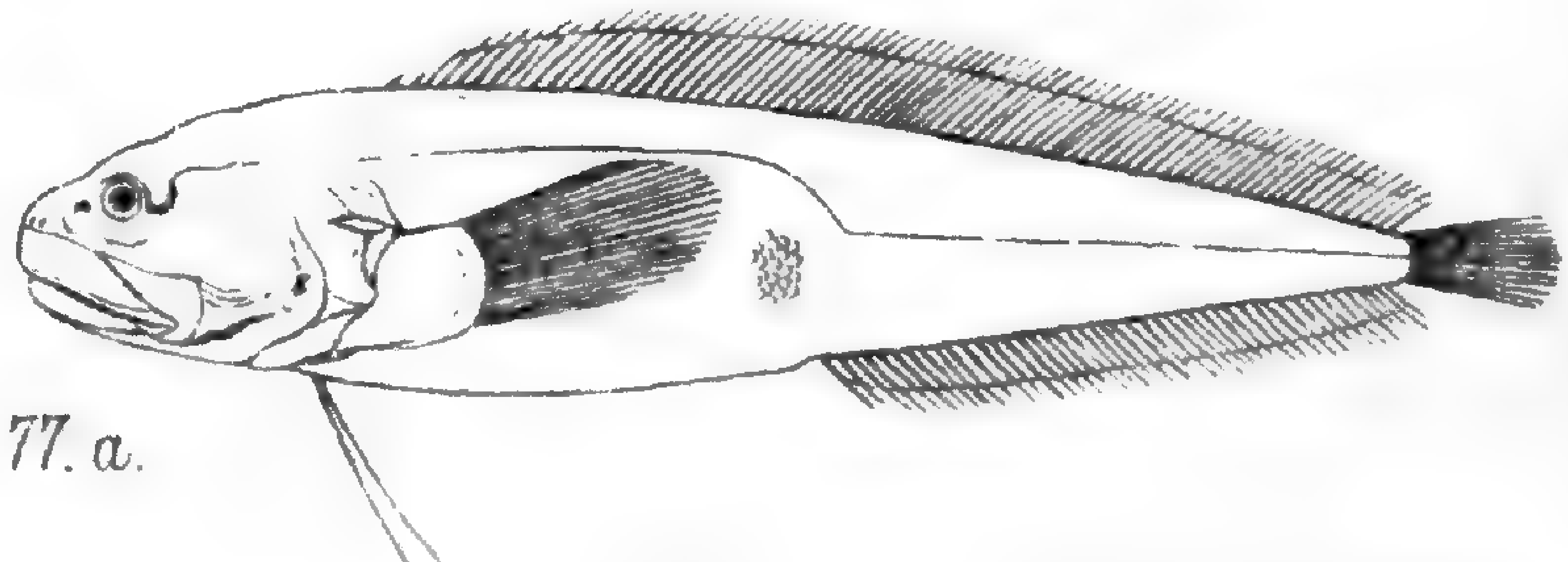


5.

UPENICHTHYS VLAMINGII, Gunth.



A



77. a.

DINEMATICHTHYS CONSOBRINUS, Hutton.

J.B. del. et lith.

does not mention the presence of two minute spines in front of the dorsal. If these are present in the other species the genus will have to be placed in the curious intermediate family of *Gadopsidæ*. In the "Cat. Col. Museum," 1870, I recorded the occurrence of *Gadopsis marmoratus* in New Zealand, but it has dropped out of subsequent lists.

8b. CHIRONEMUS FURGUSSONI.

Haplodactylus fergussoni, Hector. "Trans. N.Z. Inst.," VII., p. 243.

Pl. VIII.

Native name—Hiwi-hiwi.

D. 14–1/17; P. 6/8; A. 3/6; L.L. 60; L.T. 11/16.

Pectoral fins elongate, acute, with six simple rays.

This species was described from a mutilated specimen, and I now find, from a well-preserved example, that the teeth do not form a distinct row of trenchant incisors in front, and that it must be referred to *Chironemus*.

Height of body is one-fourth the total length and five-sixths the length of the head; diameter of the eye equals the orbital interspace, and is one-fifth of the head and one-half the snout, which is pointed, with fleshy lips; gape extends to the vertical of anterior nostrils, which have a double fringe; form of body elongated, with convex profile, the orbital interspace being concave transversely; præoperculum rounded, entire; operculum with two blunt spines and sub-opercular flap; cheeks with small scattered scales imbedded in the skin, which is minutely punctate. The length of the pectoral, which is pointed, exceeds the height of the body, the lower rays being stout and flexible and free from the membrane; the first and fourteenth are very short, the fifth is longest, and is two-fifths the length of head; spinous and soft portions nearly equal.

Scales cycloid, the largest being half the diameter of the eye, those on the sides having a bright yellow spot in the centre of each; teeth strong, villiform, in broad triangular patches; vomerine teeth minute.

Body marked brown and yellow, like tortoise-shell; belly yellow; fins yellow, with dark bars.

	Inches.
Total length	9·5
Height of body	2·1
Length of head	2·6
Diameter of eye...	0·5
Length of pectoral	2·5

This fish is very nearly *C. marmoratus*, Günth., II., 76, but has a more elongate form and pointed pectoral fin. It differs from the fish referred by Captain Hutton to *C. georgianus*, Cuv., which has short pectorals with seven rays, and a short spinous dorsal.

Specimen in spirit presented to the Museum by Mr. W. T. L. Travers, F.L.S., from the Bay of Islands, where it is not uncommon at certain seasons.

6c. GIRELLA SIMPLEX, Rich.

"Voy. '*Ereb.*' and '*Ter.*'" Fishes, p. 25. Günther, I. 429. *Girella percoides*, Hect. ("Trans. N.Z. Inst.," Vol. VII., p. 243).

Pl. VIII., 6c.

A fresh specimen of the New Zealand Black Perch, caught near Wellington, enables me to give a better figure of the fish, which was formerly drawn from a badly-mounted specimen;* and a careful comparison of the fresh fish with the minute description given by Sir John Richardson leads me to abandon its specific distinctness from the fish of Sydney Harbour.

107a. MURÆNA KRULLII.

Pl. VIII.

Posterior nostrils not tubular; anterior nasal tubes minute. Teeth, uniserial, mandibles with twelve irregular-sized teeth on each side. Eight short teeth in a crowded row in front. Vomerine teeth few, but long. Tail portion of the body longest. Length of head to gill-opening contained 3½ times in that of the trunk. Snout compressed, blunt. Fin only slightly elevated, not so high as length of snout. Very thick and fleshy, with a very narrow membranous margin, except near the extremity of the tail. Eye minute. Colour uniform dark brown, without any light patches or darker markings.

	Inches.
Total length	31·5
Snout to vent	15
,, ,, dorsal fin	3
,, ,, gill opening	3·7
Length of snout...	0·6
Length of gape	1·2
Diameter of eye...	0·1

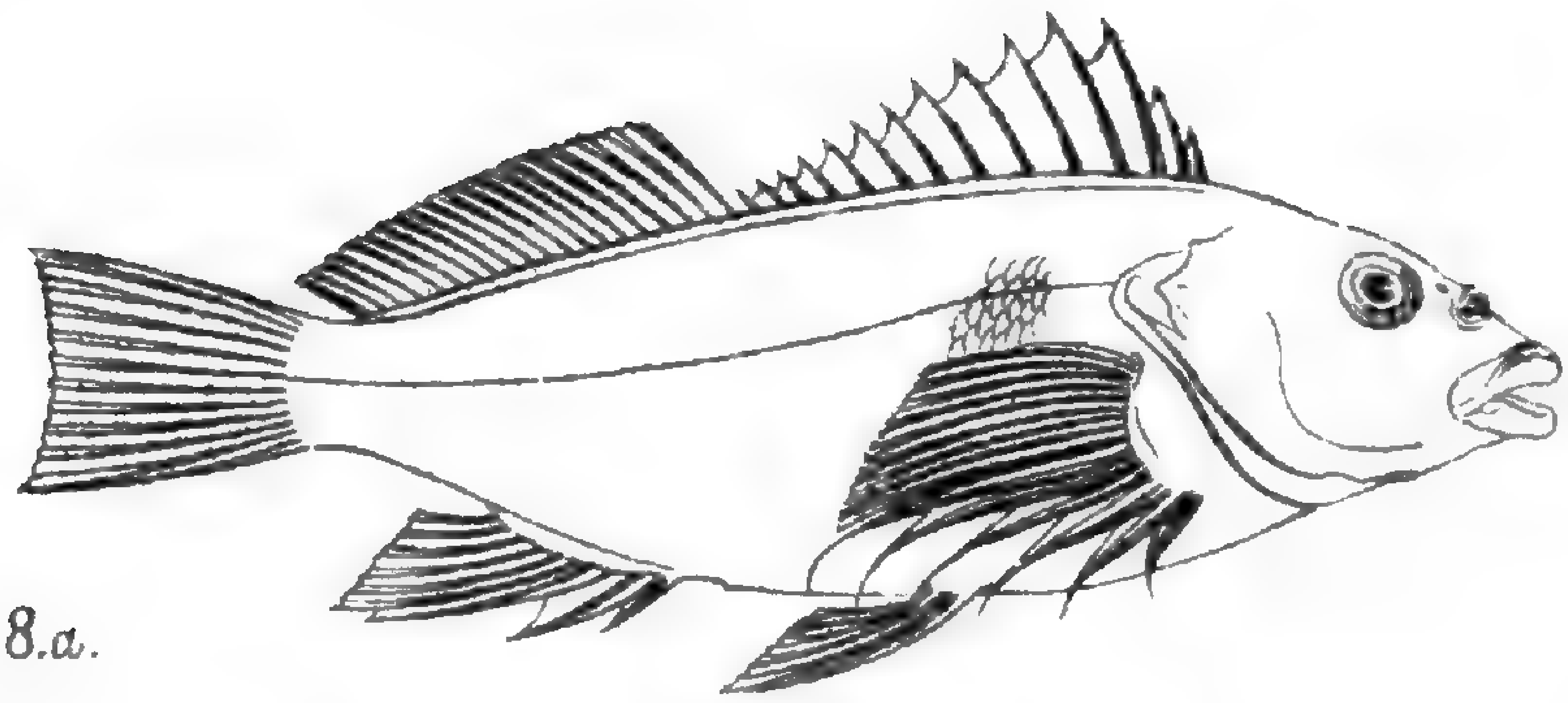
Specimen in spirit presented by Mr. W. T. L. Travers, F.L.S., caught in the Bay of Islands by a whaling vessel belonging to Mr. F. Krull, Cr.P., Consul for the German Empire, and to whom the species is dedicated.

138a. MYLIOBATIS TENUICAUDATUS.

Pl. X.

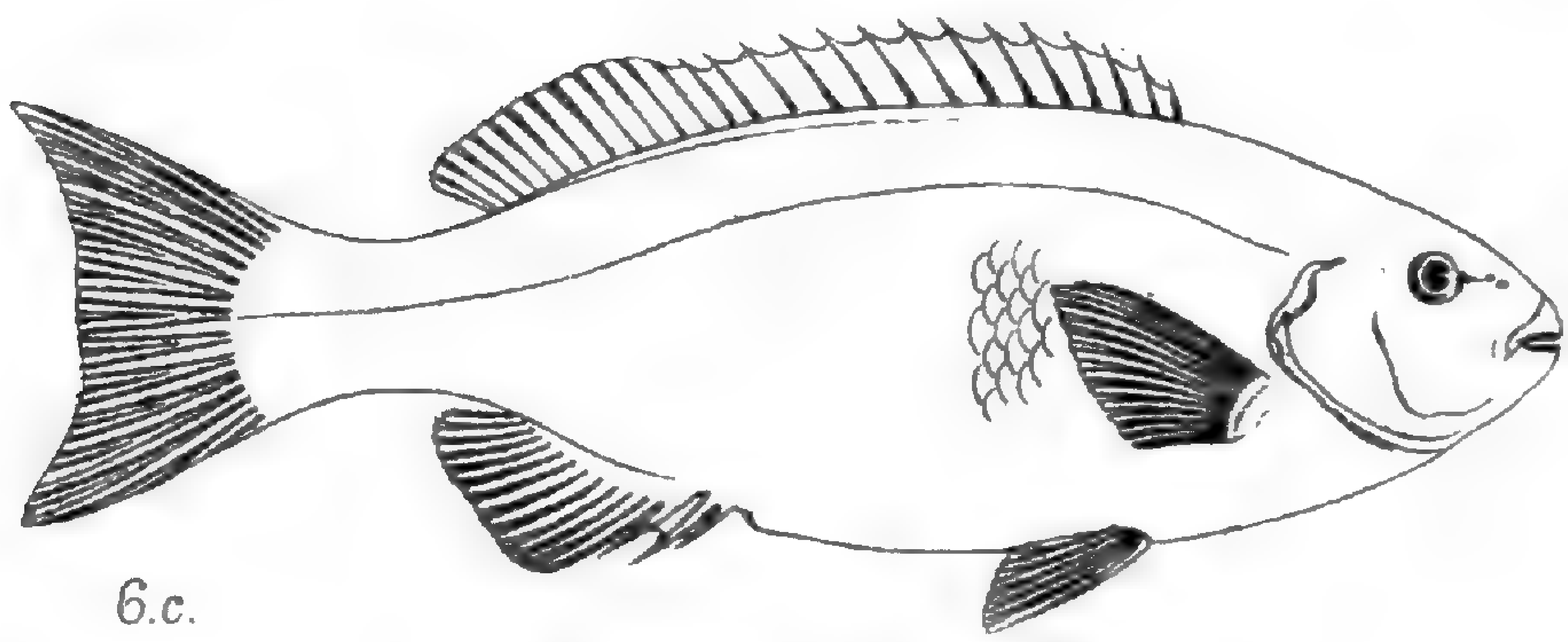
Tail shorter than the disc, very slender. Dorsal finlet commences before the posterior limit of the ventrals. Claspers extend to the caudal spine, which springs half the length of the dorsal, behind that fin, and is equal in length to its base. Body slopes gradually into the fin portion of the disc;

* *Loc. cit.*, Pl. VII.



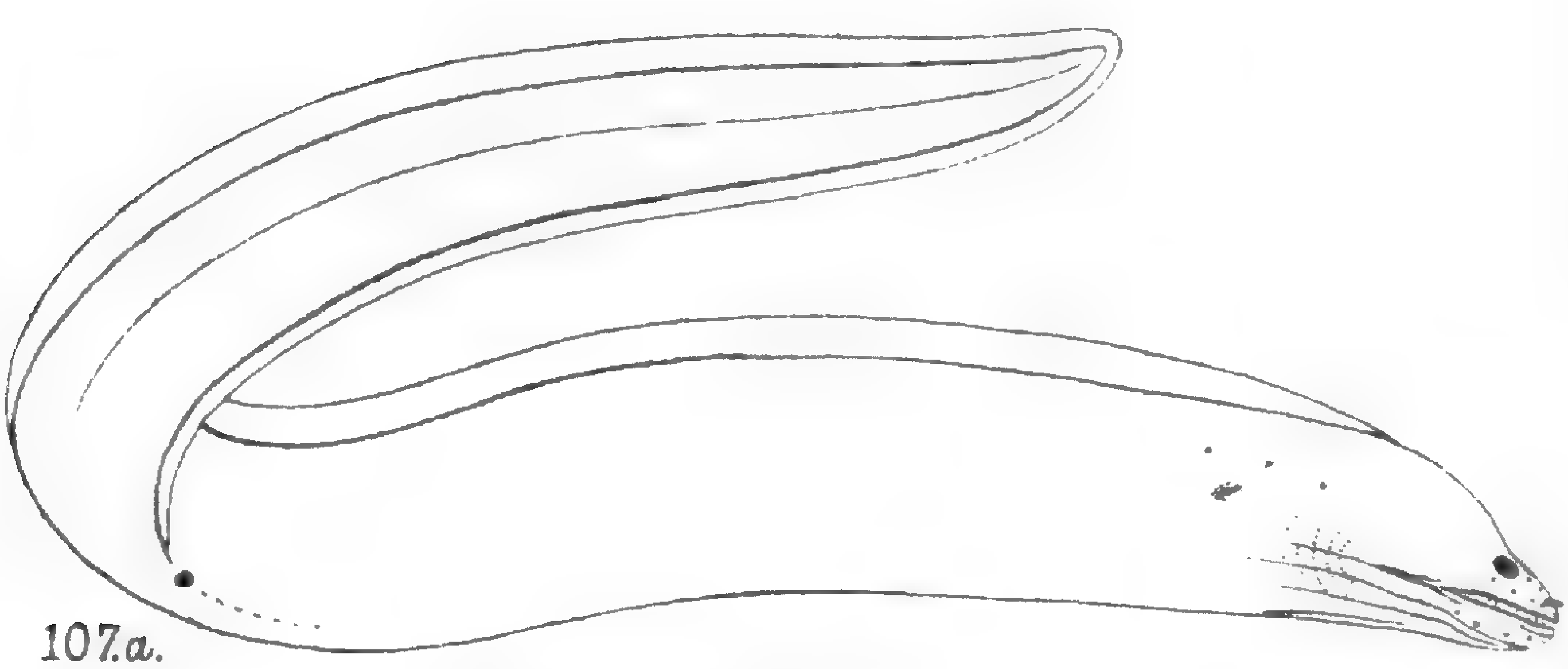
8.a.

CHIRONEMUS FERGUSSONI. Hector.



6.c.

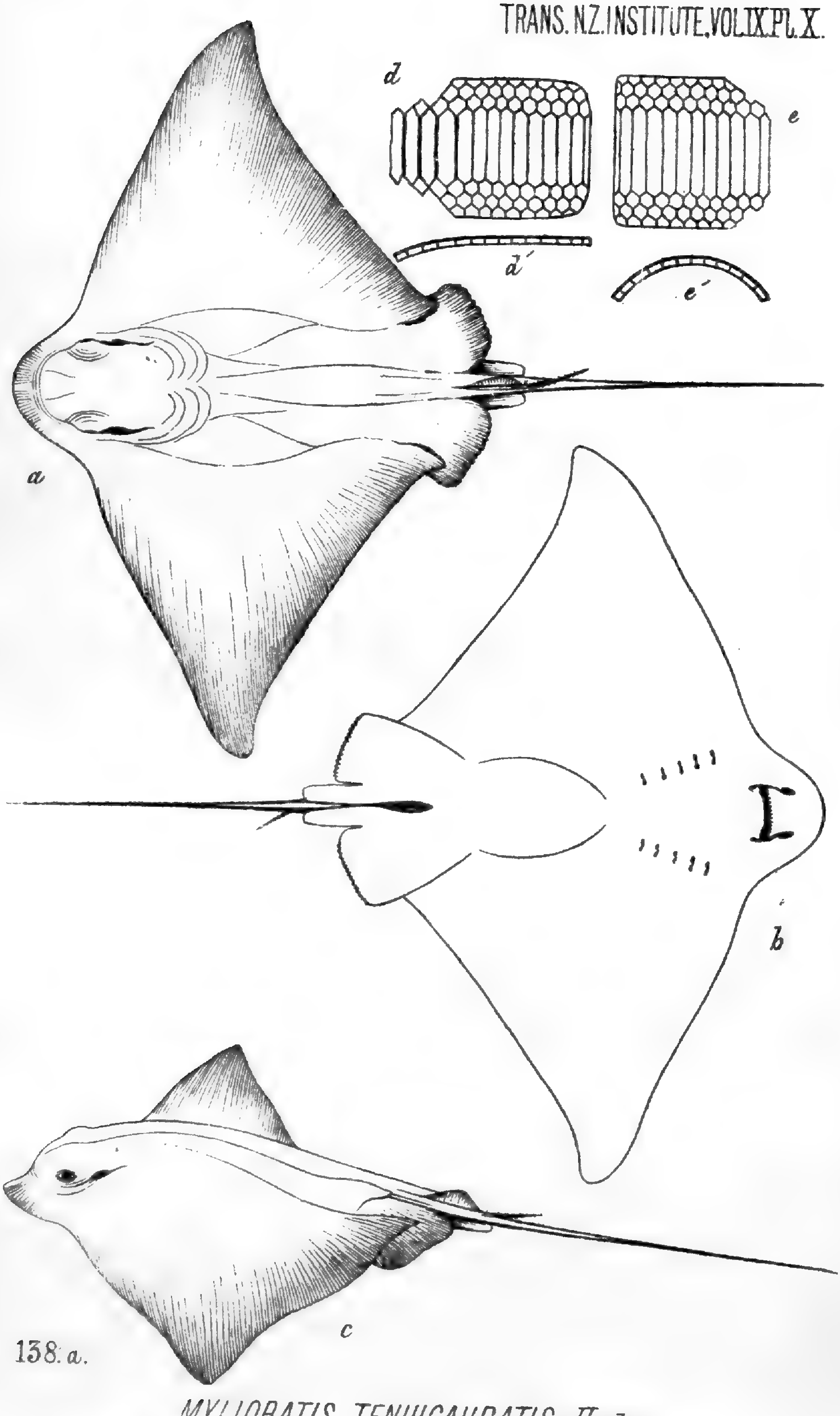
GIRELLA SIMPLEX, Rich.



107.a.

MURÆNA KRULLI, Hector.

J.B. del. et lith.



138. a.

MYLIOBATIS TENUICAUDATIS, Hector.

J.B. del. et lith.

head elevated; eyes lateral, but without an over-hanging ridge. Nasal disc rounded, blunt, profile of mouth concave, and equal in length to the orbital interspace.

Colour dark brown, with blue bars, white beneath. Teeth of lower jaw four times as wide as long (*d–d'*), of upper jaw six times (*e–e'*).

Specimen caught in Wellington Harbour.

	Inches.
Diameter of disc	36
Length, snout to vent	19
Length, snout to caudal fin	23
Length of tail	17

I append extracts from a paper by Dr. Albert Günther, F.R.S., giving the results of a critical examination of some of our fish which he has recently made.

ART. LXIII.—*Remarks on New Zealand Fishes.* By Dr. ALBERT GUNTHER, F.R.S., Keeper of the Zoological Department, British Museum.*

Anthias richardsonii, Gthr.

This fish also occurs on the coast of New Zealand, *Scorpis hectori* of Hutton ("Fishes of New Zealand," p. 4, Fig. 4), being evidently the same species.

Chilodactylus spectabilis (Hutton, 1872, Febr).

This name is to be adopted instead of *Ch. allporti* (Gthr., 1872, Sept.)

Anema monopterygium.

After having re-examined a number of examples of this fish, I cannot agree with Capt. Hutton that two species are confounded under this name. The filament within the mouth of these fish appears often to be accidentally lost, and is probably reproduced.

Leptoscopus.

I regard *L. huttonii* (Haast, "Trans. N.Z. Inst.," V., p. 275) as identical with *L. macropygus*, and *L. robsonii* (Hector, 1875) as the young of *L. angusticeps* (Hutton, 1873). I am indebted to Dr. Hector for a specimen of this *L. robsonii*, which was obtained in Cook Strait.

Seriolella.

Additional examples of various ages of the species of *Neptomenus* (Gthr.), from New Zealand and Tasmania, have convinced me of the identity of this genus with *Seriolella* (Guichen). In young age the præoperculum is distinctly denticulated, radiating bony spicules projecting beyond its margin; with advancing age the interspaces between the projections are filled up

* "Ann. and Mag. Nat. Hist.," May, 1876.

with bone. That this genus belongs to the *Carangidæ* I have already mentioned in "Proc. Zool. Soc.," 1869, June 10.

PLATYSTETHUS HUTTONII.

D. 13 | 36; A. $\frac{3}{32}$; L. lat. 90.

Body much compressed, its height being one-third the length of the head, one-fourth of the total (without caudal). Eye of moderate size, two-ninths of the length of the head, situated a little before the middle of the head, not far below the upper profile. Præorbital at least as wide as the eye. Mouth oblique, with the lower jaw very prominent, very narrow, the maxillary not extending to the front margin of the eye. Dorsal spines feeble, of moderate length; the soft dorsal and anal low. Anal spines short, but stronger than those of the dorsal fin. Pectoral broad, rounded, half the length of the head. Ventrals small. Caudal deeply forked. Silvery; back above the lateral line, greenish; the spinous dorsal black.

Two specimens, 6½ inches long, from Dunedin, New Zealand, were sent by Capt. Hutton.

NEOPHRYNICHTHYS LATUS.

D. 9 | 17; A. 14; P. 23; V. 2.

The whole fish is enveloped in a loose, smooth skin. Head very broad, the interorbital space being especially wide and flat; snout short, rounded, with the lower jaw projecting beyond the upper. The cleft of the mouth reaches to below the front margin of the eye, which is lateral and of moderate size. Pectorals very large, extending somewhat beyond the origin of the anal. Ventrals very short, externally simple, but really consisting of two rays. Caudal subtruncate. Brown, covered all over with round whitish spots.

One specimen, 6½ inches long, from Dunedin, obtained from the Otago Museum. This fish has been named by Capt. Hutton *Psychrolutes latus;* and, from a careful comparison with *Psychrolutes paradoxus*, I can confirm the correctness of his view as regards the affinity of these two fishes; but the presence of a well-developed first dorsal appears to me to demand the separation of the New Zealand fish into a distinct genus. The discovery of this fish led me to re-consider the position which the *Psychrolutidæ* ought to take in the system. As the absence of the first dorsal cannot be retained as one of the characters of the family (which would connect it with the *Gobiesocidæ*), I think those fishes ought to be removed from the division of *Gobiesociformes* to that of the *Cottoscombriformes*, where it would follow the *Batrachidæ*.*

* In my systematic synopsis of the families of *Acanthopterygian* fishes, a misleading error has crept in (p. ix), the family *Psychrolutidæ* being characterized by "Ventrals none," instead of "No adhesive ventral apparatus." Also the diagnosis of the fourteenth division should be corrected by striking out the words "or entirely absent."

CREPIDOGASTER HECTORIS.

D. 7; A. 8.

Snout flattened, not produced, its length being not quite twice the diameter of the eye, or equal to the width of the interorbital space. The length of the head is two-sevenths of the total (without caudal). Caudal peduncle slender, longer than the caudle fin, the short dorsal and anal being widely separated from the latter fin. Ventral sucker small, not broader than long. Red.

One specimen from the southern shore of Cook Strait, 26 lines long; presented by Dr. Hector, C.M.G.

Labrichthys celidota, Forst.

The specimens described by the New Zealand naturalists as *L. psittacula* are not the Australian species so named by Richardson; they appear to me to be the adult of *L. celidota*, in which the dark lateral spot has disappeared or is disappearing. The true *L. psittacula* has one and a-half series of scales between the lateral line and dorsal fin; *L. celidota* two and a-half.

Bregmaceros punctatus.

In a small collection of fishes from Cook Strait, received from Dr. Hector, I have found an example of the interesting fish described by Capt. Hutton as *Calloptilum punctatum.** I do not think that it should be generically separated from *B. macclellandii*, the actual separation ofthe soft dorsal into two fins being evidently an individual character, as in our specimen the two portions are connected by intermediate rudimentary rays. A similar interruption, though much less perfect, can be seen also in the anal fin. In the latter fin I count 57 rays, and in the anterior portion of the dorsal 22, Capt. Hutton giving them respectively as 44 and 11. The long isolated ray in front of the anal, shown in the figure given by Capt. Hutton, is not present in our specimen. I have also to add that minute teeth are present in both jaws, and that the gill-membranes are separate to the chin.

Rhombosolea tapirina, Gthr.

We have received from Capt. Hutton, under this name, a specimen with the eyes on the left side, and with two ventrals. I believe that he is right in considering it to be merely an accidental variety, the development of a second ventral being in connexion with the reversal of the sides.

SCOPELUS HECTORIS.

D. 12; A. 16; L. lat. 39.

The height of the body is two-ninths of the total length (without caudal), the length of the head two-sevenths. The least depth of the tail is less than half the height of the body. Eye rather large, two-sevenths of the

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* "Trans. N.Z. Institute," V., 267, pl. 11.

length of the head, or one-half of its distance from the end of the operculum. Posterior margin of the præoperculum obliquely descending backwards. Snout very short, obtuse, with the lower jaw scarcely projecting. Cleft of the mouth slightly oblique. The maxillary reaches to the angle of the præoperculum, and is scarcely dilated behind. Origin of the dorsal fin nearer to the end of the snout than to the root of the caudal, above the root of the ventral; its last ray is just in front of the vertical from the first anal ray. Pectoral fin short, scarcely reaching the ventral. Scales perfectly smooth, those of the lateral line rather smaller than the others.

One specimen $2\frac{1}{3}$ inches long, from the southern side of Cook Strait, New Zealand; presented by Dr. Hector, C.M.G.

Maurolicus amethystino-punctatus, Cocco.

Having seen a specimen of *M. australis*, described by Dr. Hector in "Trans, N.Z. Institute," VII., p. 250, and presented by him to the British Museum, I believe it to be identical with the Mediterranean species named by Cocco. The number of fin-rays is difficult to ascertain whenever the specimens are not well preserved; but the New Zealand specimen appears to agree with the European species also in this respect.

Syngnathus blainvillianus. (Eyd. and S.)

Of this fish, which hitherto has been found on the west coast of South America only, we have received an example from Cook Strait, New Zealand, through Dr. Hector.

Art. LXIV.—*Notes on New Zealand Crustacea.* By James Hector, M.D., F.L.S.

[Read before the Wellington Philosophical Society, 9th December, 1876.]

The publication of the Catalogue of our Crustacea* has led to the revision of the collection in the Colonial Museum, and the detection of several new species, one of which I have now to record.

The only previously published list of the Crustacea of the New Zealand area is that given by the late Dr. Gray in the Appendix to Deiffenbach's work, and as that list enumerates only nineteen species, whilst the catalogue describes 140 species, some idea may be formed of the extensive addition which has been made to our knowledge of this interesting order, chiefly due to the American, French, and Austrian expeditions that have visited these shores. At the same time many species are recorded as from New Zealand which are unknown to local collectors, so that it is possible that the list

* "Catalogue of the Stalk and Sessile-eyed Crustacea of New Zealand," by E. J. Miers, F.L.S., London, 1876, 136 pp., 3 plates. Prepared and published for the Colonial Museum and Geological Survey Department.

will have to be reduced in number. Mr. Miers has pointed out the remarkable resemblance which exists between the Crustacea of New Zealand and those of the British seas, so that a comparison of the number recorded for the two areas may suggest where our knowledge of the subject is still most incomplete.

Of Sessile-eyed Crustacea, which are mostly of minute size and frequently parasitic on fish, 101 species occur in the British seas, whilst only 47 are recorded from New Zealand. Of Stalk-eyed Crustacea, such as crabs, lobsters, prawns, and the like, which are more obvious, 98 species are known in Britain, and there are already 93 recorded for New Zealand.

The absence of the larger species of crabs and lobsters, used as food in other countries, from the coast of New Zealand, is remarkable, as the conditions for their development appear to be favourable, and, from their fossil remains, such large limbed forms must have abounded in the seas of the early tertiary period. When we consider the character of the New Zealand coast, with its deep inlets and rocky islets covered with kelp, affording lurking-places for large predaceous Crustacea, it is remarkable that only one large species of crayfish should be found of size suitable to be used as food, and I would suggest the introduction of the crab and lobster as a matter deserving of the attention of our Acclimatization Societies.

PLATYONYCHUS OCELLATUS

Differs from *P. bipustulatus*, M. Edwd.,* in having only three interorbital spines, and in the absence of a middle lobe in the orbital margin. The regions are not well defined, and the limbs are more granulated, the second pair hardly differing from the third and fourth. Abdomen narrow, with five segments. Colour brownish, with red granulated spots.

Length, 2·2 inches; breadth, 2·6 inches.

A single specimen, labelled *Portunus ocellatus* (MSS. by Capt. Hutton), in the Colonial Museum collection.

Locality: Wellington Harbour.

POSTSCRIPT.—March 1st, 1877.

A drawing of this species was sent to Mr. Miers, and in reply the following information has been received:—

The *Platyonychus* I believe to be without doubt the *P. ocellatus*, Latr., which inhabits the Atlantic coast of America and the Gulf of Mexico. I send you the description of that species by M. A. Milne Edwards for comparison. So far as I know *P. ocellatus* has not been found further south than the Straits of Florida.

* Miers, *loc. cit.*, p. 32.

PLATYONYCHUS OCELLATUS.

Cancer ocellatus, Herbut, "Naturg. Krabben a Krebse," Vol. III., p 61, Pl. XLIX., Fig. 4 (1799). *Portunus pictus*, Say., "Journ. Ac. Nat. Sci., Phil.," Vol. I., p. 62, Pl. IV., Fig. 4 (1817). *Platyonychus ocellatus*, Latr., "Encycl. Mith.," Vol. X., p. 152 (1825; M. Edw., "Hist. Nat. Crust.," Vol. I., p. 437 (1834); "Archis. Mus. Hist. Nat.," Vol. X., p, 415, Pl. XXXVI., Fig. 4 (1861).

Carapace broad, very finely granulous, and with the regions scarcely marked. Latero-anterior margins divided into five well-separated acute teeth, which are directed forwards. Front narrow, and divided into three teeth, the median long and acute, the lateral ones shorter. Orbital margin straight, and divided by a single fissure. External maxillipedes long, the third joint deeply notched on the inner side for the insertion of the mobile portion. Endostome smooth. Anterior legs moderate. Arm with five denticules upon its anterior margin. Wrist with two spines, one at its antero-internal angle, the other on its outer surface. Head longitudinally traversed with slightly granulous carinæ, and with a spine on the inside above the base of the mobile finger. Ambulatory legs short and slender. Last joint of the swimming legs broad and oval. Abdomen of male tongue-shaped, five-jointed, the seventh very small and encased in the sixth.

Hab.: Coasts of United States; Gulf of Mexico.

With reference to a doubtful form of *Halimus*, also submitted to Mr. Miers, he remarks :—

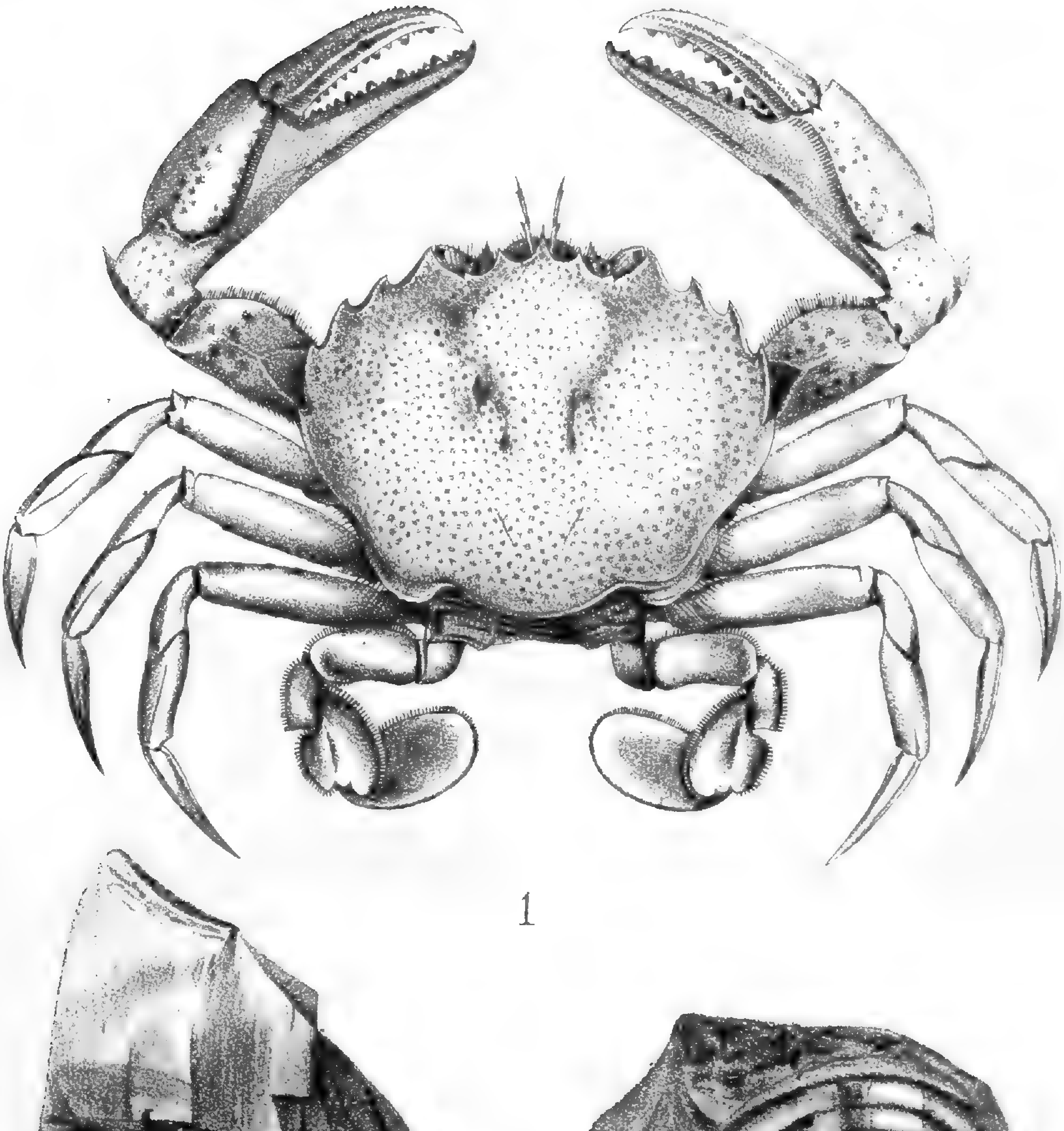
"The *Halimus*, of which you showed a drawing, may prove to be a distinct species. It is evidently closely allied to *H. hectori*, Miers, the tubercles occupying the same position, but being in some places replaced by spines, also the rostral spines are longer and more acute. These differences may be due to age or sex. M. A. Milne Edwards has informed me that he described *H. hectori* as a new genus and species under the name of *Erichoplatus huttoni*, but I believe my name has the priority by a few weeks. Only an actual comparison of your variety with the type of *H. hectori* would enable me to determine whether it is really distinct, and whether M. Milne Edwards' genus can be adopted."

Mr. Miers also furnished a notice of an additional species to his catalogue, and further notes referring to our fresh-water crayfish: —

SQUILLA ARMATA.

Squilla armata, M. Edw., "Hist. Nat. Crust.," Vol. II., p. 521 (1834); Gray, "Hist. Chile. Zool.," Vol. III., Crust., p. 223 (1849).

M. Milne Edwards merely says of this species that "it is very nearly allied to *S. mantis*, from which it is distinguished by the absence of crests



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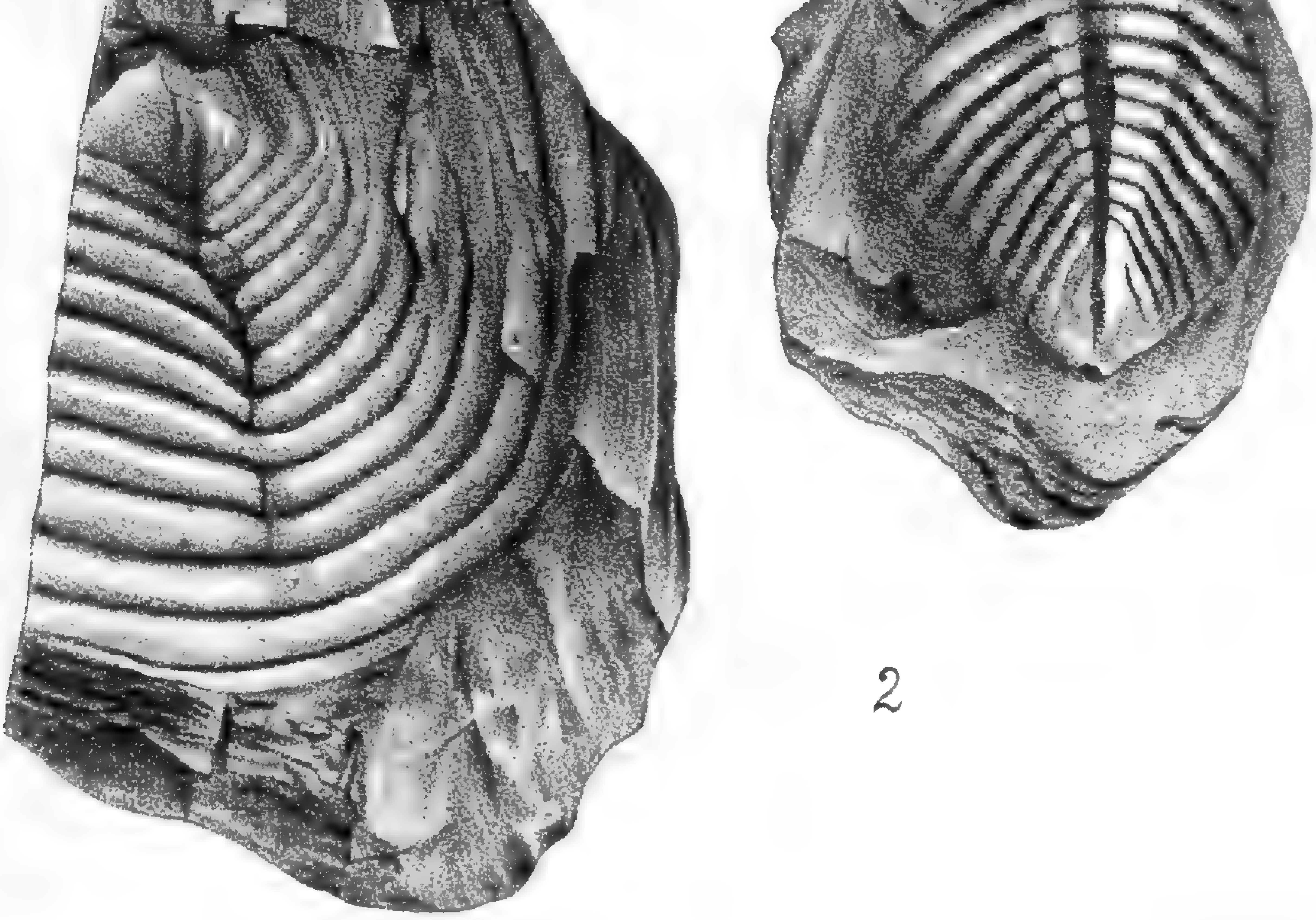

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J. B. del. et lith.

upon the carapace, and by the existence of two spiniform teeth upon the upper surface of the ophthalmic ring. The terminal joints of the large prehensile limbs (griffes) have seven teeth. Length, 3½ inches."

Hab.: Auckland Islands; Laurie Harbour. ("Coll. Brit. Mus.") Chili. (Mus. Paris.)

In the example in the British Museum collection the carapace is smooth, with two longitudinal grooves above, and somewhat emarginate behind, the antero-lateral angles being armed with two small spines. The rostral plate is semi-oval, and rounded at its distal extremity. The spines upon the ophthalmic segment are small but distinct. There are two longer spines upon the basal joint of the antennules. There are six longitudinal carinæ upon each of the first six segments of the abdomen, which terminate posteriorly in spinules upon the fourth to sixth segments. There is a high median longitudinal ridge terminating posteriorly in a spine upon the terminal segment, which has six longer marginal spines, besides the small intervening spinules.

The specimen from Auckland Islands agrees with Milne Edwards' short diagnosis, and in all important particulars with the longer description in the "Historia de Chile," except that in that description no mention is made of the small spines at the antero-lateral angles of the carapace.

ART. LXV.—*Notes on the Genera* Astacoides *and* Paranephrops. By EDWARD J. MIERS, Assistant in the Zoological Department, British Museum.*

IN the "Annals" for last month Professor J. Wood-Mason published a very interesting note "On the Mode in which the Young of the New Zealand *Astacidæ* attach themselves to the Mother." He states (p. 306) that he observed this peculiar mode of attachment in the young of "a female of *Astacoides zealandicus*," which, he adds in a foot-note, "= *Paranephrops setosus*, Hutton;" and, in another foot-note, he cites the genus *Paranephrops* of White as synonymous with *Astacoides* of Guérin-Méneville. As it appears to me still uncertain to what species Professor Wood-Mason refers in his communication, the following observations may be of interest.

Guérin-Méneville founded the genus *Astacoides*, in April, 1839,† for a species of Crayfish described as occurring very frequently in the rivers of Madagascar, to which he applied the name of *A. goudotii*, after its dis-

* From "The Annals and Magazine of Natural History" for November, 1876, p. 412.
† "Revue Zoologique," II., p. 109 (1840).

coverer, M. Goudot. This species was noticed almost almost contempoaneously by M. Milne-Edwards,* and subsequently described at greater length and well figured by him,† under the name of *A. madagascariensis.* Of this species, unfortunately, no specimens are in the collection of the British Museum; but the published descriptions and figure suffice, I think, to show that the genus is well characterized by its robust form, powerful anterior legs, with broad hands and short palm, and the position of the antennæ, which are inserted *beneath* the antennules and are furnished with a small or rudimentary basal scale.

In the genus *Paranephrops* of White,‡ as exemplified in the typical species *P. planifrons*, which is also the commonest species of the genus, the body is comparatively slender, the anterior legs elongated, with the palm more than twice as long as broad, and clothed externally with longitudinally seriate tubercles and spines; moreover the antennæ are inserted *externally* to the antennules, and are furnished with a very large basal scale, which is longer than the peduncle of the antennæ. It is true that in other species of both genera (as, for example, *Astacoides serratus*, Shaw, and *A. franklinii*, Gray, from Australia, and *Paranephrops zealandicus*, White) the distinctive characteristics are somewhat less strongly marked; but so far as the materials in the collection of the British Museum afford means of comparison, I can see no necessity for uniting the genera.

Professor Wood-Mason refers, I believe, to *Paranephrops zealandicus*, White, § in speaking of "*Astacoides zealandicus*;" but this species is certainly distinct from *P. setosus*, Hutton.‖ In *P. zealandicus*, of which the type specimens are in the British Museum collection, the hands are clothed externally with tufts of hair, arranged in longitudinal series, and are armed with spines only upon the superior margins, and the sides of the carapace are smooth. In *P. setosus* there are spines arranged seriately upon the external surface as well as the upper margin of the hand, and the branchial and hepatic regions of the carapace are armed with numerous unequal conical spines. A specimen agreeing well with Hutton's description is in the National collection.

I may say, in conclusion, that a somewhat analogous mode of attachment has been observed among the Edriophthalmata, in the case of the

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* "L'Institut," p. 152 (1839).

† "Archives du Muséum d'Histoire Naturelle," II., p. 35, pl. iii., figs. 1-5 (1841).

‡ "Zoological Miscellany," II., p. 79 (1842).

§ *Astacus zealandicus*, White, "P.Z.S.," 1847, p. 123; "Ann. and Mag. Nat. Hist.," ser. 2, i., p. 225 (1848); *Paranephrops zealandicus*, Miers, "Zool. 'Ereb.' and 'Terr.,'" Crust., p. 4, pl. ii., fig. 2 (1874); "Cat. New Zeal. Crust.," p. 73 (1876).

‖ "Ann. and Mag. Hist.," Ser. 4, Vol. XII., p. 402 (1873).

young of *Arcturus*, by Sir J. G. Dalyell, whose account is quoted by Messrs. Spence, Bate, and Westwood, in their "History of the British Sessile-eyed Crustacea," II., p. 370. In this genus the young individuals affix themselves in clusters to the antennæ of the mother, clasping the peduncles of those organs with their prehensile three posterior pairs of pereiopoda; and a specimen of *A. baffini*, actually exhibiting this mode of attachment, is preservəd in the collection of the British Museum. The young specimens are clustered chiefly on the under-side of the antennæ, with the head pointing toward the body of the parent. In this instance no specially modified prehensile organ exists, nor, indeed, is such required.

ART. LXVI.—*Notes on New Zealand* Cetacea. By JAMES HECTOR, M.D., C.M.Z.S.

[Read before the Wellington Philsophical Society, 1876.]

Tursio metis.

Gray, "Cat. Seals and Whales," 256; Hector, "Trans. N.Z. Inst.," V., 162; Hutton, *Id.*, VIII., 180.

Plates.

This species was founded on a skull in the British Museum, but its habitat was unknown until I determined its occurrence on the New Zealand coast from an imperfect skull obtained in Dusky Bay in 1872. Two specimens were captured by Capt. Fairchild in the same locality in 1875, the smaller of which has been described shortly by Capt. Hutton; and the skeleton of the other, which has been placed in the Colonial Museum, I have now to describe.

The total length of the animal in the flesh was noted as 9½ feet. This agrees with the length of the skeleton on making the usual allowance for the intervertebral cartilage and soft parts, as follows:—

	Inches.
Length of skull	19
Total length of vertebral centra	76
Soft parts of snout	2
Caudal...	9
Intervertebral cartilage	8
	104 = 9ft. 6in.

Skull.—Cranial portion moderate, rounded behind, with large prominent condyles and parietal crests; nasal bones prominent but rounded; posterior maxillary area steep; supra-orbital horizontal, with rough margin round the notch, and a flat area extending forward to the middle of the beak; premaxillaries only slightly shorter posteriorly, with a comparatively small depressed triangular area in front of the nasal aperture, which is crescentic; rostrum bevelled, with a narrow intermaxillary groove widening towards the tip.

Palate flat, contracted behind, with a mesial groove towards the tip, in which the premaxillæ and the vomer are exposed. Dental groove divided into large deep alveoli, and extending along the margin of the beak, as far back as a constriction, which occurs two inches in advance of the notch. Lower jaw massive, $\frac{23}{23}=\frac{23}{23}$, irregular. Teeth 1·3 inches in length, the exposed portion being bluntly conical and incurved, and the fangs generally crooked.

Ear-bell triangular, moderately solid, with a deep groove on the exterior. It measures 1·5 × 8 inches.

Vertebræ.—Cervical, seven in number, have the atlas and axis anchylosed, forming a solid mass, with the spinous process compressed, beak-like, and directed backwards. Width of the anterior articular surface is 4·3 inches.

The posterior cervicals are very short and compressed, and have large slender neural arches, the third cervical only has a lateral foramen, and the seventh is without any inferior lateral process.

The dorsals are twelve in number, and have stout lateral processes, which from the eighth to the eighteenth vertebræ spring from the neural arches, and then descend on to the centrum.

The posterior vertebræ have thin expanded processes and rounded centra as far as the 38th, where the metapophysis and chevron bones commence.

The first appearance of a lateral foramen, is on the 46th. The lateral process disappears on the 48th, and the 54th is the last vertebra that has a neural canal. The chevron bones, seventeen in number, extend from the 38th to the 55th vertebra. The centra of the caudals are oblong, and taper rapidly in size from the 55th to the 64th.

Ribs.—The first rib is compressed, wide, and strongly curved. The first four only have tubercles. Sternum is narrow and elongated, and consists of four segments, which are strongly united, the anterior being expanded into one anterior and two posterior notches. There are five articular attachments on each side. Scapula triangular, the posterior margin ascending at 20° to the plane of the glenoid articulation. Anterior superior angle is produced and slightly hooked over the acromion process, which is much expanded and incurved, while the corocoid is also thin and expanded, and at the tip is curved outwards on the prescapular fossa.

Paddle bones.—The humerus is short and stout, with a large tuberosity. The radius and ulna are one-third longer than the humerus, while the manus, though some of the terminal phalanges are lost, appears to have been about twice as long as the arm bones.

TABLE OF MEASUREMENTS.

Skull—	Inches.
Total length ...	19·0
Occipital height	8·0
Greatest width	10·5
Orbital width ...	8·0
Width at notch	5·5
,, Middle of beak	4·0
,, Premaxillaries	2·0
Length of triangle ...	4·5
Diameter of blowhole ...	2·5
Length of dental groove	9·0
,, Lower jaw ...	16·5
Posterior height of do.	4·0
Anterior ,, ,,	1·7
Length of symphysis ...	3·0

Extreme Dimensions, including Neural Spine.

Vertebræ—	Transverse.	Vertical.
Nos. 1st and 2nd	6·6	4·0
8th	5·0	4·0
14th	5·8	5·0
19th	9·8	5·8
27th	10·5	8·0
38th	7·0	6·0
48th	5·0	2·5

Size of Neural Canal and Centra.

	Canal.	Centra.
8th	2 × 1·2	1·4 × 1·8
14th	1·7 × 1·5	1·6 × 1·5
19th	1·2 × 1·0	1·8 × 1·6
25th	1·1 × 0·8	1·1 × 0·8
38th	0·7 × 0·3	

Length of Centra.

	Total Length. Inches.
Atlas and axis	1·3
Nos. 3–7	1·3
8–11	4·0
12	3·0
18	11·2
19	1·5
20–25	9·0
26–30	7·0
30–37	9·1
38	1·3
39–41	4·2
42–51	15·5
52–54	4·5
55–64	6·0

Ribs—

	Inches.
1st.—Length of articular process	2·0
Width at the angle	1·3
Distance from head to tip	7·0
5th.—Articular process	3·0
Distance from head to tip	15·0
12th.—Styliform—Length	13·0
Sternum—Length	12·0
,, Width of first segment	5·0
,, ,, of middle	1·5
Scapula—Length	10·5
,, Height	7·0
,, Glenoid diameter	1·5
Humerus—Length	3·0
,, Width	2·0
Ulna—Length	4·0
Manus	14·0

From the similarity of the external measurements to those of *Delphinus forsteri*, given by me ("Trans. N.Z. Inst.," Vol. VI., p. 85), Captain Hutton has concluded that I have mistaken *Tursio metis* for that species, overlooking my remark that the skull agreed with that described and figured by me in Vol. V., p. 162, Pl. III., and which has a prominent ridge on the palate and double the number of teeth. As the palatal aspect of the skull affords a ready means of distinguishing the skulls of our dolphins, which are


ELECTRA CLANCULA.
CLYMENIA OBSCURA.
DELPHINUS FORSTERI.
CLYMENIA NOVÆ ZEALANDIÆ
TURSIO METIS.
J.B. del.

the parts of the skeletons more frequently brought under observation, and I cannot find that this aspect of the skulls has been anywhere published, I have arranged figures of the different species for convenience of comparison in Plate No. XI.

DESCRIPTION OF PLATE XII.

Fig. 1. Cervical articulation.	Fig. 5. 48th Vertebra.
Fig. 2. 8th Vertebra.	Fig. 6. 1st Rib.
Fig. 3. 19th "	Fig. 7. Scapula.
Fig. 4. 38th "	Fig. 8. Sternum.

Globicephalus macrorhynchus.

Gray, " Zool. '*Ereb.*' and *Terror,*'" P. 33 ; " Cat. Seals and Whales," p. 320. Hector, " Trans. N.Z. Inst.," Vol. II., p. 28 ; Vol. V., p. 164 ; Vol. VII., p. 261., Pl. XVI., figs. 1 and 2, (not Pl. XVI.*, which is *Orca pacifica*). *Globicephalus scammoni*, Cope., " Proc. Phil. Acad.," 1869, p. 22.

Large-headed Pilot Whale, or South Sea Blackfish.

Only a few skulls of this species were to be found in the European collections until Mr. Charles Traill obtained the two individuals at Stewart Island in January, 1874, the external characers of which I recorded in a former communication. The skeletons of these specimens are now in the British Museum, but in January last a school of Blackfish ran ashore in Lyall Bay, outside Wellington Harbour, and ten complete skeletons were secured. One of them, of a large male, in course of preparation for the Colonial Museum, I have now to describe.

Mr. J. Buchanan, F.L.S., took the accurate drawing shown in Pl. XIII., as it lay stranded on the beach.

The total length was nineteen feet from the snout to the fork of the tail. In form it was cylindrical in the forward part of the body, and compressed vertically in the posterior portion. The forehead blunt and globular, and separated from the snout by a groove. The blowhole situated over and slightly in advance of the eye. The dorsal fin rises over the middle and thickest part of the body. The anterior limb is elongate and acute. The colour was black, but with an ill-defined dark grey streak on each side of the back, and a double V-shaped streak along the belly, uniting at the vent, and a lighter patch over and behind the eye, but not being in any case sufficiently defined to admit of being described as bands.

It is very doubtful if this species should be separated from *G. melas*, or the common Caaing Whale, of the North Atlantic, an excellent figure of which s given by Dr. Murie, F.Z.S.,† and certainly no reason has been

* This figure was crowded out of the preceding Plate, and the wrong name affixed by a mistake of the draughtsman.

† " Trans. Zool. Soc.," Vol. VIII., Pl. XXX.

shown for distinguishing under a new specific name the Blackfish of the Pacific, when it appears on the Californian coast. The Black fish has the same habits and range as the Sperm Whale, frequenting the subtropical seas in large schools, and occasionally, like the great Cachelot, extending their migrations to temperate latitudes, and even doubling Cape Horn. As there is now generally admitted to be only one species of Sperm Whale common to all seas, the division of the Pilot Whales into distinct species should require very definite proof, so that the skeletons which have been transmitted to various museums in Europe and America will enable an accurate comparison to be made with the northern forms, and settle this interesting question of distribution.

The only differential characteristics are to be found in obscure shades and patches of lighter colour, and in the number and form of the teeth, which are notoriously mere individual characteristics among this group of Cetacea, the teeth showing a marked tendency to disappear wholly, or in part, in old individuals. Among the school of Pilot Whales under review some have only nine and others twelve teeth in the upper jaw, while the usual number in the lower jaw was ten.

The great individual variety in the number and position of the teeth that are either absorbed or are lost early in life, becomes, however, still more marked among the Ziphioid Whales, and has led to the temporary establishment of species and even generic distinctions in numerous instances.

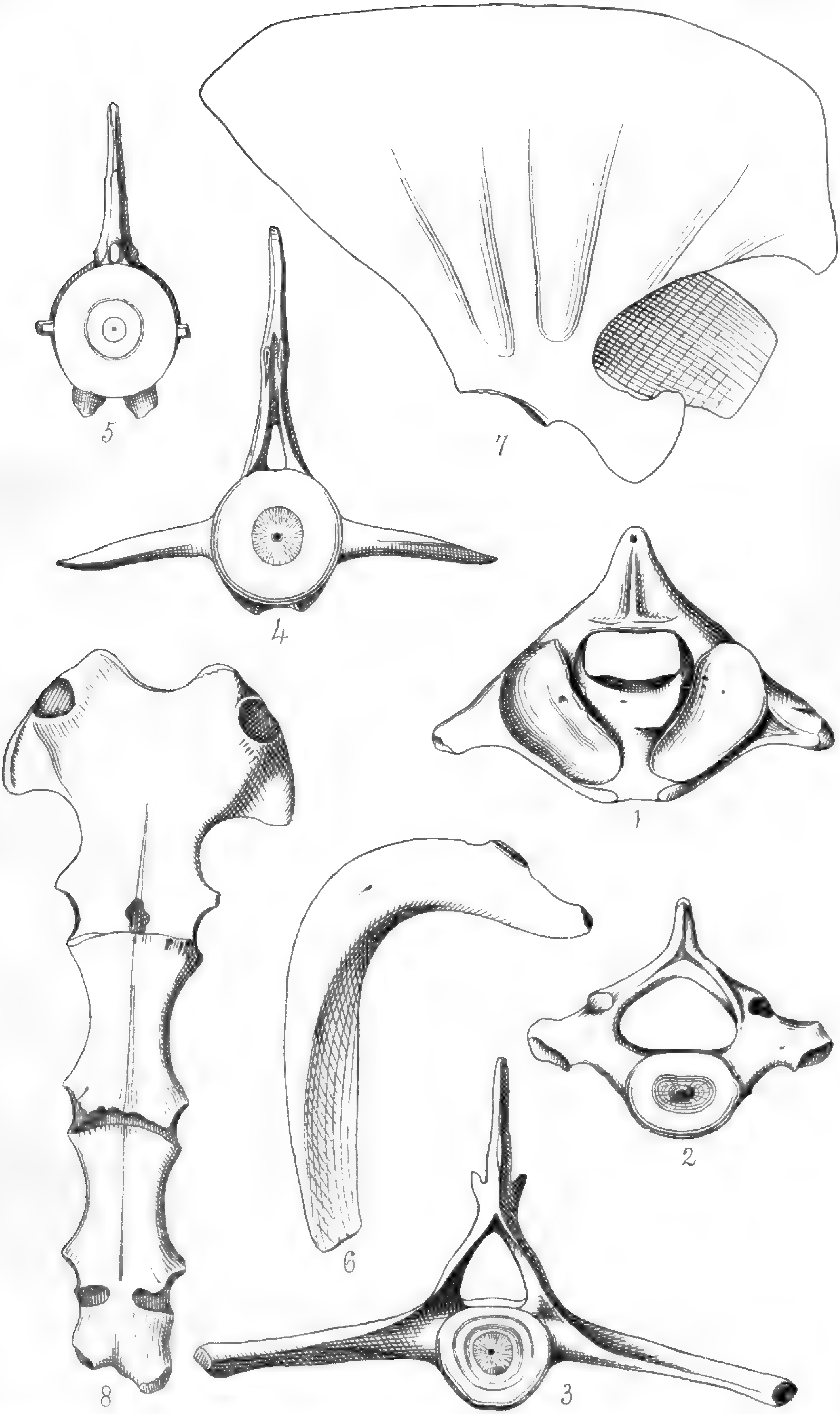
The state of the bones proved that the animal was of mature age.

The skull is 28 inches along the floor, with an extreme width behind the orbit of 19 inches. Of this total length the beak occupies exactly one-half (28 inches). It is broad, flat, and slightly bent down on the top. Its upper part is formed by an expansion of the callous premaxillaries, which are slightly depressed in the middle line between the notches, and are separated throughout by a wide groove. The entire vertex of the cranium is formed by the nasal bones, which are very prominent.

The lower aspect of the beak is formed entirely of the maxillaries, the palatine bones only showing as a narrow band between the maxillæ and the pterygoids, and the premaxillaries only showing in this aspect as a small area on the top of the rostrum.

The tooth series occupies the borders of the maxillæ for half their length, and show ten alveoli with raised margins, but some are almost obliterated.

The lower jaw, which is rather slender, has nine alveoli in a groove, which is wider at the symphysis and narrow behind. The symphysis only extends back as far as the fourth tooth from the top.



J.B. del et lith.

TURSIO METIS, Gray.

GLOBIOCEPHALUS MACRORHYNCUS, Gray.

The number of vertebræ is as follows :—

Cervical...	7
Thoracic	11
Lumbar	13
Caudal with chevrons	29
Total number	60

The first six cervical vertebræ are soldered into a solid mass by the adhesion of their centra and neural arches, the divisions being only distinctly visible on the lateral branches of the arches. The cervical mass formed by the spinous processes of the atlas, axis, and third vertebra, is directed backwards and is separated by a fissure from the posterior spine of the mass, which is composed on the left side of the sixth arch only, and on the right side by the fifth and sixth, the fourth segment having an incomplete arch.

The length of the anchylosed vertebræ is 3·9 inches. The seventh vertebra is a compressed lammellate bone in all its parts. The centrum is 0·7 inch in length, and has a rough patch but no distinct articular facet for the attachment of the first rib.

The arch is directed backward, and the transverse processes slightly downwards. There is no trace of an inferior transverse process.

The dorsals, 11 in number (Nos. 8 to 18) have a total length of 38 inches. They gradually increase in length backwards, the body of the 8th being 1·6 and that of the 18th 3·6 inches. The transverse process of the ten anterior segments are stout and short, with a wide articular facet for the ribs. They rise on the side of the arch for the first five vertebræ, and then descend till, on the 18th, the process, which is longer and expanded like that of the surrounding vetebræ, springs from the upper third of the centrum. There is no costal articulation on the transverse process of this vertebra. The lumbar vertebræ are thirteen in number, the first chevron bone appearing between the 31st and 32nd vertebræ. No. 27, or the ninth lumber, is the largest in the spinal column, the length being 4·6 and the diameter of the centrum 4 inches, while the total length, including the neural spine, is 12 inches, and the width through the transverse processes is 13 inches. The hæmal surface is compressed and excavated on each side of a mesial ridge. The average breadth of the processes is 2·5 inches.

The caudal vertebræ, 29 in number, continue to have centra of equal size as far as the ninth (No. 42), when they become compressed, though retaining the same height to No. 48, after which they rapidly decrease in size. The first vertical arterial foramen appears on No. 38, and on No. 42 the lateral process is reduced to a mere tubercle. The last trace of a spinal canal is on No. 48.

The first rib is a very stout, strongly curved, compressed bone, thirteen inches in length from tip to tip, while the fifth, which is longest, is twenty-six inches. Only the first seven have a double articulation with the vertebral column.

The sternum consists of three segments, and shows four articulations, its total length being sixteen inches.

The hyoid is a crescentic bone twelve inches in length.

The pelvic bones are prismatic styliform bones, nine inches in length.

The scapular is triangular and strongly ridged, the posterior edge forming an angle of 35° to the plane of the articulation. Acromion thin, expanded, and incurved; corocoid thicker; both three inches long, or one-fifth the length of the superior edge.

Humerus and arm bones firmly united. Manus long and pointed, the second digit being the longest. The number of phalanges is as follows:—

I., 4; II., 13; III., 10; IV., 3; V., 1.

DESCRIPTION OF PLATES.

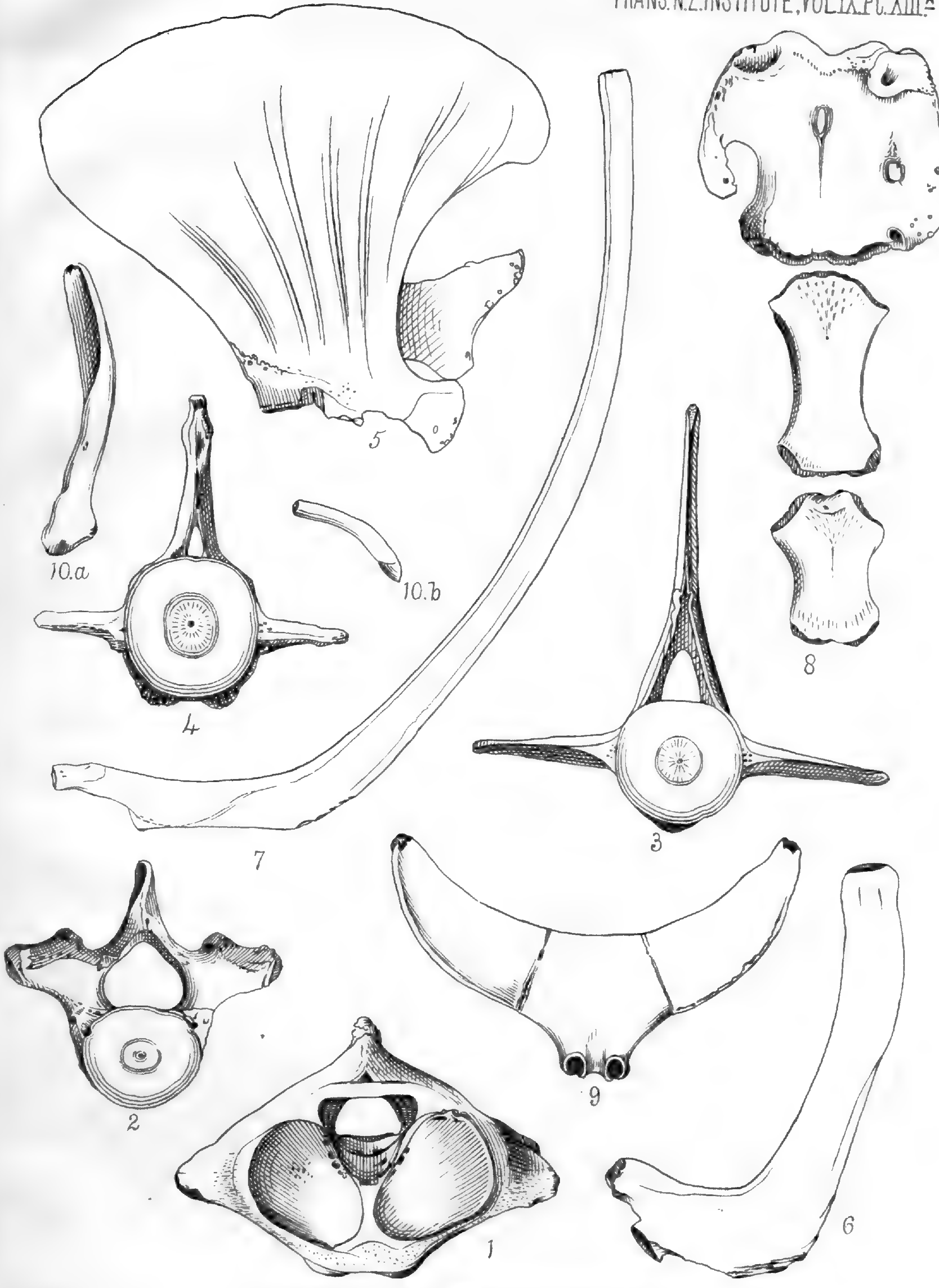
Sketch of the External Form, Pl. XIII.

Cervical mass. Pl. XIIIa., Fig. 1.
13th vertebra. Fig. 2.
23rd ,, Fig. 3.
39th ,, Fig. 4.
Scapula Fig. 5.
1st rib. Fig. 6.
5th Rib. Fig. 7.
Sternum. Fig. 8.
Hyoid bone. Fig. 9.
Pelvic bone. Fig. 10, *a*, male; *b*, female.

Art. LXVII.—*Fish and their Seasons.* By P. Thomson.

[*Read before the Otago Institute, August 1st, 1876.*]

The following table had its origin in a conversational discussion which took place at one of the meetings of the Institute during last session. It was mentioned, among other things, that there was a good deal of doubt about the times when the ordinary food fishes were actually in season, and a few particulars as to the length of time they were to be caught might be useful. In the hope that the following may go some way towards supplying what was wanted, I venture to bring it before the members of the Institute. I may state that the mode adopted in gathering the information was by noting down the various sorts of fish exposed for sale in the windows of the fishmongers' shops, as well as by occasional enquiries elsewhere. The work was begun on the 1st August, 1875, and was continued daily till the 31st July of the present year. During a short absence from Dunedin the notes were taken by a friend, who adopted the same method.



J.B. del. et lith.

GLOBIOCEPHALUS MACRORHYNCUS, Gray.

Name of Fish.		Number of Days in Market.												
Native or Common.	Scientific.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June	July.	Totl.
Hapuka, Groper ..	*Oligorus gigas*	none	2	13	13	12	11	20	17	8	18	11	18	143
Kahawai, Salmon ..	*Arripis salar*	none	none	none	none	none	2	none	none	none	1	none	none	3
Tamure, Snapper ..	*Pagrus unicolor*	none	none	none	none	none	none	1	none	none	none	none	none	1
Kohikohi, Trumpeter	*Latris hecateia*	1	2	none	none	none	1	none	none	none	5	none	none	9
Moki	*Latris ciliaris*	none	4	4	7	12	8	13	12	3	none	8	11	82
Hiku, Frostfish ..	*Lepidopus caudatus* ..	2	none	none	none	none	none	none	none	none	none	none	none	2
Mangu, Barracoota ..	*Thyrsites atun*	none	1	1	18	15	20	11	11	3	9	13	4	106
Arara, Trevally ..	*Chilodactylus macropterus*	none	2	none	2	4	4	none	7	15	22	16	17	89
Haku, Kingfish ..	*Seriola lalandii*	none	none	none	none	none	1	none	none	none	none	none	none	1
Pakirikiri, Blue Cod ..	*Percis colias*	5	6	3	4	9	2	4	5	3	11	10	17	78
Red Cod	*Lotella bacchus*	9	6	3	14	10	7	1	8	9	19	11	14	111
Ling	*Genypterus blacoides* ..	1	none	2	1	6	6	9	9	16	20	23	16	109
Marare, Butterfish ..	*Labricthys bothryocosmus*	1	none	1	2	4	2	none	5	6	9	2	2	34
Aua, Mullet, Herring	*Agonostoma forsteri* ..	2	12	none	3	5	10	17	20	22	24	22	22	159
Ihi, Garfish	*Hemirhamphus intermedius*	none	none	3	4	5	none	none	5	1	none	1	none	19
Sandling or Eel ..	*Gonorhynchus greyi* ..	none	none	none	none	none	none	1	7	12	5	5	4	34
Patiki, Flounder ..	*Rhombosolea monopus* ..	7	12	5	11	12	17	19	20	21	26	25	26	201
Sole	*Peltorhamphus, N.Z.* ..	none	3	2	2	4	3	2	1	none	1	5	7	30
Skate	*Raja nasuta*	1	2	none	2	none	1	3	none	none	2	1	1	13
Days on which there were no fish		11	5	8	3	..	1	1	3	..	..	..	..	32
Prevailing weather		stormy, dull, cold.	variable.	stormy, wet, cold.	fine, stormy at close	wet.	fine.	fine.	fine. dull & stormy at close	variable.	fine.	fine, wet at close.	cold, frosty, dull.	

A few other fishes occasionally come to market, such as the Gurnard (*Trigla kumu*), a pretty fish with fine long fins like wings, but it is seldom eaten, though of good quality, being very bony. The Hardhead (*Kathetostoma monopterygium*) is also seen occasionally, but its forbidding appearance is sufficient to prevent its being eaten, though wholesome enough. There is another fish, termed the *Agriopus leucopoccilus* (Leather Jacket, or Pig-fish), quite different from the fish of that name in the North, which is very palatable, with firm white flesh; but it is very seldom eaten, though common enough in Otago Harbour.

As supplementary to the table, I give the following particulars of the fishes there treated of:—

Groper was in the market 143 days, and might almost be said to be in season the whole year through. This fish is caught off the rocky points of the coast, in five fathoms and upwards of water, just outside the kelp.

Kahawhai is a rare visitor here, and only to be caught in the summer, a few being brought to market every year.

Snapper is also rare, and a summer visitor.

Trumpeter is never plentiful; a few are brought to market at irregular intervals.

Moki has been abundant nearly all the year. It is noteworthy that this fish used to be very seldom seen in our market, but of late the superior knowledge of the fishermen has been rewarded by a plentiful supply of this excellent fish.

Frostfish only find their way to market in winter time, and are very irregular in supply.

Barracoota have not been in such excessive supply during the past as in former years. This is owing, I think, in great measure to the reduced demand, not from any falling off in the amount of fish, which is as abundant as ever, but from other fish having been in better supply, and people generally in better circumstances and more able to purchase superior quality.

Trevally.—This fine little fish has been in fair supply, particularly towards the autumn,

Kingfish is only occasionally a visitor to our shores; a few are caught every summer.

Blue Cod is a very common fish, and to be caught all round the coast. Two different fishes are included in this term, and one of them is sometimes called Black Cod. They are very much alike in shape, but the scales are different. A good many Blue Cod are sent up from Stewart Island.

Rock Cod, or Red Cod, is very common, occurring in the Harbour in large shoals, and a favourite object of sport from all the jetties and piers as well as from boats in the channels. It is also caught outside the Heads in from five to ten fathoms of water.

Ling has a sickly look about it, which keeps people from fancying it much; but it is, nevertheless, a most palatable article of food, and, moreover, can be salted down with great ease. It is caught in the Harbour occasionally, but is mostly got off the coast.

Butterfish is a misnomer. At least the fish so termed here is not the same as the one known by that name in the North. It is pretty commonly caught in the Harbour, but is never very numerous, the seiners finding a few in the nets among Flounders, etc. A true Butterfish was exhibited in Mr. Melville's window on Thursday last; a very different fish from the one known here.

Mullet, or Herring of the fisherman.—This fish is very abundant at times, large shoals filling the bays in the lower Harbour, particularly during summer and autumn, and great hauls are often made. It takes bait, too, and is a source of pleasureable employment to many, from boats or from the jetties. A true Herring visits the coast in immense profusion in the autumn, particularly off Green Island and Sandfly Bay, when the settlers generally manage to catch a few, but they are never brought to market. The time of their arrival on the coast is uncertain, and is only known by the great flocks of birds, etc., which attend the shoals.

Garfish are pretty common in the summer and autumn months, and are generally caught in nets. This fish is never very large, but is excellent eating,

The Sandling, or Sand-eel, is not an Eel at all. It is also a summer fish, and not uncommon.

Flounders are in the market all through the year; they are netted in the Lower Harbour and the various inlets up and down the coast, as well as speared in the shallows. Flounders are rather over-fished, and are neither so large nor so plentiful as they used to be.

Soles are now more plentiful than formerly, but are in very irregular supply.

Skate is common enough, but not very often brought to market. I wonder more attention is not paid to this fish, considering it is such a favourite article of food in the old country. I remember a pretty large Stingaree being caught, nearly four feet square. It was cut up and sold in Dunedin.

Subjoined are a few miscellaneous particulars regarding fish supply during the year:—

August was a rather stormy month, and there were eleven days during which there were no fish in the market. Crayfish were plentiful during the month.

September was characterized by steady weather, and fish were rather scarce all through; on fine days there were no fish. Crayfish adundant. On the 27th, two Barracoota were brought to market—a long time in advance of the regular date. It is curious that odd Barracoota are caught now and then in the winter time, while Cod or Groper fishing outside. It happens generally when the hook is just about reaching the bottom, as if the fish were then feeding near the bottom, and came to the surface when the water became warmer and feed more plentiful.

Very changeable weather prevailed during October, and during eight days there were no fish. The Barracoota arrived in force on the 30th.

November was very stormy, with some cold wet days, but fish were in pretty good supply, except for three days, when there were none. On the 30th, a fine Sea Trout, weighing 10½ lbs., was caught in the Lower Harbour.

December saw the market well supplied, except for a few days towards the end, when thick dirty weather prevailed. A feature was, that a good many Blue Cod and some Granite Trout were sent up from Port Molyneux, having been caught near the Nuggets.

All the month of January there was a good supply of fish. On the 17th, a Swordfish, 10 ft. 4 in. long by 4 ft. 6 in. round, was caught near Quarantine Island. On the 24th, a Conger Eel, 4 ft. long, was exhibited in one of the shops, and another Salmon Trout, 10½ lbs. weight, was caught in the Lower Harbour.

On the 3rd February, a strange fish, resembling a Trevally, was brought to town. It was over 2 ft. long and 10 in. deep, sharp pectoral fin and forked tail, bright white round scales.

On March 2nd, a fish, called "Fiddle Head," was caught outside the Heads. It measured 6 ft. long by 4 ft. broad, and weighed 2 cwt. About the middle of the month a great many very small Flounders, Herrings, etc., were brought to market, too small for use, causing a good deal of remark as to the bad tendency of such a practice.

April was marked by a continuance of good weather, with but one break from "sou'-west," and fish were in good supply the whole month. On the 5th, a few fresh-water Eels were on sale, some of them large. Herrings were very plentiful, and about the middle of the month the supply of Ling was extremely good, the fish mostly large and of good quality.

During May the supply was good, except during a few stormy days.

Fish were in rather small supply during the first half of June. A large Conger Eel was shown on the 2nd.

July was characterized by a succession of calm frosts, and at times dull weather, till towards the close of the month, when there was a northerly gale. The supply of fish was liberal, and the variety and quality both alike good.

At the present time (July, 1876), and for some months back, there have been employed in the fishing trade, in the Harbour of Otago, 32 boats, employing about 80 men. In the net fishing in the Harbour, 16 boats are pretty regularly employed, worked by 36 men; most of the boats have only two men as crew. In the outside or deep-water branch of the trade, 17 boats are engaged, with over 40 men as the crews. Most of the seining boats are out at work nearly every tide, while the others are more dependent on the weather, the state of the sea, etc., which causes give rise to long spells of enforced idleness, and also prevent the boats from venturing very far from the Heads, there being no place to run for shelter in case of emergency. As an example of this, the fatal accident of last week is a case in point: the men fishing near Cape Saunders were driven south, and ran their boat in on the rocks at Sandfly to escape drowning. The boat was lost, and one of the men killed attempting to climb the high cliff there.

Complaints have been frequently made during the past few months about the size of the fish brought to market. This is most apparent in the case of flat fish, particularly Flounders and Soles, which are often exposed for sale of a ridiculously small size. It is a wonder that this evil is not apparent to the fishermen themselves, for it is really destroying their means of existence. If the practice is carried on much longer, the Flounder will soon become a very rare fish in our waters. Legislative interference has been talked of, either by insisting on a close time, or by regulating the size of the meshes of the nets used. The first would be a very difficult matter to arrange, as the fishes are not all in season at the same time, so that a close time would simply mean a time when there would be no fish at all. Restricting the size of the meshes in the nets used would hardly do either, the system adopted in Otago Harbour and the various tidal inlets in the neighbourhood, being seine fishing, when a long narrow net with a deep bunt is used. This net is made to catch all fish that are to be found in the Harbour. The meshes in the nets vary from an inch in the wings to about half an inch in the bunt. A much larger mesh would do to catch even small Flounders, but all other fish—Herrings, Trevally, Sandling, Garfish, and the like—would pass through and never be seen; the small mesh in the bunt of the net is the very thing for catching the miscellaneous shoals of fish which come up the Harbour with the young flood tide. I have seen over a dozen sorts of fish in one haul, ranging from Barracoota and Elephant Fish down to Garfish and Herrings—the smaller sorts all meshed in the neighbourhood of the bunt, causing no end of trouble ere the net could be cleared again for another haul. Now, any alteration in the way of increasing the size of the mesh would prevent all those sorts of fish being retained in the net; they would all escape through the wide meshes.

Instead of meddling with the net, I would suggest that it be made illegal to bring fish under a certain size ashore for sale. It would be a very easy matter for the fishermen, when gathering the fish from the net, to leave behind all those under a certain prescribed size, and they would soon find their way into the deep water again. Although a good deal of the seine fishing is done during the night, there is nothing to hinder this being done. A somewhat similar practice is carried out in the Oyster-dredging trade in the Old Country—all under a certain size are thrown overboard again. If the fishermen were to be fined so much for every fish under a certain size found in their boats, the evil would soon cure itself. I would further suggest that an Inspector should be appointed to look after the above and other matters connected with it; one thing in particular being the protection of the Salmon Trout which are now known to frequent the Harbour, and which will soon become extinct if the indiscriminate system of fishing be allowed to continue much longer.

In connection with this subject, there is another matter I should like to mention, though perhaps this is hardly the place for doing so—I mean the want of a Market-place for the sale of fish, where the consumer could meet with the fisherman directly, instead of, as now, through the medium of a middle-man or a shopkeeper. This has been a long-felt want, and has tended more than anything else to keep back the fishing trade; into which many enterprising men have entered only to be discouraged, and eventually disgusted, with the want of encouragement shown to them. Were a proper Market established in some convenient central position, put under proper regulations, and kept clean and tidy, I have not the slightest doubt that in a very short time such a thing as a scarcity of fish, except when caused by a continuance of stormy weather, would very seldom be heard of.

III.—BOTANY.

Art. LXVIII.—*Notes on a* Lomaria *collected in the Malvern District.*
By T. H. Potts, F.L.S.

[*Read before the Philosophical Institute of Canterbury, 6th April, 1876.*]

Lomaria duplicata, n. sp.

Rhizome, very long, slender or moderately stout, creeping, brown.

Fronds, few, barren and fertile, of various habits, single, double, rarely treble; coriacious, pinnate, 9–24 inches long, sub-erect or pendulous; upper surface, bright green shaded, lightest on the margin of pinnule; under surface, uniform light green.

Stipes, stout, with few scales, scaly at base, often forked, rarely twice forked at varying distances from the base, pendulous.

Rachis, smooth, with few scales above and below, sometimes branched.

Barren pinnules, finely toothed, few, alternate, less commonly in pairs, ensiform or lanceolate, ascending, 2–3 inches long, stipitate, the upper adnate to the rachis, acuminate.

Costa, naked, rarely chaffy.

Veins, numerous, simple or forked, ascending.

Fertile pinnules, narrow, on long, stout, erect, separate fronds, single or double, longer by one-third and upwards than those bearing barren pinnules.

This curious form of *Lomaria* was found growing on poor whitish cob, beneath a rather dense undergrowth, in a *Fagus* forest in the Malvern district, about 1,500 feet above sea level. It appears to be a late grower, as but few fertile fronds were met with amongst upwards of one hundred plants seen by the writer, whilst those of *L. procera*, *discolor*, *fluviatilis*, *alpina*, *patersoni*, etc., were observed in great abundance (March 16).

One plant that came under notice had barren fronds single and double, whilst every fertile frond was double, giving the fern a remarkable appearance; the long short stipes carrying the fertile pinnules high above the delicately-shaped, pendulous, barren fronds.

The writer proposes to name this plant provisionally *Lomaria duplicata*, from its peculiar habit of bearing barren and fertile fronds in duplicate.

ART. LIX.—*Notes on* Panax lineare, *Hook., f.* By T. KIRK, F.L.S.

[*Read before the Wellington Philosophical Society, 29th July, 1876.*]

DURING a recent botanical excursion in the Waimakiriri District, Mr. J. D. Enys and myself were greatly interested in collecting, at altitudes below 4,000 feet, a number of plants, hitherto supposed to be restricted to the extreme south-western portion of the Colony, or to the Auckland Islands:—*Donatia novæ zealandiæ, Drosera stenopetala, Gaimardia celiata, G. setacea, Lyperanthus antarcticus, Panax lineare,* etc.

Panax lineare was observed in several localities, and a good series of specimens collected, elucidating the changes it undergoes before it reaches maturity. The interest attached to this species, from its remarkable character and great rarity, has induced me to draw up the following description, which supplies a few omissions in the diagnosis given in the "Handbook to the New Zealand Flora,"

Panax lineare, Hook., f.

A small, sparingly branched, diæcious shrub, 5–8 feet high, ultimate branchlets very short and crowded. Leaves in the young state 6–9 inches long, $\frac{1}{4}''$–$\frac{1}{3}''$ wide, crowded, ascending, simple, coriaceous, linear, acute, apiculate, gradually narrowed into a short broad petiole, midrib stout, prominent above, margins thickened, distantly serrate; gradually passing into the mature leaves, which are crowded at the ends of the branchelets, intermixed with numerous hard, coriaceous, subulate scales with membranous margins, spreading, linear-lanceolate, acute, or obtuse, margins thickened, finely and distantly serrate, midrib flattened above, keeled below; petiole very short and stout, not jointed. Flowers in terminal umbels, sessile or very shortly peduncled; male umbels shorter than the leaves, of from 4–6 spreading bracteolate, 5–6 flowered rays, calyx teeth minute, ovate; female umbels smaller, shortly peduncled, of from 3–7 or more simple, 1–3 flowered rays; fruit ovoid, elongated; styles 5, connate for one-third of their length, the upper portion free and recurved.

The description in the Handbook was drawn from two small specimens collected by Lyall in Chalky Bay in 1848; Hector and Buchanan collected it in Dusky Bay in 1863. It appears to have escaped further notice until observed by Mr. Enys and the writer, in January last, not far from the Waimakiriri Glacier, and in several spots in Bealey Gorge, altitude 2,500 to 3,000 feet. The herbarium of the Colonial Museum contains a small specimen recently collected on Mount Cook by Mr. McKay, of the Geological Survey Department.

In the diminished size and alteration of form which characterize the leaves, as this plant approaches maturity, it resembles *P. crassifolium*, Den. and Planch., but differs from that species in the ascending position of the leaves in their young state, and in their uniformly simple character at all ages. In these respects, it also resembles an undescribed species discovered by Dr. Hector and myself near Nelson, and for which I have proposed the MS. name of *P. ferox*, while it approaches it closely in the linear and entire character of the mature leaves.

An abnormal specimen collected by Mr. Buchanan in Dusky Bay, and now in the Otago Museum, has the mature leaves ovate, much broader than those of the typical form, and with the midrib less prominent. Another specimen exhibits a sessile male umbel with 16 or 17 rays.

In habit and appearance *Panax lineare* closely resembles the simple-leaved form of *Solanum laciniatum* when growing in exposed situations.

ART. LXX.—*Description of a new species of* Rumex. By T. KIRK, F.L.S.

[*Read before the Wellington Philosophical Society, 16th September, 1876.*]

Rumex neglectus, n. s.

ROOTSTOCK stout, giving off creeping branches. Leaves rosulate, 1–2 inches long; petioles nearly as long as the blade; linear-oblong, obtuse, truncate at the base, margins crenate and slightly waved. Panicle stout, depressed, rarely 2 inches in height, sometimes reduced to a single whorl produced from the apex of the rootstock; flowers bisexual, densely crowded in racemed whorls, the lower whorls each with a single petiolar leaf. Outer lobes of the perianth short, obtuse; inner lobes lanceolate, with two short teeth on each side; midrib tuberculate, elongated, tips elongated, enclosing the nut; nut trigonous, smooth.

Hab.: On shingle beaches, Wellington—(T. K.) Dusky Bay, (J. Buchanan).

My first knowledge of this very distinct species was obtained in 1870, when I examined a few imperfect specimens preserved in the herbarium of the Colonial Museum. Mr. Buchanan informed me they were collected on the shingly beach of Dusky Bay, where the plant occurred in such abundance that it was often collected by Dr. Hector's exploring party, and used for food, forming a welcome change to their somewhat monotonous diet. Last year I had the pleasure of collecting specimens on Ocean Beach, near Wellington, and at once recognised it as identical with the plant collected by Dr. Hector and Mr. Buchanan. It will probably be found on shingly beaches from New Plymouth to the Bluff.

From *R. flexuosus*, the common Native Dock, it is at once distinguished by the branched rootstock, rosulate leaves, peculiar habit, stout depressed panicle, and crowded inflorescence, and especially by the tuberculated inner lobes of the perianth.

Art. LXXI.—*Notes on the Economic Properties of certain Native Grasses.*

By T. Kirk, F.L.S.

[*Read before the Wellington Philosophical Society, 11th November, 1876.*]

The following notes embody the result of observations made in different parts of the Colony, and extending over a lengthened period. They are placed on record chiefly in the hope of assisting those settlers who are testing the value of our Native Grasses by actual experiment. The fact that in Auckland and Canterbury, seeds of some few Native Grasses and condimental plants are now in demand at remunerative prices, may be taken as a proof of the success of their efforts, and of the interest taken in the subject. If we consider the valuable aid afforded by a few native species in facilitating the progress of settlement in the Southern Island, we shall find that its importance cannot be easily over estimated.

If a colonial botanic garden had been in existence, on a proper basis, many important questions connected with the subject would have been solved years ago, and the welfare of the community advanced. Many doubtful points of interest can only be made clear by experiments extending over a series of years, and conducted on a uniform plan. Work of this kind is of necessity costly, and it would be unreasonable to expect that the few settlers who are competent to conduct investigations of this kind should do so at their own expense. Experiments of this kind can only be carried out at the cost of the community, and it is to be hoped that New Zealand will not much longer be the only Australasian Colony in which no provision is made by the Government for an experimental botanic garden.*

Microlæna stipoides, Br.

This is a common grass north of the Taupo country, becoming rather local in the southern part of the North Island, although it crosses Cook Strait and is found growing freely about Nelson. It is a nutritious grass, closely cropped by horses, cattle, and sheep, wherever it grows, and is taking its place in permanent pasture about Auckland and Wellington. On the shingle at the mouths of some of the small streams running into Cook Strait it is almost the only grass, and the first to commence a new growth after the winter rest.

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* See "Trans. N.Z. Inst.," Vol. II., p. 102; Vol. IV., p. 292.

About Wellington and Nelson it suffers slightly from the early frosts, but not to so great an extent as might be expected.

It grows with equal luxuriance on the light scoria soils and tertiary clays of the Auckland Isthmus, and, allowing for the difference of climate, in the jurassic clays of Wellington and Nelson. Although it would yield rather less per acre than Rye-grass or Meadow-fescue, it commences to grow earlier in the season, and is of quicker growth after cropping, while it is adapted for a greater variety of soils than either. If we add to these good qualities, its high nutritious value, it must be allowed a high place amongst the best of our Native Grasses, and may be recommended for all permanent mixed pasture at low elevations in the North Island at least.

Microlæna avenacea, Hook., f.

This species produces a considerable quantity of rather coarse herbage, which is eaten by horses and cattle in the absence of better kinds. As it grows under the shade of trees, it is well adapted for sowing in woods to which cattle have access, but it is not suitable for mixed open pasturage.

Hierochloe redolens, Br.

Further observation of this grass has confirmed the opinion already expressed, that although eaten by horses and cattle it is not adapted for general cultivation. In the South Island it ascends to 3,500 feet, and becomes less coarse in habit. In this state it is sometimes cropped by sheep, but in nearly all cases it may be advantageously replaced by other species.

Hierochloe alpina, Ræm. and Sch.

In the South Island this species occurs from 2,000 to 4,000 feet, mostly in sheltered moist spots. Although of slender habit it yields a considerable quantity of herbage, which is eaten by stock of all kinds. It seems of value for mixed sub-alpine pasturage, especially in moist situations.

Paspalum distichum, Burm.

Apparently restricted to maritime situations north of the Taupo country. Not adapted for general cultivation, but of special value for sowing in salt marshes and swamps, where it is always sought after by horses and cattle.

Isachne australis, Br.

This species is plentiful in swampy places and by river-sides, from the North Cape to Upper Waikato, occurring sparingly from that district to Lake Taupo.

It is a slender species, affording a heavy yield of excellent herbage, which is greedily eaten alike by horses, cattle, and sheep. Its value was fully realized during the early settlement of the Waikato, where in many situations it was almost the only species available during the summer months.

For cool moist lands, especially those liable to occasional inundation, it must be considered a grass of the highest value, and should be generally cultivated in these situations. On the margins of rivers it assumes a subfluitant habit, and in some parts of the Waikato may be pulled from the water-margin in immense quantities. It is not adapted for cultivation in the South Island.

Zoysia pungens, Willd.

A creeping-rooted grass, which often forms a dense sward of short herbage, especially in moist places near the sea. The herbage is sweet and nutritious, and is of quick growth after cropping. Although greedily eaten, especially by sheep, its peculiar dwarf habit renders it ineligible for mixed cultivation. It is plentiful in the Taupo country, where it usually exhibits a depauperated appearance, caused by the dry character of the soil.

Dichelachne crinita, Hook., f.

This grass is common on all dry soil of ordinary quality, and is usually abundant on deserted Maori cultivations. It affords a considerable yield of useful herbage for horses and cattle, but is not a grass of the first-class.

Dichelachne sciurea, Hook.

This species appears to be remarkably local. I have not seen it south of the Manukau. It occurs freely on dry soils in several localities about Auckland, where it is closely cropped by horses and cattle, but suffers from drought, almost disappearing with the first continued dry weather.

Sporobolus elongatus, Br.

Rat's Tail or Chilian Grass of the settlers. This grass occurs in abundance from Cape Reinga to Taupo, when it becomes rare and local. It is found in a few places about Wellington, and sparingly near Nelson. Like *Microlæna stipoides*, it is increasing from the extension of agricultural operations. In some districts, as at Hokianga and Port Waikato, it has taken possession of cleared places on the hills, and forms a dense sward, to the exclusion of other grasses.

It adapts itself to soils of the most opposite descriptions, and grows with equal luxuriance on the stiffest clays, the lightest scoria, and the finest sand, while its deep-rooted habit enables it to resist the most severe drought.

It is somewhat harsh, so that horses and cattle accustomed to Rye-grass do not care about it at first, but soon acquire a liking for it, and eat it with avidity.

It does not appear so well adapted for general mixed pasturage, as for special mixtures for working cattle, but this can only be settled by actual experiment. The best testimony to its nutritive value is the capital condition of cattle feeding largely or exclusively upon it. In many places it forms a dense sward under the Tea-tree, where it is kept as closely cropped as if constantly mown. A walk over the cropped surface gives the sensation of walking over the surface of a hard-bristled brush.

This species is somewhat tussocky in habit when not closely cropped, but yields a vast quantity of extremely nutritious herbage, although of a slightly harsh quality.

Agrostis canina, L.

A variable plant; in this Colony restricted to mountain districts, where it ascends to 5,000 feet. The larger forms afford a moderate supply of nutritious herbage, but except in sub-alpine districts it offers no advantages to the cultivator.

Agrostis pilosa, A. Rich.

This species occurs from Lake Taupo southwards, but is most abundant in the South Island; where it ascends from the sea level to 3,500 feet, and attains its greatest luxuriance in open places in forests. It is coarser in habit than the last, and yields a much larger quantity of valuable herbage. It appears to be well adapted for mixed permanent pasturage on ordinary soils.

Agrostis quadriseta, Bn.

A variable grass, attaining great luxuriance on ploughed land of ordinary quality. It is usually eaten by horses and cattle, but is scarcely worth cultivation. Found throughout the colony, and ascends the mountains to 3,500 feet.

Danthonia cunninghamii, Hook., f.

Occurs from the Bay of Islands to Otago, but is rather local; ascends to 2,500 feet.

Danthonia flavescens, Hook., f.

Southern Island, ascending to 3,000 feet.

Danthonia raoulii, Stend.

From the Ruahine Mountains, to Southland, ascending to 3,500 feet.

The above three species are the chief "snow grasses" of the South Island, but the first is less plentiful than the others, and its herbage not quite so harsh. All are large "tussock" grasses, the leaves being often from 3–5 feet in length. After the flowering season, the large grain, which they produce in great abundance, forms the chief food of cattle and horses which can gain access to them. The coarse stringy herbage is not much eaten except when snow is on the ground and the smaller grasses are not accessible. It is, however, a common practice to burn off the tussocks in the spring to encourage a younger growth, which is greedily eaten by sheep, but the tussocks are speedily destroyed by this process.

It will be seen that, although of great value in the early settlement of a sub-alpine district, they are not adapted fer cultivation, and will recede before the advance of agriculture; although a wise policy would encourage their preservation in gullies and broken country on account of the great value of their copious herbage during the severe portion of the winter. They afford excellent material for paper manufacture, for which purpose they are largely used at the Mataura Paper Mills.

Danthonia semi-annularis, Br.

The most generally diffused grass in New Zealand, being found from the North Cape to Stewart Island, and ascending from the sea level to 6,000 feet. As may be expected it varies widely in habit and value.

Var. *a* (*D. unarede*, Raoul) is usually found in rocky places near the sea, and is easily distinguished by the drooping tips of its deep green leaves, and the large size of its florets. It is eaten by horses and cattle, but I have no data on which to found an opinion as to its value for cultivation, although inclined to regard it favourably.

β. pilosa. This form is distinguished by its slender habit and small panicle. The joints of the culm are usually hairy. It is the most common form, and is found in all soils and situations, except those of a moist character, from the sea level to 6,000 feet, where it forms the chief herbage on dry soils, as on the hills above Wellington Harbour; it becomes harsh and brown early in the season, giving for two or three months a parched appearance to the landscape, but when mixed with European grasses on ordinary soils it retains its verdure through the year, and produces a large quantity of rather dry but very nutritious herbage. It is eaten by stock of all kinds, especially when mixed with the ordinary introduced grasses, which are greatly improved by the addition.

Several sub-varieties occur alike in lowland and mountain districts, but the only one requiring special notice is a small form with an unbranched pale-coloured panicle. It is not uncommon about Auckland, where it forms a compact sward of fine herbage on light soils.

All the forms of this variety are of high value for ordinary mixed pasturage. They are also well adapted for sparing use in lawn mixtures.

Var. *alpina.* This remarkable variety is chiefly confined to altidudes of from 2,500 to 5,500 feet, where it forms the "carpet grass" or hassock grass" of the shepherds, the name being given in allusion to its depressed cushion-like habit. In dry weather it becomes very harsh and slippery.

Deschampsia cæspitosa, Pal.

This handsome grass is abundant in moist places in mountain districts, and attains its northern limit at the Waihi Lake, Waikato. It is occasionally eaten by horses and cattle, but is not adapted for cultivation.

Kœleria cristata, Pers.

A slender grass of considerable value, although its yield is less than that of Meadow Fescue or Rye-Grass. It is highly nutritious and well adapted for mixed permanent pastures on ordinary soils. Of similar habit and value to the Dog's-tooth Grass, *Cynosurus cristatus.*

In New Zealand it is restricted to the South Island, where it ranges from the sea-level to 3,500 feet. Cultivated in England.

Trisetum antarcticum, Trin.

A nutritious grass, affording a considerable yield of slender herbage, eaten by horses, cattle, and sheep. It is found throughout the Colony, but is most abundant in the South Island, ranging from the sea-level to 4,500 feet. It is one of the most valuable of our Native Grasses, and should form part of all ordinary mixed pasture, especially in rather moist soils. I am inclined to prefer it to the European *T. flavescens*—the Yellow-oat Grass, which is generally cultivated.

Glyceria stricta, Hook.

This species is confined to maritime localities, ranging from the North Cape to Dunedin, and, although not very nutritious, is occasionally eaten by horses and cattle. It is, however, inferior to other grasses for cultivation in salt marshes and places liable to marine inundations.

Poa imbecilla, Forst.

A slender species, occurring in greater abundance and luxuriance in the South Island than the North, but not adapted for cultivation on account of its brief duration, although it is always eaten where it grows in abundance.

Poa breviglumis, Forst.

Not uncommon on sandy soils, especially in maritime situations, where it is closely cropped by stock of all kinds. A grass of great value, well adapted for general cultivation, especially on light or sandy soils, although it does not yield so heavy a crop as the Common Meadow Grass. This species will be found of great value in the reclamation of coastal sand wastes.

Poa foliosa, Hook., f.

Of this valuable species there are two forms :—

α. with long leafy culms, the leaves longer than the culms, and yielding a large amount of herbage. This variety is confined to the Auckland Islands, etc.

β. is distinguished by the broad leaves, shorter than the culms, and the singular drooping habit of the panicle. It is common in mountain districts, where it ascends to nearly 6,500 feet, and is everywhere greedily eaten by sheep, horses, and cattle.

In all probability both forms would prove suitable for cultivation on cool moist land. They appear to be adapted either for special crops or for general mixtures, *Poa enysi*, M.S.

A remarkable species with the habit of *Zoysia pungens*, and producing a dense even sward of short but nutritious herbage at altitudes of 3,000 to 4,000 feet in the South Island. It is a great favourite with sheep, but, although valuable in the localities where it occurs, is not adapted for general cultivation.

Poa purpurea, M.S.

A grass apparently undescribed, occurring at an elevation of 3,000 to 4,000 feet in the Valley of the Clarence, where it is eaten alike by horses, cattle, and sheep. It appears well adapted for mixed pasturage on cool lands, but requires further observation.

Poa anceps, Forst.

A variable plant which in one or other of its forms ranges throughout the Colony from the sea level to 6,000 feet, the large forms affording a heavy yield of herbage of good quality, eaten by all kinds of stock.

a. elata.—This variety is recognised by its large open panicle, which is sometimes ten or twelve inches in length. It appears to be restricted to the Auckland district, where it is occasionally found growing amongst cultivated grasses, and must be considered a valuable grass for cultivation.

β. foliosa.—This is the most common form, and is especially plentiful on maritime cliffs. It has a considerable range in altitude, but above 3,000 feet usually assumes a depauperated aspect. On the Rimutaka mountains it is abundant, and kept closely cropped by cattle and sheep. It is probably inferior in nutritive value to var. *a*, although it produces a larger amount of herbage.

γ. breviculmis.

δ. densiflora.

ε. alpina.

These are small varieties only found in mountain districts, where they are kept closely cropped by sheep, but so far as present observations extend do not appear to offer any decided advantages to the cultivator. Var. *ε* is apparently confined to mountain shingle, and appears to be a distinct species.

Poa australis, Br.; var. *lævis*.

Silver Tussock Grass.

This species is abundant from central Waikato southwards, forming tussocks of harsh dry herbage, eaten by cattle and horses in the absence of better food, but not in any way valuable for cultivation.

In a paper on New Zealand Grasses, written seven years ago, I wrote of this plant as a grass of great value, having mistaken for it a slender form of the variety *elata* of *Poa anceps*. At that time I had not seen the present plant, which is (erroneously as it appears to me) regarded by Mr. Buchanan as "a grass of the first quality."

An attempt made a few years back to establish sheep stations in the Taupo country resulted in great loss to the projectors, the only grass available being the present species (*P. australis*, var. *lævis*), which contains but a small amount of nutritive matter, so that the sheep began to fall away as soon as they were placed on the runs.

When travelling in the Taupo country I observed that my horses would never eat it, so long as any other kind was available, and that usually they preferred the old dry leaves and culms to those of younger growth.

This plant is often difficult to eradicate. Mr. Potts, of Ohinetahi, pointed out a paddock which had been ploughed several times and sown with European grasses, but the tussocks of the *Poa* were as numerous as ever among the introduced grasses, which surrounded but could not overcome them.

It is the common Tussock Grass of the Canterbury Plains and Port Hills, wrongly referred to *Poa anceps* by Mr. Armstrong,* as that species never assumes the rigid tussocky habit of the present plant.

Poa colensoi, Hook., f.

One of the most valuable grasses in the Colony. With the exception of a single species, *Festuca duriuscula*, it has contributed more largely than any other to the prosperity of the settlements in the South Island.

It is a low-growing species, occurring at an elevation of 1,500 feet in the Taupo country and ascending to fully 5,000 feet in the Southern Alps. It produces a large yield of slender nutritious herbage, which is eaten by stock of all kinds, especially by sheep. On barren soils its growth is comparatively stunted, but on those of ordinary quality it is luxuriant, and flourishes on ploughed land.

It is adapted for permanent mixed pasturage on all ordinary soils, and is of the greatest value for sub-alpine sheep-runs. It would be a valuable addition to the cultivated grasses of Europe.

Festuca duriuscula, L.

The "Hard Sheeps' Fescue" is found from Hawke Bay southward, becoming more abundant in the Southern Island. It ranges from the sea-level (Port Nicholson) to 6,000 feet in the Southern Alps, and flourishes in all soils and situations, except those of a moist character. Although extensively cultivated in Europe, where its value is fully recognized, it is comparatively rare under cultivation in this Colony, especially in the Northern Island, yet from its great abundance and wide distribution, com-

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* See "Trans. N.Z. Inst.," Vol. IV., p. 303.

bined with its high nutritive qualities and hardy habit, it has more than any other grass aided the rapid progress of Canterbury and Otago. This and the preceding species ought to form part of the armorial bearings of the South Island.

When growing alone it exhibits a remarkably tussocky habit, quite foreign to its character in the British Islands, but the tussocks are not nearly so rigid as those of *Poa australis*, var. *lævis*, and they disappear when it is cultivated with other grasses. It is especially adapted for mixed pasturage on rather dry and gravelly soils, and for sheep runs at considerable altitudes, but should form part of all ordinary mixed pastures except on moist land. Of all grasses, native or introduced, this species and *Poa colensoi* are the most valuable for sheep runs, while their herbage is eaten alike by horses, cattle, and sheep.

Triticum scabrum, Br.
Blue Grass.

This is a valuable and nutritious grass, producing a large yield of herbage, which is everywhere eaten by cattle and horses. Although most abundant in the central districts of the Southern Island, it is found from the Great Barrier Island to Southland, and ascends from the sea-level to 6,000 feet.

It is perhaps less nutritious than the preceding species, with which it is often associated, but it affords a much heavier yield per acre, and will grow in moister situations. It is preferred by horses and cattle to most other kinds, and might be cultivated with great advantage either as a special crop for forage purposes, or as forming part of ordinary pasturage.

In the vallies of the South Island it is evidently increasing to a great extent, and in open places often forms large patches of the most luxuriant herbage, to the exclusion of other kinds.

On the Hanmer Plains the slender naked culms of this species sometimes become elongated and prostrate, attaining the extreme length of five or six feet.

Art. LXXII.—*Descriptions of Two New Species of* Veronica.

By T. Kirk, F.L.S.

[*Read before the Wellington Philosophical Society, 14th November, 1876.*]

Veronica obovata, n. s.

An erect glabrous shrub, 4–5 feet high, sparingly branched, branches erect, when old strongly marked with the scars of fallen leaves. Leaves concave, loosely imbricated, erect, ¾–1 inch long, narrow, obovate or oblong, narrowed into the very broad flat petiole, obtuse or slightly mucronate. Racemes two, rarely three, near the ends of the branches, much longer than the leaves, puberulous, loosely flowered, pedicels as long or longer than the calyx, calyx lobes ovate, obtuse, puberulous; corolla small; capsules not seen.

Hab.: Broken River, Canterbury. *Alt.*: 2,000 feet. J. D. Enys and T. Kirk.

Allied to *V. lævis*, Hook., f., from which it is readily distinguished by the larger leaves, the lax racemes, and peculiar habit.

Veronica canescens, n. s.

Plate XIX.

A small procumbent herb, stems 1–2 inches in length, more or less hispid. Leaves opposite, $\frac{1}{12}$–$\frac{1}{10}$ of an inch long, shortly petioled, broadly ovate, obtuse, nearly rounded at the tip, ciliated, and usually clothed on both surfaces with white retrorse hairs. Flowers solitary, axillary, on slender peduncles, $\frac{1}{5}$–$\frac{1}{3}$ inch long, with two hispid bracts near the base, sepals lanceolate, hispid; corolla very large for the size of the plant; capsule not seen.

Hab.: Lake Lyndon, Canterbury. *Alt.*: 2,800 feet. J. D. Enys and T. Kirk. Oamaru District, Otago. J. Buchanan.

This very distinct species is one of the most minute flowering plants in the New Zealand Flora, and is the only indigenous species which produces solitary axillary flowers.

It is probably not uncommon, as, from the grey tint of the hispid foliage, it is easily overlooked, except during the flowering season, when its delicate but showy pale blue corolla at once attracts attention. In habit this plant closely approaches *Anagallis tenella*, L.

DESCRIPTION OF PLATE.

Plate XIX.—1. *Veronica canescens*, natural size. 2. Leaf. 3. Flower. 4. Pistil, enlarged.

Art. LXXIII.—*On the Botany of Kawau Island: Physical features and causes influencing distribution of Species.* By John Buchanan, F.L.S.

[*Read before the Wellington Philosophical Society, 2nd September, 1876.*]

In attempting a descriptive sketch of the botany of Kawau Island it will be necessary, for the better appreciation of the subject, to notice shortly some of the influences which have contributed towards its existing facies. And first among these, and most important, is its geographical position.

Kawau, the property of Sir George Grey, K.C.B., stands as an outlying island on the east coast of the North Island, 27 miles north of Auckland, being one of many islands in that neighbourhood which no doubt at one time formed part of the main land, its proximity to the latter being distant only four miles, and possessing no higher altitudes, will naturally indicate a closely allied or nearly identical Flora.

The island is irregular in form, three and a half miles north and south, by three and a quarter miles east and west, and containing 5,200 acres of land.

According to Dr. Hector's Geological Report, the rocks from which the soil is derived are "palæozoic slates and tertiary sandstones." On the higher ridges and spurs are found stiff clay and sandy soils, similar to much of that on the main land; on the lower slopes again the soil is much superior; and on the lower levels and small vallies it is very rich, as shown by the luxuriant vegetation growing there.

The indirect influence of arid soils has through the progress of time produced much of the varied features of the existing vegetation, as from drought on stiff clay or sandy soils, making repeated burnings easy, and preventing the growth of trees, hence the present amount of scrub land and fern. Again, at critical times the native grasses are burnt out.

The whole surface drainage of the island is westerly, the easterly side presenting a precipitous face, a part of the island in that direction having apparently been removed by the action of the sea.

This peculiar system of drainage is more strikingly seen in the Island of Kapiti, in Cook Strait, where the highest alitudes are situated along the edge of the seaward cliff, which at one time appears to have formed the longitudinal centre of the island.

Kawau, viewed from the sea as it is approached from the south or west, presents a most picturesque combination of headlands, bays, and smooth grassy downs, with large masses of bush, reminding one of the cultivated park scenery of Britain. Much of the surface condition of New Zealand before settlement possessed this park-like appearance, being especially fine in Southland; but in the clearer atmosphere of the North the colour-effects are more varied and pleasing.

Kawau is well watered by numerous streams, which fall into the harbours and bays which indent its westerly shores. The surface configuration being rounded, and the higher elevations under 600 feet, the rugged and grand does not exist, but in its place a quiet beauty reigns, much of it in places being the outcome of artistic cultivation. On shore, as the island is traversed, the ever-changing scenery is beautiful, and the Fauna might puzzle the visitor as to his whereabout on the face of the earth. The Deer of Britain may be seen hurrying past to the covert; the Kangaroo of Australia, spanning across the path, pulls up erect to view the stranger; Tree Kangaroos from New Guinea are seen hopping up and down Puriri trees; the visitor is ever kept on the alert by the whirr of Californian Quail, or Chinese Pheasants, and the Wallabi Kangaroo, in numbers, keep zig-zagging across his path; the Cape Barren Goose might also exhibit to him the unusual sight of a bird carrying her young under her wings The introduction of so many animals and plants must produce some influence on the indigenous Flora of the island either for good or evil in future years.

Flora of the Island.

The lists appended have no claim to be considered as exhaustive of the Flora of Kawau, and future collectors on the island may therefore search with hope of being rewarded for their labours by further discoveries both in native and introduced plants.

Many interesting plants collected by Mr. Kirk on the Great and Little Barrier Islands, and Arid Island to the eastward, do not seem to be found in Kawau. The absence of sufficient altitude may account for this with such species as *Ixerba brexioides, Dacrydium colensoi, Phylloclades glauca, Archeria racemosa,* and others, and the rare plant *Pisonia umbellifera* is not likely to be found so close to the main land.

Indigenous Species.

A remarkable feature in the indigenous Flora of Kawau Island is the great number of orders and genera represented by so few species. The following are the proportions:—75 orders, 189 genera, 348 species and varieties, which give nearly $4\frac{3}{4}$ species to each order, and about $1\frac{5}{6}$ species to each genus. When it is considered that the entire number of phænogamic orders given in Hooker's "Handbook for New Zealand" is only 87, it must be admitted that the indigenous Flora is well represented in families, if not in species.

Introduced species.

In this list only three cultivated garden plants are included, the others being chiefly accidentally, or otherwise, introduced weeds. They are, although numerous in species, with few exceptions, not abundant in numbers, and are represented by 31 orders, 96 genera, and 125 species, thus showing the same disproportion of species to genera and orders as the indigenous Flora.

In *Cryptogams,* of which ferns and allies only are given, there are 2 orders, 25 genera, and 90 species, including varieties.

Botanical divisions of the Flora.

The botanical divisions may be popularly arranged under three groups: Grass, Scrub, and Bush.

Grass.

The lists of indigenous and exotic grasses and other pasture plants were noted at an early period of the season, and consequently some might have been overlooked. The number of species, however, in the list is great, although a few are worthless as food, and several others, although valuable, are neither abundant nor wide spread. There are 65 species, including varieties, in all, among which the following are abundant everywhere, and which may be said to constitute the main part of the pasture.

Dichelachne crinita, *Dichelachne sciurea*, *Danthonia semi-annularis*, *Anthoxanthum odoratum*, *Holcus lanatus*, *Festuca myurus*, *Lolium perenne*, *Trititcum scabrum*, *Agrostis vulgaris*, *Poa annua*, *Poa pratense*, *Poa anceps*, *Trisetum antarcticum*, *Aira caryophylla*, *Dactylis glomeratus*.

The early supply of food for sheep in spring depends largely on these fifteen species, and putting the comparative nutrient value of some of them aside, they may be considered the most valuable on the whole, as being available when most needed.

The following species on the list are worthless as food, and fortunately they are neither abundant or found on the pasture, being chiefly confined to the sea-shore:—

Spinifex hirsutus, *Arundo conspicua*, *Festuca littoralis*, *Bromus arenarius*, *Bromus sterilis*, *Hordeum murinum*, and *Avena pratensis*.

Among the remaining species on the list, several are valuable as pasture grasses, but seem to be either rare or confined to certain localities, as *Sporobolus elongatus*, and *Stenotaphrum glabrum*, both valuable because permanent, although inferior as sheep grasses.

The clovers are abundant and widespread, being adapted from their deep rooting to resist droughts.

The grasses on the more exposed ridges where stiff clay or sandy soil is present, are sparse, and suffer from the heats of summer. They are also liable to displacement by the growth of arid weeds, but the lower slopes and damp vallies carry a rich growth of superior grasses.

Stomachic plants are also present, so useful in preserving the health of stock. The following are common:—Parsley, Veronicas, Yarrow, Canadian Flea-bane, Centaury, etc.

There can be no doubt that the extensive pastures of Australia and New Zealand have been deteriorating during the past 20 years, and chiefly from the disappearance of the finer fibrous-rooted grasses, whose roots ramify near the surface of the ground. The cause of this is evident, by the exposure of their roots to the excessive heat of the sun or frosts, from over-feeding with stock, and burning the grass at improper seasons. Any alleviation of this can only be obtained by the introduction of deep-rooting grasses; but the only permanent remedy will be got by the formation of resting-paddocks, or fenced divisions of the land, by which portions of the pasture may rest even for even a short time. Further notice of this does not, however, come within the limit of this paper.

Scrub.

The scrub vegetation of Kawau is the after-growth of fire, and at first is composed of species of arid growth, such as *Leptospermum* (Manuka), *Leucopogon* (Mingimingi), *Pomaderris* (Kumarahou), *Carmichaelia* (Whakaka), *Coprosma* (Karamu), etc. Under the shadow and shelter of their close growth numerous young plants of the larger trees soon appear, with a host of smaller species, and thus, after a long period of time, if no other fire occurs, is the gradual renovation of the bush accomplished.

When the dense scrub land of Otago was first burned 20 years ago, a rich growth of Native grasses sprung up afterwards, producing a pasture of the first class. It is probable, however, that, in Kawau and similar arid soils in Auckland, an early sowing of grass seed during cool moist weather would be necessary to ensure success after burning.

Bush.

Under this head are included extensive patches of valuable timber trees in general, mixed with numerous species of smaller growth, which although ornamental have little commercial value except as firewood. The growth is dense and luxuriant; in places where the Nikau Palm and Tree Ferns are abundant, as in some of the deeper vallies, forming a close canopy of foliage overhead, a gloomy silence prevails, unbroken by the sound of animal life, the numerous opossums and birds finding a more congenial sphere above in the sunshine of the higher trees.

The indigenous trees which contribute most to scenic effects are Pohutakawa (*Metrosideros tomentosa*), a valuable timber tree, in many places lining the shores of the island, and exhibiting a gorgeous beauty when in flower; Taraire (*Nesodaphne taraire*), having a rounded form of fine foliage; Puriri (*Vitex littoralis*), another valuable timber tree, with much of the sturdy gnarled aspect of the oak; Tawaapou (*Sapota costata*), with bright green foliage and rounded form; several species of pines (*Podocarpus* and *Dacrydium*), all valuable timber trees, and contrasting their peculiar small-leaved foliage with the large-leaved trees of the bush; Rewarewa (*Knightia excelsa*), a tall tapering tree, is a prominent object on the hill slopes. The wood of this tree makes beautiful furniture work. The following species are rare:—Tawhairaunui (*Fagus fusca*)—very few specimens of this tree are now found on the island. Kauri *(Dammara australis)*—this valuable pine, with the last, is confined to the higher palæozoic rocks. Pukatea *(Atherosperma novæ zealandiæ)*, always known by its large buttressed trunk, and Tangeo *(Tetranthera calicaris)*, of which only one specimen was seen.

As the visitor on leaving the island recedes from Moana Bay by steamer, the extreme beauty of the landscape, as its features change by distance, is very pleasing. There is seen to great advantage that scientific combination of nature and art, which is ever the aim of the landscape gardener. The object often necessary as a principle of this science being architecture, we have here in the middle distance Sir George Grey's residence at the head of the bay, surrounded by rare and beautiful trees and shrubs, many of them sub-tropical. On the lawn may be seen *Erythrina caffra*, the coral tree, covered with brilliant scarlet flowers; *Fourcroyia gigantea*, a plant of the Amaryllis family, with remarkable flowers. This tree produces a fine fibre, and grows well without any cultivation on the worst clay hills. *Fourcroyia flavavirides*, another fine fibre plant; *Chamaerops excelsa*, a palm tree also producing a fine fibre, and *Chaemaerops fortunii*, *Bœhmeria nivea*, another fine fibre tree belonging to the nettle family; *Musa textilis*, the Banana fibre tree from which the manilla fibre of commerce is procured; as also *Musa sapientum*, the fruit Banana, which yearly ripens fruit here; *Brousonetia papyrifera*, from which a kind of paper is made in Japan; *Punica granatum*, the pomegranate; *Olea europæa*, the Olive; a tree likely to become important in the North Island, from the oil product of its fruit as a commercial export; all the finest varieties of this valuable species are cultivated here. *Arduina grandiflora*, the Natal Plum, worthy of cultivation for its fruit; *Ficus carica*, the Fig tree, and several other species of this family; *Anona muricata*, the Custard Apple; *Ceratonia siliqua*, St. John's Bread tree; *Eriobotrya japonica*, the Loquat tree, which bears abundantly; *Zingiber officinalis*, Ginger, several species of this family; *Stilingia sebifera*, the Tallow tree, from which the Japanese manufacture candles. This plant, one of the Euphorbia family, succeeds well here. *Quercus suber*, the Cork tree, is represented by several large specimens; this tree is worthy of attention by the Forests Department. Several curious species of Japanese Oaks; groves of *Aralia papyrifera*, the Paper tree; *Xanthorea hastilis*, the curious Grass-tree of Australia; numerous species of Bamboos, including the gigantic Bamboo. These bamboos form good shelter hedges. When to this list are added Cinnamon, Camphor, Orange, Lemon, and Citron trees, sufficient proof is given of the existence of a remarkably mild climate.

It is Sir George Grey's opinion, that many of these valuable commercial plants are well adapted for the climate of Wanganui, and he is now making arrangements to send several young plants there as a trial.

The shore lines of massive Native trees flank this central portion of the landscape on either side; among them prominent, the Pohutakawa, in a full blaze of crimson blossom, harmonizing well with the dark green foliage of the Puriri and Tawaapou trees. On the rising background, numerous large grown trees, Australian and American Pines, including species of *Auracaria, Pinus, Cupressus,* etc., add to the beauty of the scene by their artistic groupings, in some places their sharp-pointed outlines, as seen against the sky, contrasting finely with the rounded forms of the Native species, and their sombre green relieved by the pale silvery-white foliage of the *Leucodendron argenteum* trees from the Cape of Good Hope. The visitor, as the island fades away from his view, can only wish that a settled population may never be found within its shores, and that its peace and beauty may always remain undisturbed.

Indigenous Flowering Plants of Kawau.

DICOTYLEDONS.

RANUNCULACEÆ.

Clematis indivisa, Willd. (Puwhananga), C.
fœtida, Raoul.
parviflora, A. Cunn.
Ranunculus hirtus, Banks and Sol.
rivularis, Banks and Sol.
acaulis, Banks and Sol.
parviflorus, Linn., var. *australis*. (Korikori.)

CRUCIFERÆ.

Nasturtium palustre, D.C. (Kowhitiwhiti.)
Cardamine hirsuta, Linn., var. *β. corymbosa*. (Panapana.)
Lepidium oleraceum, Forst. (Eketere, D'U.).

VIOLARIEÆ.

Viola filicaulis, Hook., fil.
Melicytus ramiflorus, Forst. (Mahoë.)
lanceolatus, Hook., fil.
Hymenanthera latifolia, Endl.

PITTOSPOREÆ.

Pittosporum tenufolium, Banks and Sol.
var. *fasciculatum*, (Kirk.)
crassifolium, Banks and Sol. (Karo, Kihii.)
eugenioides, A. Cunn. (Tarata), C.
cornifolium, A. Cunn. (Karo), C.
intermedium, Kirk.

CARYOPHYLLEÆ.

Stellaria parviflora, Banks and Sol. (Kohu Kohu.)
Colobanthus billiardieri, Fenzl.
Spergularia rubra, Pers., var. *marina*.

PORTULACEÆ.

Montia fontana, Linn.

HYPERICINEÆ.

Hypericum japonicum, Thunb.

MALVACEÆ.

Plagianthus divaricatus, Forst., Kirk.
Hoheria populnea, A. Cunn., var. *vulgaris*. (Houhere.)
var. *β. lanceolata*. (Houhere.)

TILIACEÆ.

Entelea arborescens, Br. (Whau.)
Aristotelia racemosa, Hook., fil. (Makomako), Cunn. ; (Mako.)
Elæocarpus dentatus, Vahl. (Hinau).

LINEÆ.

Linum monogynum, Forst. (Rauhuia), C.
marginale, A. Cunn.

GERANIACEÆ.

Geranium dissectum, Linn., var. *carolinianum*. (Pinaketere.)
var. *α. pilosum*, Kirk.
var. *β. patulum*, Kirk.
microphyllum, Hook., fil.
molle, Linn.
Pelargonium australe, Willd., var. *clandestinum*. (Kopata.)
Oxalis corniculata, Linn., var. *β. stricta*.
var. *ε. crassifolia*, Kirk.

RUTACEÆ.

Phebalium nudum, Hook., (Kirk.)
Melicope ternata, Forst. (Tataka), M. ; (Wharangi), C.
simplex, A. Cunn.

MELIACEÆ.

Dysoxylum spectabile, Hook., fil. (Kohe), C.

RHAMNEÆ.

Pomaderris elliptica, Labill. (Kumerahou), C.
phylicifolia, Lodd.

SAPINDACEÆ.

Dodonæa viscosa, Forst. (Ake), C.

ANACARDIACEÆ.

Corynocarpus lævigata, Forst. (Karaka.)

CORIAREÆ.

Coriaria ruscifolia, Linn. (Tupakihi, Tutu.)

LEGUMINOSÆ.

Carmichellia australis, Br. (Whakaka.)
Sophora tetraptera, Aiton., var. *grandiflora.* (Kowhai.)

ROSACEÆ.

Rubus australis, Forst. (Tataramoa), C.
var. *a. glaber.*
var. *β. schmideloides.*
var. *γ. cissoides.*
Potentilla anserina, Linn.
Acæna sanguisorbæ, Vahl. (Hutiwai.)

SAXIFRAGÆ.

Quintinia serrata, A. Cunn., (Kirk.)
Carpodetus serratus, Forst. (Piripiriwhata.)
Weinmannia sylvicola, Banks and Sol. (Towai.)

CRASSULACEÆ.

Tillæa verticillaris, D.C.

DROSERACEÆ.

Drosera binata, Labill.
auriculata, Backhouse.

HALORAGEÆ.

Haloragis alata, Jacq. (Toatoa).
tetragyna, Labill. (Piripiri.)
micrantha, Br.
Callitriche verna, Linn.

MYRTACEÆ.

Leptospermum scoparium, Forst. (Kahikatoa), M.
ericoides, A. Rich. (Manuka) Col.
Metrosideros florida, Sm. (Ratapika), R. Cunn.
albiflora, Banks and Sol.
hypericifolia, A. Cunn.
robusta, A. Cunn. (Rata.)
tomentosa, A. Cunn. (Pohutakawa.)
scandens, Banks and Sol. (Akakura.)
Myrtus bullata, Banks and Sol., (Kirk.)
Eugenia maire, A. Cunn. (Whawhaka.)

ONAGRARIEÆ.

Fuchsia excorticata, Linn., fil. (Kohutuhutu), C.
Epilobium nummularifolium, A Cunn. (Hinatoli.)
alsinoides, A. Cunn.

Epilobium rotundifolium, Forst.
tetragonum, Linn.
junceum, Forst., (Kirk.)
pubens, A. Rich.
billardierianum, Seringe.
pallidiflorum, Sol.

PASSIFLOREÆ.

Passiflora tetrandra, Banks and Sol.

CUCURBITACEÆ.

Sicyos angulatus, Linn.

FICOIDEÆ.

Mesembryanthemum australe, Sol.
Tetragonia expansa, Murray. (Kohihi.)

UMBELLIFERÆ.

Hydrocotyle elongata, A. Cunn.
americana, Linn.
asiatica, Linn.
pterocarpa, F. Muell., (Kirk.)
moschata, Forst.
Crantzia lineata, Nutt.
Apium australe, Thouars.
leptophyllum, F. Muell., considered indigenous by Kirk.
filiforme, Hook.
Angelica rosæfolia, Hook.
Eryngium vesiculosum, Labill.
Daucus brachiatus, Sieber.

ARALIACEÆ.

Panax simplex, Forst.
crassifolium, Dene and Planche. (Hohoeka.)
lessonii, D.C. (Whauwhau), R. Cunn.
arboreum, Forst. (Whauwhaupaku), C.
Schefflera digitata, Forst. (Pate, Patete.)

CORNEÆ.

Griselinia lucida, Forst. (Pukatea), C.
Corokia buddleoides, A. Cunn., (Kirk.)

LORANTHACEÆ.

Loranthus micranthus, Hook., fil., (Kirk.)
Tupeia antarctica, Cham. and Schl. (Pirita.)

CAPRIFOLIACEÆ.

Alseuosmia macrophylla, A. Cunn.
linariifolia, A. Cunn.
quercifolia, A. Cunn., (Kirk.)

RUBIACEÆ.

Coprosma lucida, Forst. (Karamu), C.
grandifolia, Hook., fil. (Papaaumu), C.
baueriana, Endl.
robusta, Raoul. (Karamu.)
cunninghamii, Hook., fil.
arborea, Kirk, M.S., (Kirk.)
spathulata, A. Cunn. (Mamangi.)
rotundifolia, A. Cunn.
tenuicaulis, Hook., fil.
divaricata, A. Cunn., (Kirk.)
propinqua, A Cunn.
acerosa, A. Cunn. (Tatarahake), C.
Nertera dichondræfolia, Hook., fil.
Galium tenuicaule, A. Cunn.
umbrosum, Forst, (Kirk.)

COMPOSITÆ.

Olearia furfuracea, Hook., fil. (Akepiro), C.
cunninghamii, Hook., fil. (Akewharangi.)
albida, Hook., fil.
Celmisia longifolia, Cass.
Vittadenia australis, A. Rich.
Lagenophora forsteri, D.C.
petiolata, Hook., fil.
Bidens pilosa, Linn., (Kirk.)
Cotula coronopifolia, Linn.
australis, Hook., fil.
minor, Hook., fil.
dioica, Hook., fil., (Kirk.)
minuta, Forst.
Cassinia leptophylla, Br.
Craspedia fimbriata, D.C.
Ozothamnus glomeratus, Hook., fil.
Gnaphalium keriense, A. Cunn.
filicaule, Hook., fil.
luteo-album, Linn.
involucratum, Forst.
collinum, Labill.
Erechtites prenanthoides, D.C.
arguta, D.C.
scaberula, Hook., fil., (Kirk.)

Erechtites quadridentata, D.C. (Pekapeka.)
Senecio lautus, Forst.
Brachyglottis repanda, Forst. (Pukapuka), C.; (Rangiora), C.M.
Sonchus oleraceus, Linn. (Pororua, Puwha.)

CAMPANULACEÆ.

Wahlenbergia gracilis, A. Rich.
Lobelia anceps, Thunb.
Pratia angulata, Hook., fil.
Sellieria radicans, Cavan.

ERICEÆ.

Gaultheria antipoda, Forst., var. *a.* (Kirk.)
var. *ε.* (Korupuku), C.
Cyathodes acerosa, Br. (Mingi), C.
Leucopogon fasciculatus, A. Rich. (Mingimingi.)
frazeri, A. Cunn. (Patotara).

MYRSINEÆ.

Myrsine salicina, Heward.
urvillei, A. D.C. (Mapau), C.; (Tipau, Matipau.)

PRIMULACEÆ.

Samolus littoralis, Br.

SAPOTEÆ.

Sapota costata, A. D.C. (Tawaapou), C.; (Orewa).

JASMINEÆ.

Olea cunninghamii, Hook., fil. (Maireraunui), C.
lanceolata, Hook., fil., (Kirk.)

APOCYNEÆ.

Parsonsia albiflora, Raoul. (Kaiku.)
rosea, Raoul, (Kirk.)

LOGANIACEÆ.

Geniostoma ligustrifolia, A. Cunn. (Hangehange), C.

BORAGINEÆ.

Myosotis forsteri, Roem. and Sch.

CONVOLVULACEÆ.

Convolvulus sepium, Linn. (Pohue, Panahi.)
tuguriorum, Forst., (Kirk.)
soldanella, Linn. (Nahinahi.)
Dichondra repens, Forst.

SOLANEÆ.

Solanum aviculare, Forst. (Kohokohu, Poroporo).
nigrum, Linn.

SCROPHULARINEÆ.

Veronica salicifolia, Forst. (Koromiko.)
macrocorpa, Vahl. (Koromiko.)
parviflora, Vahl.

GESNERIACEÆ.

Rhabdothamnus solandri, A. Cunn. (Matata. Wainatua.)

VERBENACEÆ.

Vitex littoralis, A. Cunn. (Puriri), C.
Avicennia officinalis, Linn. (Manaawa), C.
Myoporum lætum, Forst. (Ngaio), C.

LABIATÆ.

Mentha cunninghamii, Benth.

PLANTAGINEÆ.

Plantago raoulii, Decaisne. (Kopakopa.)

CHENOPODIACEÆ.

Chenopodium triandrum, Forst.
urbicum, Linn.
glaucum, Linn., var. *ambiguum*, (Kirk.)
Atriplex billiardieri, Hook., fil.
Salicornia indica, Willd.

PARONYCHIEÆ.

Scleranthus biflorus, Hook., fil. (Kohukohu,)

POLYGONEÆ.

Polygonum minus, Huds., var. *decipiens*.
aviculare, Linn. (Tutunawai), C.
Muhlenbeckia adpressa, Lab.
complexa, Meisn.
Rumex flexuosus, Forst.

LAURINEÆ.

Tetranthera calicaris, Hook., fil. (Tangeo.)
Nesodaphne tarairi, Hook., fil. (Taraire.)
tawa, Hook., fil. (Tawa.)

MONIMIACEÆ.

Atherosperma novæ zealandiæ, Hook., fil. (Pukatea.)
Hedycarya dentata, Forst. (Kaiwhiria, Porokaiwhiria.)

PROTEACEÆ.

Knightia excelsa, Br. (Rewarewa.)

THYMELEÆ.

Pimelia longifolia, Banks and Sol.
virgata, Vahl.
prostrata, Vahl., var. *a*.
var. *β*., (Kirk.)

SANTALACEÆ.

Santalum cunninghamii, Hook, fil. (Maire.)

EUPHORBIACEÆ.

Euphorbia glauca, Forst. (Waiuatua), C.

CUPULIFERÆ.

Fagus fusca, Hook., fil. (Tawhai.)

URTICEÆ.

Epicarpurus microphyllus, Raoul. (Towhai), R.
Urtica incisa, Poiret. (Ongonga.)
Parieteria debilis, Forst.

PIPERACEÆ.

Peperomia urvilleana, A. Rich.
Piper excelsum, Forst. (Kawakawa.)

CONIFERÆ.

Dammara australis, Lambert. (Kauri.)
Libocedrus doniana, Endl.
Podocarpus ferruginea, Don. (Miro), Cunn.
totara, A. Cunn. (Totara), Cunn.
spicata, Br. (Maii), C.
dacrydioides, A. Rich. (Kahikatea), Cunn.
Dacrydium cupressinum, Sol. (Rimu), C.

MONOCOTYLEDONS.

ORCHIDEÆ.

Earina mucronata, Lindl.
autumnalis, Hook., fil.
Dendrobium cunninghamii, Lindl.
Bolbophyllum pygmæum, Lindl. (Piripiri.)
Sarcochilus adversus, Hook., fil.
Gastrodia cunninghamii, Hook., fil. (Perei), C.
Acianthus sinclairii, Hook., fil., (Kirk.)
Corysanthes oblonga, Hook., fil.
Microtis porrifolia, Spreng.
Caladenia minor, Hook., fil.
Pterostylis banksii, Br.
trullifolia, Hook., fil., (Kirk.)
Thelymitra longifolia, Forst.
pulchella, Hook., fil. (Maikaikai.)
Prasophyllum colensoi, Hook., fil.

IRIDEÆ.

Libertia ixioides, Spreng. (Turutu.)
micrantha, A. Cunn.

PANDANEÆ.

Freycinetia banksii, A. Cunn. (Kiekie.)

TYPHACEÆ.

Typha latifolia, Linn. (Raupo.)

NAIADEÆ.

Lemna minor, Linn.
Triglochin triandrum, Michaux.
Zostera marina, Linn.

LILIACEÆ.

Rhipogonum scandens, Forst. (Kareao.)
Cordyline australis, Hook., fil. (Ti.)
banksii, Hook., fil. (Tiparæ.)
pumilio, Hook., fil.
Dianella intermedia, Endl. (Turutu.)
Astelia cunninghamii, Hook., fil. (Kowharawhara), C.
solandri, A. Cunn. (Kahakaha), C.
trinervia, (Kirk.)
banksii, A. Cunn. (Kowharawhara), C.
Arthropodium cirrhatum, Br. (Rengarenga.)
candidum, Raoul.
Phormium tenax, Forst. (Harakeke.)
colensoi, Hook., fil. (Wharariki.)

PALMEÆ.

Areca sapida, Sol. (Nikau.)

JUNCEÆ.

Juncus vaginatus, Br. (Whiwhi).
australis, Hook., fil.
communis, E. Meyer.
planifolius, Br.
holoschœnus, Thunb.
bufonius, Linn.
novæ zealandiæ, Hook., fil.
Luzula campestris, D.C., var. γ. *pallida*.

RESTIACEÆ.

Leptocarpus simplex, A. Rich. (Toetoe.)

CYPERACEÆ.

Cyperus ustulatus, A. Rich. (Toetoe.)
Schœnus axillaris, Hook., fil.
tenax, Hook., fil.
tendo, Banks and Sol., (Kirk.)
Scirpus maritimus, Linn. (Kiriwaka.)

lacustris, Linn.
triqueter, Linn.
Eleocharis gracilis, Br.
var. *β. gracillima.*
var. *γ. radicans.*
acuta, var. *platylepis.*
Isolepis nodosa, Br. (Wiwi.)
prolifer, Br.
riparia, Br.
aucklandica, Hook., fil.
Desmoschœnus spiralis, Hook., fil. (Pingao.)
Cladium glomeratum, Br.
junceum, Br.
gunnii, Hook., fil., (Kirk.)
sinclairii, Hook., fil., (Kirk.)
Gahnia setifolia, Hook., fil.
procera, Forst.
lacera, Steud.
ebenocarpa, Hook., fil.
arenaria, Hook., fil.
pauciflora, Kirk.
Lepidosperma tetragona, Labill.
concava, Br., (Kirk.)
Uncinia australis, Pers.
cæspitosa, Boott.
banksii, Boott.
rubra, Boott.
Carex inversa, Br.
virgata, Sol.
var., *β. secta.*
ternaria, Forst. (Rautahi.)
raoulii, Boott.
lucida, Boott.
pumila, Thunb.
forsteri, Wahl.
breviculmis, Br., (Kirk.)
lambertiana, Boott, (Kirk.)
vacillans, Sol.

GRAMINEÆ.

Microlæna stipoides, Br.
avenacea, Hook., fil.
polynoda, Hook., fil., (Kirk.)

Alopecurus geniculatus, Linn.
Hierochloe redolens, Br. (Karetu.)
Spinifex hirsutus, Labill.
Paspalum scrobitulatum, Linn.
distichum, Burrman, (Kirk.)
Panicum imbecille, Trinius.
Isachne australis, Br., (Kirk.)
Echinopogon ovatus, Palisot.
Dichelachne stipoides, Hook, fil.
crinita, Hook., fil.
sciurea, Hook., fil.
Sporobolus elongatus, Br.
Agrostis æmula, Br.
billardieri, Br.
quadriseta, Br., (Kirk.)
Arundo conspicua, Forst. (Kakaho, Toetoe.)
Danthonia semi-annularis, Br.
var. β.
var. γ.
Deschampsia caespitosa, Palisot.
Trisetum antarcticum, Trinius.
Glyceria stricta, Hook., fil.
Poa anceps, Forst., var. β. *foliosa.*
Festuca littoralis, Br.
duriuscula, Linn.
Bromus arenarius, Labill.
Triticum multiflorum, Banks and Sol., (Kirk.)
scabrum, Br.

CRYPTOGAMIA.

FILICES.

Gleichenia circinata, Swartz. (Waewaematuku), C.
Cyathea dealbata, Swartz. (Ponga.)
medullaris, Swartz. (Mamaku).
Hemitelia smithii, Hook.
Dicksonia squarrosa, Swartz. (Weki.)
Hymenophyllum tunbridgense, Sm.
var. *minimum.*
multifidum, Swartz.
rarum, Br.
dilatatum, Swartz.
javanicum, Spreng.

Hymenophyllum polyanthos, Swartz.
demissum, Swartz.
scabrum, A. Rich.
flabellatum, Labill.
Trichomanes reniforme, Forst.
elongatum, A. Cunn.
humile, Forst.
venosum, Br.
Davallia novæ zealandiæ, Col.
Lindsaya linearis, Swartz.
trichomanoides Dryan.
Adiantum hispidulum, Swartz.
diaphanum, Willd., (Kirk.)
affine, Willd.
fulvum, Raoul.
Hypolepis tenuifolia Bernh.
distans, Hook.
Pellæa rotundifolia, Forst.
Pteris aquilina, Linn., var. *esculenta*. (Aruhe. Rahurahu.)
tremula, Br. (Turawera), C.
scaberula, A. Rich.
Pteris incisa, Thunb.
macilenta, A. Rich.
comans, Forst.
Lomaria filiformis, A. Cunn.
procera, Spreng.
var. α.
var. β.
var. γ.
var. δ.
fluviatilis, Spreng.
elongata, Blume.
lanceolata, Spreng.
discolor, Willd.
alpina, Spreng.
banksii, Hook., fil.
fraseri, A. Cunn.
Doodia media, Br.
caudata, Br.
Asplenium obtusatum, Forst. (Paretao), C.
var. *lucidum*.
var. *lyallii*.

Asplenium flabellifolium, Cavan.
falcatum, Lam.
hookerianium, Forst.
bulbiferum, Forst.
var. *laxa*.
var. *tripinnata*.
flaccidum, Forst. (Pohutakawa), C.
var. *α*.
var. *δ*.
umbrosum, J. Smith.
Aspidium aculeatum, Swartz.
richardi, Hook.
capense, Willd.
Nephrodium velutinum, Hook., fil.
decompositum, Br.
hispidum, Hook.
Polypodium australe, Mett.
grammitides, Br.
tenellum, Forst. (Kirk).
punctatum, var. *β*
pennigerum, Forst., (Piupiu), C.
serpens, Niph.
cunninghamii, Hook.
pustulatum, Forst.
billardieri, Br.
Todea hymenophylloides, Rich and Less.
Lygodium articulatum, A. Rich.
Schizea dichotoma, Swartz.
Ophioglossum lusitanicum, Linn.

LYCOPODIACEÆ.

Lycopodium varium, Br,
billiardieri, Spreng.
densum, Labill. (Waewaekoukou), C.
laterale, Br.
cernuum, Linn. (Kirk).
voluble, Forst. (Waewaekoukou.)
Tmesipteris forsteri, Endl.

Introduced Flowering Plants of Kawau.

DICOTYLEDONS.

RANUNCULACEÆ.

Ranunculus repens, Linn. (Creeping Crowfoot.)
pusillum, Linn.

FUMARIACEÆ.

Fumaria officinalis, Linn. (Fumitory.)

CRUCIFERÆ.

Barbarea præcox, Br. (Winter Cress.)
Nasturtium officinale, Br. (Common Watercress.)
Sisymbrium officinale, Linn. (Hedge Mustard.)
Capsella bursa-pastoris, D.C. (Shepherd's Purse.)
Brassica sinapistrum, Boiss. (Charlock.)
Lepidium ruderale, Linn. (Narrow-leaved Pepper-wort.)
Senebiera coronopus, D.C. (Swines' Cress.)
didyma, D.C. (Swines' Cress.)
Brassica oleracea, Linn. (Sea Kale or Cabbage.)
Raphanus raphanistrum, Linn. (Field Raddish or White Charlock.)

CARYOPHYLLACEÆ.

Silene quinquevulnera, Linn. (Variegated Catchfly.)
Sagina procumbens, Linn. (Procumbent Pearl-wort.)
Stellaria media, With. (Common Chickweed.)
Cerastium glomeratum, Thuill. (Broad-leaved Mouse-ear Chickweed.)
triviale, Linn., (Kirk.)

LINACEÆ.

Linum usitatissimum, Linn. (Common Flax.)

MALVACEÆ.

Malva sylvestris, Linn. (Common Mallow.)
rotundifolia, Linn. (Dwarf Mallow.)

HYPERICINEÆ.

Hypericum androsæmum, Linn. (Tutsan, St. John's Wort.)
perforatum, Linn. (Perforated St. John's Wort).

GERANIACEÆ.

Geranium pratense, Linn. (Meadow Crane's Bill.)
Erodium cicutarium, Sm. (Hemlock Stork's Bill).

LEGUMINOSÆ.

Ulex uropæus, Linn. (Furze.)
Sarothamnus scoparius, Wimm. (Yellow Broom.)

ROSACEÆ.

Fragaria vesca, Linn. (Wood Strawberry).
Sanguisorbeæ officinalis, Linn. (Great Burnet.)
Poteria sanguisorbeæ, Linn. (Common Salad-Burnet.)
Rosa rubiginosa, Linn., (Kirk.)

ONAGRAREÆ.

Œnothera stricta. (Common Evening Primrose.)

LYTHRACEÆ.

Lythrum hyssopifolium, Linn. (Hyssop-leaved, Purple Loose Strife.)

Portulaceæ.

Portulaca oleracea, Linn. (Common Purslane.)

Paronychiaceæ.

Polycarpon tetraphyllum, Linn. (Four-leaved All Seed.)

Cucurbitaceæ.

Caladium esculentum, Willd.

Umbelliferæ.

Petroselinum segetum, Benth. (Corn Parsley.)
Caucalis nodosa, Scop. (Hedge Parsley.)

Rubiaceæ.

Galium aperina, *Linn.* (Goose Grass or Cleavers.)
Sherardia arvensis, Linn. (Blue Sherardia or Field Madder.)

Compositæ.

Hypochæris radicata, Linn. (Long-rooted Cats-ear.)
glabra, Linn. (Smooth-leaved Cats-ear.)
Helminthia echioides, Gaert.
Taraxicum dens-leonis, Desf. (Common Dandelion.)
Crepis virens, Linn., (Kirk.)
Lapsana communis, Linn. (Common Nipple-wort.)
Carduus lanceolatus, Gaert. (Spear Thistle.)
Erigeron canadensis, Linn. (Canadian Flea-bane.)
Senecio vulgaris, Linn. (Common Groundsel.)
Bellis perrenis, Linn. (Common Daisy.)
Chrysanthemum leucanthemum, Linn. (Great White Ox-eye.)
Anthemis arvensis, Linn. (Corn Chamomile.)
Achilleæ millefolium, Linn. (Common Yarrow.)

Apocyneæ.

Vinca major, Linn. (Greater Periwinkle.)

Gentianeæ.

Erythræa centaurium, Pers. (Common Centaury.)

Solaneæ.

Physalis peruviana, With. (Cape Gooseberry.)

Scrophularineæ.

Veronica arvensis, Linn. (Wall Chickweed, Speedwell.)
serpyllifolia, Linn. (Thyme-leaved Speedwell.)
Verbascum thapsus, Linn. (Great Mullein.)

Labiatæ.

Stachys arvensis, Linn. (Corn Woundwort.)
Marrubium vulgare, Linn. (White Horehound.)
Prunella vulgaris, Linn. (Self-heal.)
Mentha piperita, Smith. (Peppermint.)

Satureia hortensus, Linn. (Summer Savory.)
Nepeta cataria, Linn. (Cat-mint.)

VERBENACEÆ.

Verbena officinalis, Linn. (Common Vervain.)

PRIMULACEÆ.

Anagallis arvensis, Linn. (Common Scarlet Pimpernel.
var. *β. cærlueæ.* (Blue Pimpernel.)

PLANTAGINEÆ.

Plantago major, Linn. (Greater Plantain).
lanceolata, Linn. (Ribwort Plantain.)

AMARANTHACEÆ.

Amaranthus retroflexus, Linn., Kirk.

POLYGONEÆ.

Polygonum aviculare, Linn. (Common Knot Grass.)
Rumex obtusifolius, Linn. (Broad-leaved Dock.)
viridis, Sibth. (Green-veined Dock.)
ascetosella, Linn. (Sheeps' Sorrel.)
crispus, Linn. (Curled Dock.)

EUPHORBIACEÆ.

Euphorbia peplus, Linn. (Petty Spurge.)

MONOCOTYLEDONS.

IRIDEÆ.

Iris germanica, Willd. (Large White Iris.)
Sisyrhynchium bermudiana, Linn. (Blue-eyed Grass.)

LILIACEÆ.

Calla æthiopica. Willd. (African Lily.)

Introduced Forage and Pasture Plants.

LEGUMINOSÆ.

Vicia sativa, With. (Common Vetch.)
Medicago lupulina, Linn. (Black Medick or Nonsuch.)
maculata, Sibth. (Spotted Medick.)
denticulata, Willd. (Reticulated Medick.)
Melilotus officinalis, Linn. (Common Yellow Melilot.)
Trifolium repens, Linn. (White Trefoil or Dutch Clover.)
minus, Relph. (Lesser Yellow Trefoil.) (Kirk.)
pratense, Linn. (Common Purple Clover.)
medium, Linn.
Vicia tetrasperma, Lois. (Smooth Tare.)
hirsuta, Koch. (Hairy Tare.)

GRAMINEÆ.

Digitaria sanguinalis, Scop.
Anthoxanthum odoratum, Linn. (Sweet-scented Vernal Grass.)
Phalaris canariensis, Linn. (Canary Grass.)
Alopecurus pratensis, Linn. (Meadow Fox-tail.)
Phelum pratense, Linn. (Cat's-tail Grass.)
Agrostis australis, Linn. (Bent Grass.)
vulgaris, With. (Fine Bent Grass.)
alba, Linn. (Marsh Bent Grass.)
Aira caryophylla, Linn. (Hair Grass.)
Glyceria fluitans, Br. (Floating Sweet Grass.)
Holcus lanatus, Linn. (Soft Grass.)
mollis, Linn. (Kirk.)
Poa pratensis, Linn. (Smooth Meadow Grass.)
trivialis, Linn. (Roughish Meadow Grass.)
nemoralis, Linn. (Wood Meadow Grass.)
annua, Linn. (Annual Meadow Grass.)
Eragrostis brownii, Kunth. (No common name.)
Briza maxima, Linn. (Quaking Grass.)
minor, Linn. (Quaking Grass.)
Dactylis glomerata, Linn. (Cocksfoot Grass.)
Cynosurus cristatus, Linn. (Dog's-tail Grass.)
Festuca myurus, Smith. (Barren Fescue Grass.)
var. *sciuroides*. (Barren Fescue Grass.)
Bromus sterilis, Linn. (Barren Brome Grass.)
racemosus, Linn. (Smooth Brome Grass.)
mollis, Linn. (Soft Brome Grass,)
Ceratochloa unioloides, P. de Beauv. (Prairie Grass.)
Avena pratensis, Linn. (Narrow-leaved Oat Grass.)
Hordeum murinum, Linn. (Wall Barley.)
Lolium perrenne, Linn. (Rye Grass.)
var. *multiflorum*. (Rye Grass.)
var. *uniflorum*. (Rye Grass.)
Cynodon dactylon, Pers. (Dog's-tooth or Doab Grass.)
Stenotaphrum glabrum, Trinius. (Buffalo Grass.)

Critical Notes on certain Species of Plants doubtfully indigenous to Kawau.
By T. KIRK, F.L.S.

Viola filicaulis, Hook., fil. The most northern *habitat* known, and quite unexpected.

Colobanthus billardieri, Fenzl. This is extremely rare north of the Waikato; at least I never gathered it in Auckland district.

Montia fontana, Linn. Doubtful. The nearest *habitat* for this plant is fully 250 miles further south in the Taupo country.

Potentilla anserina, Linn. The same remarks apply, and additionally it has not been previously found north of Auckland Isthmus.

Metrosideros albiflora, Banks and Sol. Quite unexpected at so low an altitude in the north, as anything to be found on the Kawau does not occur at Cape Colville and Manaia under 1,500 feet at least.

Eryngium vesiculosum, Labill. Not known in an indigenous state north of the East Cape. I have seen it cultivated at Matakana.

Lomaria elongata, Blume, and *Lomaria alpina*, Spreng. Certainly not indigenous to Kawau.

Lomaria banksii, Hook., fil. Extremely rare and local north of Waikato.

Doodia caudata, Br. Doubtfully indigenous in Kawau.

Asplenium umbrosum, J. Sm. Doubtfully indigenous in Kawau.

Scirpus triqueter, Linn. On my last visit to Hokianga, May and June, 1876, I made special search in that locality, the Wairoa, Kaihu, Bay of Islands, etc., for this plant, but without success. It is extremely rare in the Auckland district; the most northern *habitat* known to me being Shortland. I do not think *Juncus lamprocarpus* occurs north of the Wellington district. It certainly would not be found on Kawau unless it also occurred on the adjacent islands or the mainland, from all of which it is absent.

Galium tenuicaule, A. Cunn. I doubt the occurrence of this plant north of the Auckland Isthmus.

Craspedia fimbriata, D.C. Certainly not indigenous on Kawau.

Gnaphalium filicaule, Hook., fil. Certainly not indigenous on Kawau.

Erechtites prenanthoides, D.C. Not found on adjacent mainland or outlying islands.

Prasophyllum colensoi, Hook., fil. Not found on adjacent mainland or outlying islands.

Juncus vaginatus, Br. Is this not mistaken for some form of *J. australis*, Br.? The *J. vaginatus* of my Great Barrier list is certainly nothing more than an open-panicled form of *J. australis*. Still, true *J. vaginatus* ocurs on Motutapu, where I think it attains its northern limit.

Juncus novæ zealandiæ, Hook., fil. Certainly not indigenous on Kawau.

Isolepus aucklandica, Hook., fil. Certainly not indigenous on Kawau.

Gahnia procera, Forst. (Query? *G. paciflora*, Kirk, MS., is plentiful in Kawau.)

Uncinia cæspitosa, Boott. Query?

rubra, Boott. Certainly not indigenous on Kawau.

Deschampsia cæspitosa, Pal. Certainly not indigenous on Kawau.

Festuca duriuscula, L. Certainly not indigenous on Kawau.

Hymenophyllum minimum, A. Rich. Certainly not indigenous on Kawau.

bivalve, Swartz. Some form of *H. multifidum*, Swartz, has been mistaken for *H. bivalve*, which does not occur, even at Cape Colville, under 2,000 feet altitude.

NOTE.—[I am indebted to Mr. Kirk, who is well acquainted with the botany of the Auckland district, for several additional species collected by him on Kawau Island not found by myself there. They are distinguished in the lists by the addition of Mr. Kirk's name.—J. B.]

ART. LXXIV.—*On the Root-stock of* Marattia fraxinea, *Smith*.

By JOHN BUCHANAN, F.L.S.

[*Read before the Wellington Philosophical Society, 29th August, 1877.*]

THE root-stock, or rhizome of *Marattia*, is described by Hooker, in the "Flora of New Zealand," as "a large-rounded, hard, fleshy mass, as large as the head," and, in the "Handbook of the New Zealand Flora," as "a large tuberous rhizome." Again, De Vriese and Harting, in their "Illustrated Monograph of Ferns," published at Leyden, in 1853, describe it as "a succulent irregularly-shaped tuberous mass upon which the stems are articulated."

As no additional information is given in the more recent accessible work on Ferns, "Species Filicum of Hooker and Baker," I have been induced to place before the Society the result of observations made on the New Zealand species of this genus *Marattia fraxinea*, Sm., as to its method of reproduction by the root, which may add to our knowledge on this subject. The rhizome, or root-stock of the New Zealand species, is composed of an irregular agglomerated mass of thick fleshy scales, each scale being formed by the enlargement of a stipe base, the stipe separating by an articulation above the swelling, after the frond has performed its functions. The articulated surface of the scale shows a scar mark much resembling the imprint of a horse-hoof.

Such a root-stock approaches the scaly bulb more in structure than a fern rhizome, but without a central mass round which the scales might be arranged in order.

The continued addition of new scales outwards and upwards often raises the rhizome above the surface of the ground, but the frond-buds of those scales only which are in contact with the soil throw out independent roots.

This form of root-stock may therefore be named a scaly sub-ariel rhizome, without internodes.

The procedure in propagating *Marattia* by scales is very similar to that of the common Potato. When the plant is grown from a detached scale, the buds may sprout from any part of its surface, differing in this respect from the potato in having neither points or eyes, and when a frond springs from the crown of the rhizome, or from a scale above the surface of the ground, it derives its nourishment through the parent scales.

The bud swells to a considerable size before the crozier bursts through the cuticular bark. During this process the latter is split and the edges carried upwards, forming the so-called adnate stipules of authors, and remain as a sharp ridge round the scar where the stipe articulated. The new stipe begins to swell at its base at a very early period, spreading over the adjacent surface, and forming a new scale.

The growth of the *Marattia* rhizome is remarkably slow, being under favorable circumstances only one inch diameter in one year, and as the height is less than the diameter it may be safely calculated that a Maori will consume in one day the growth of five years, which fact may account for this fern disappearing in New Zealand wherever the Maoris are numerous. The rhizome, by a process of renewal and movement, lives for an indefinite time, shifting its position in the ground by its growth outwards from a centre, the exhausted scales accumulating in a hard mass on the original site. In this way, like certain fungi, rings or detached clumps may be formed at equal distances from the centre, if no obstructiou exists. Before the exhaustion of the rhizome mass, adventitious frond-buds sprout from various parts of its surface above or beneath the soil.

DESCRIPTION OF PLATE XVIII.

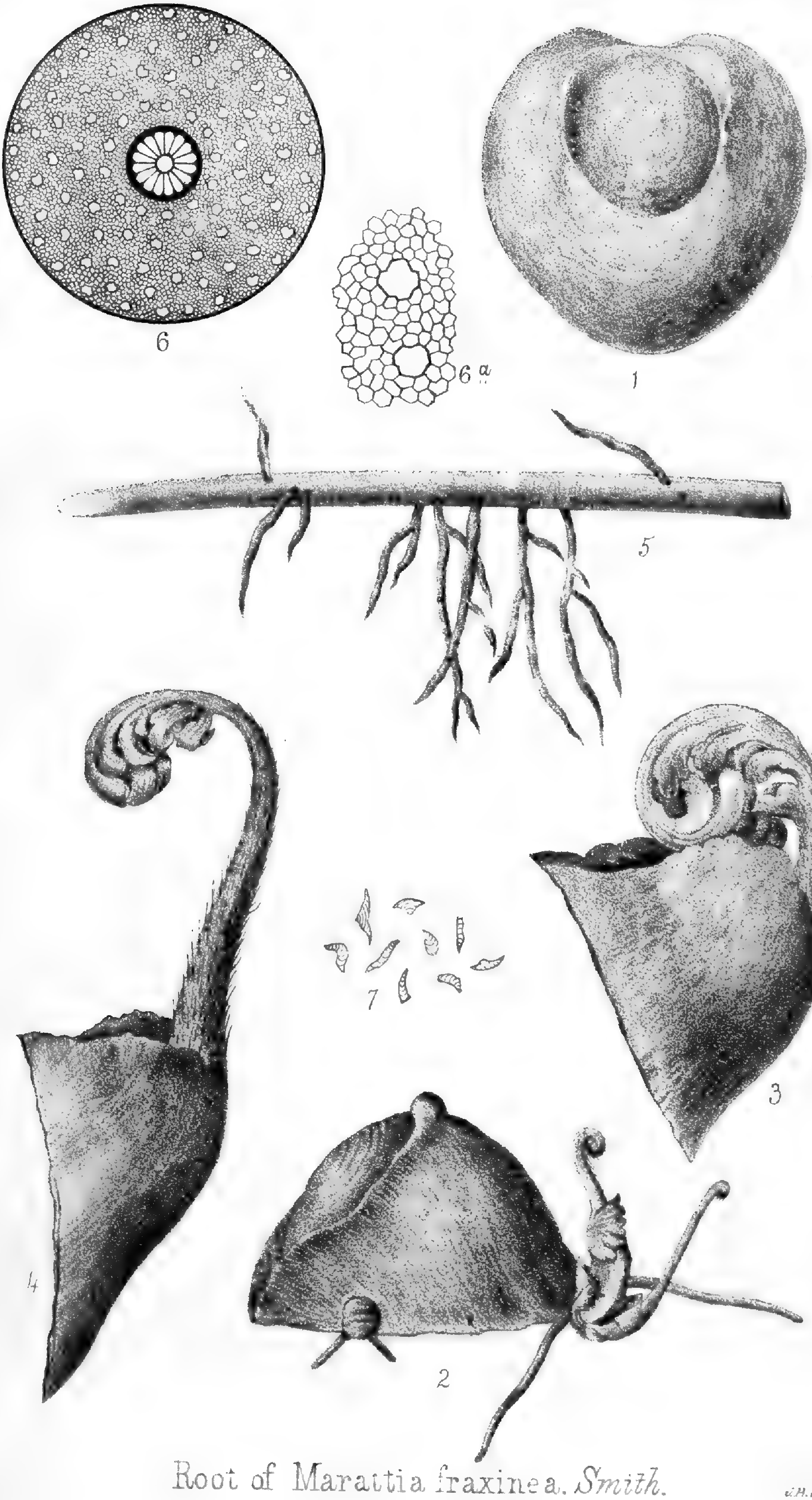
Fig. 1.—Front view of a scale half the natural size. It is composed of cellular tissue filled with starch grains, fibro-vascular bundles, and covered by an adhering bark. The cut section shows numerous small orange-coloured spots, which exude on the surface, when newly cut, a viscid gum-resinous matter.

Fig. 2.—A scale after three months in the ground, showing the method of bud growth with roots proceeding from the bottom of the bud. Half the natural size.

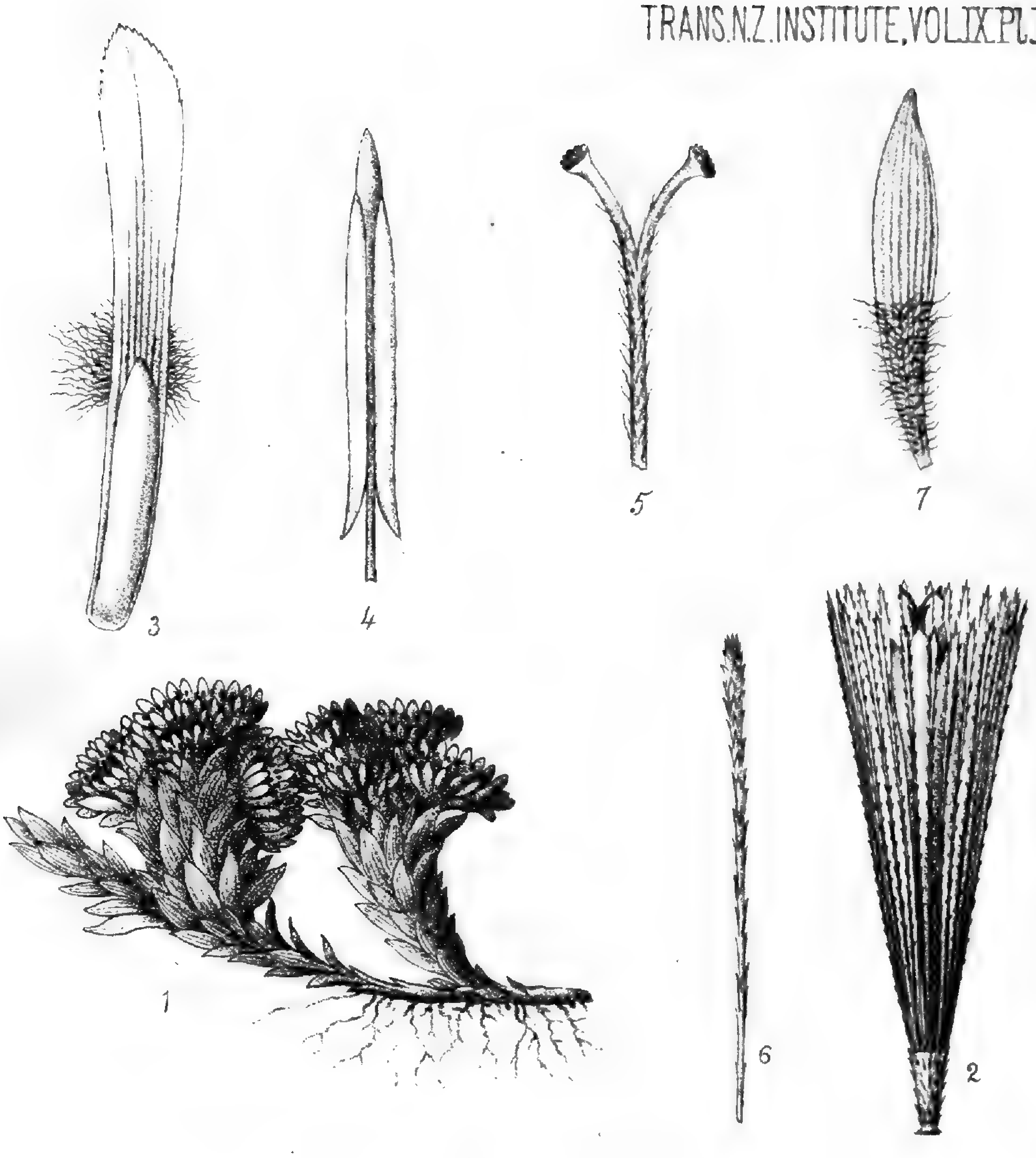
Figs. 3 and *4* are two illustrations of the frond growth above ground, showing the croziers in two stages of development, and the formation of the adnate stipules. Half the natural size.

Fig. 5.—Root process, showing rootlets proceeding chiefly from the lower side of root; the whole very flexible. Half the natural size.

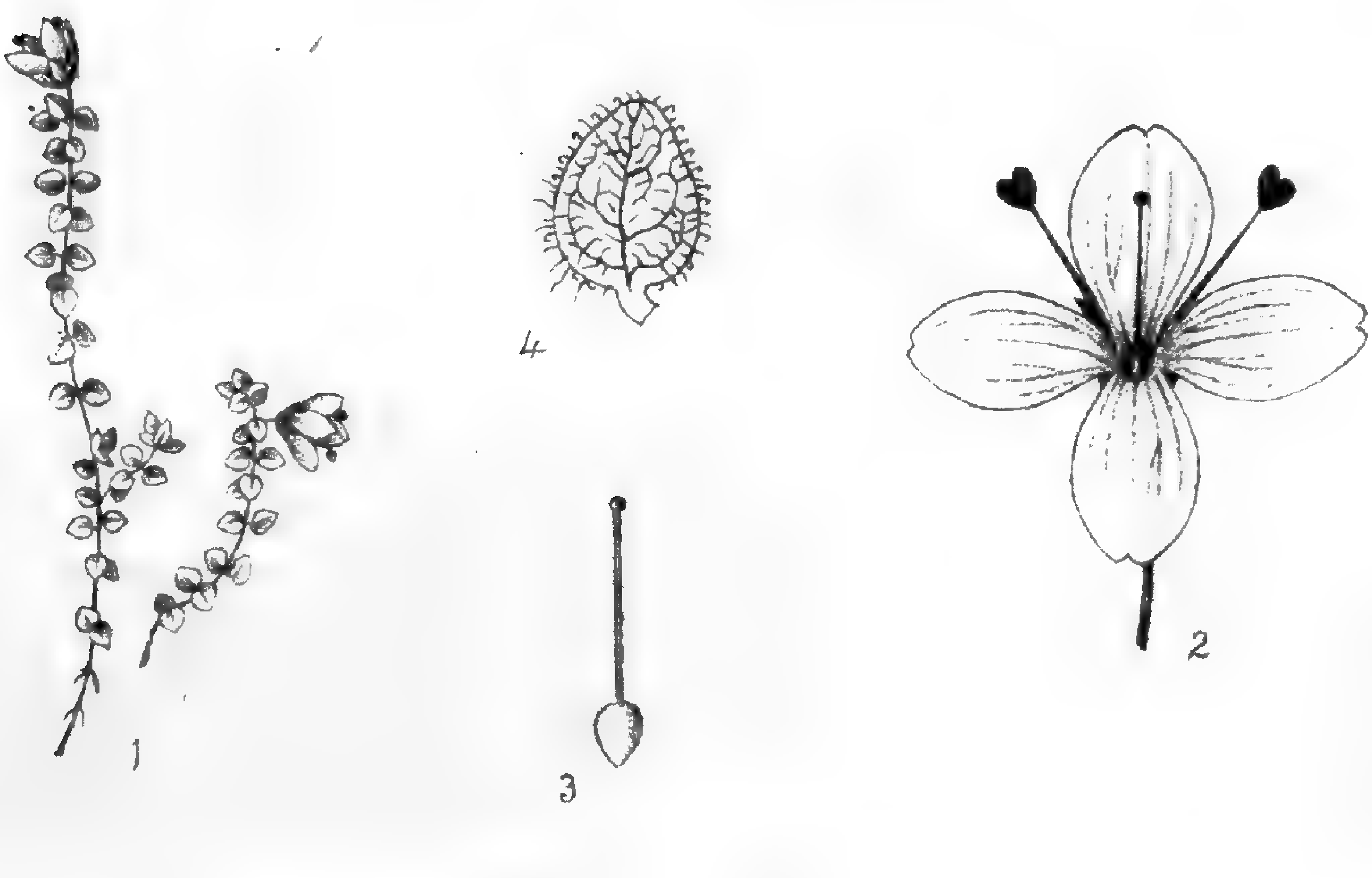
Figs. 6 and *6a.*—Sections of root enlarged. The chief component mass is cellular tissue and starch grains, with lacunæ. There is also a star-



Root of Marattia fraxinea. *Smith.*



GNAPHALIUM FASCICULATUM, n.s.



VERONICA CANESCENS, n.s.

J. Buchanan, del. et lith.

shaped nuclei of fibro-vascular and scalariform bundles. The bundles distinctly wedge-shaped, the root thus showing a stronger affinity in structure to the *Equisetaceæ* than to Ferns, and presenting an additional reason to the difference in *Sporangia*, why *Marattiaceæ* should be separated from Ferns.

Fig. 7.—Starch grains of *Marattia fraxinea*, Sm.

Note.—I am also of opinion, although requiring longer observation to prove satisfactorily, that the rhizomes of the New Zealand *Botrychium* and *Ophioglossum* are built up, or added to, by a similar method to that of *Marattia.*

Art. LXXV.—Gnaphalium (Helicrhysum) fasciculatum, *sp. nov.*

By John Buchanan, F.L.S.

[*Read before the Wellington Philosophical Society, 16th September, 1876.*]

Plate XIX.

A densely-tufted plant with wiry thread-like roots. Stems $1\frac{3}{10}$ inch high, branching. Leaves imbricating all round the branches, erect, $\frac{4}{10}$ inch long, narrow oblong, acuminate, obtuse, striate, upper half covered on both sides with closely appressed, silvery-white tomentum; lower half brown, glabrous in front, covered on back with soft silky white hairs. Heads, 1–4 flowered on each branch, forming a sessile closely compacted fascicle, involucral scales in 2 or more series, narrow linear, spathulate, rounded or notched at top, and finely serrated, glabrous and shining, white on upper half, shining pale green or white on lower half, with a tuft of silky hairs near centre of upper surface; receptacle conical, rough or hispid; pappus hairs few, swollen, scabrid. Achene linear, silky, with a thickened areola at bottom.

Collected by H. H. Travers on the Tararua Mountain, where it was found growing on the ground in close patches.

This species is very similar to *Raoulia grandiflora*, Hook., fil., and might be taken for a many-flower-headed variety; it is larger in all its parts, and a more showy plant.

DESCRIPTION OF PLATE.

1. Plant, nat. size. 2. Floret of the disc. 3. Involucral scale, back view. 4. Anther. 5. Pistil. 7. Leaf.

Art. LXXVI.—*Revised descriptions of two species of New Zealand* Panax.

By John Buchanan, F.L.S.

[*Read before the Wellington Philosophical Society, 16th September, 1876.*]

No. 1. Panax crassifolinm, Dcne. and Planch.

A small tree 20–25 feet high. Stem 8–12 inches diameter, irregularly branched, bark greenish or dirty brown. Leaves in young plants under 20 years of age 1–5 foliolate, very coriaceous and stiff, reflected downwards, 12–18 inches long, 1 inch broad, linear and enlarged at top, narrowed at bottom into short, stout, exstipulate petiole, deeply, distantly sinuate-serrate, serratures cuspidate, variegated in colour, purplish below, dark green above, with pale green spots on the base or point of each tooth, mid-rib stout, reddish. Leaves of old plants erect, 4–6 inches long, ½ inch broad, linear, quite entire, with a few sinuate serratures on the obtuse top, or serrated, narrowed at bottom into a short, stout, exstipulate petiole. Umbels unisexual, terminal, twice compound, peduncles of fruiting umbels ¾–1 inch long, male racemose umbels 1–2 inches long, pedicles very short, bracteate. Flowers small, largest in the fruiting umbels. Fruit large, globose when fresh, ¼ inch diameter, 5-celled. Styles 5, connate into a cone, with their summits free and re-curved.

Common near Dunedin and Nelson. This species is of very slow growth. A young plant, 12 inches high, was removed from the bush, Anderson Bay, near Dunedin, in 1856, and planted in the North East Valley by myself. The stem is now, in 1876, only 10 feet high and 2 inches diameter at base, and it has not yet flowered or acquired the upright foliage.

This species will be distinguished from *Panax longissimum*, Hook., fil., by the deep sinuations in the leaves of young plants, the small compact twice compound umbels, 5-celled large fruit, and racemose male umbels.

DESCRIPTION OF PLATE XX.

Fig. 1. Plant, nat. size. Fig. 2. Fruit, nat. size. Fig. 3. Section of fruit enlarged.

No. 2. Panax longissimum, Hook., fil.

A small tree, 20–25 feet high. Stem, 8–12 inches in diameter; bark, dirty whitish brown; branches usually collected on top of the long bare stem, in an umbellate manner. Leaves in young plants under fifteen years old, 1–5 foliolate, very coriaceous and stiff, reflected downwards, 12–24 inches long, ½–1 inch broad, linear, tapering to a point, and narrowed at bottom into a short, stout, exstipulate petiole, distantly serrate, serratures often cuspidate, very irregular both in distance and size, often large or scarcely visible, green, or dark purplish-green, with sometimes pale green spots on serrations, mid-rib stout, reddish. Leaves of older plants erect, 5–10 inches long, 1–2 inches broad, oblong, or linear acuminate, with small cuspidate serrations, or nearly entire, narrowed at bottom into a short, stout, exstipulate petiole. Umbels unisexual, terminal, thrice compound, wide-spreading, peduncles 2–3 inches long, pedicels 1 inch, bracts small, sometimes racemose above. Flowers rather large. Fruit small, globose,

PANAX CRASSIFOLIUM, *Dcne and Planch.*

J. B. del. et lith.

PANAX LONGISSIMUM, *Hook. fil.*

J. B. del. et lith.

1½ tenths inch diameter. Cells 4. Styles 4, connate into a cone, with their summits free, but scarcely recurved.

Common throughout the islands. The trifoliate state of the young leaves is rare at Dunedin, as also at Wellington, but common in Auckland and Canterbury Districts.

This species may be distinguished from *Panax crassifolium* by the long linear leaves of the young plant, more or less serrate, the thrice compound wide-spreading umbels, and the small 4-celled fruit.

Much difficulty has been experienced by local collectors in discriminating between the present species and *Panax crassifolium,* in consequence of the absence of a full description of *P. longissimum* in the "Handbook of the New Zealand Flora;" and, as this difficulty can be easiest remedied in the Bush, the present attempt—the result of observations made there—is offered for that purpose.

DESCRIPTION OF PLATE XXI.

Fig. 1. Plant nat. size. Fig. 2. Fruit nat. size. Fig. 3. Section of fruit enlarged. Fig. 4. Fruit enlarged.

ART. LXXVII.—*On a few of the Grasses and other Herbage Plants that might be advantageously introduced into Cultivation in New Zealand.*

By Dr. S. M. CURL.

[*Read before the Wellington Philosophical Society, September 16th, 1876.*]

THE introduction, acclimatisation, and cultivation of economic plants in a young colony like New Zealand is a work not only of interest to those engaged in it, but is of the utmost importance to all colonists, and to the best interests and progress of the Colony generally, as from these plants articles of commerce and raw materials for manufactories are procured, and the dwellers in urban and extra-urban districts participate in the advantages.

In Colonies with a climate similar to New Zealand, where the flocks of sheep and herds of cattle and horses are not only of importance to the grazier and pastoralist, but to all the mercantile and other classes who dispose of the products, wool, tallow, hides, riding and draught horses, etc., but also to all who eat the meat of the sheep and cattle, it must be a matter of consequence to introduce and get into cultivation those grasses, clovers, and fodder plants that will improve the fields and pastures whereon the flocks and herds are kept and fed. Impressed with these views, I have for a number of years obtained from other countries, and endeavoured to acclimatize here, new exotics, and among them certain grasses, clovers, and fodder plants, which my experiments have shown would be very valuable if cultivated in the fields and pastures of this colony. For although in the New Zealand flora *Gramineæ* are numerous, and experiments prove to me that many of the New Zealand grasses are very valuable for their feeding and fattening properties, such as the *Danthonias*, *Isachnes*, *Hierochloe redolens*, the *Poas*, *Festucas*, *Dichelachnes*, and others; yet in the winter, and also in the summer, the growth is not rapid enough, and the nutrient elements are not sufficiently developed in the indigenous grasses, to supply the flocks and herds with all that they require.

The introduction of the *Dactylis glomerata*, the *Festucas* of various kinds, the *Alopecurus pratensis*, *Anthoxanthum odoratum*, *Cynosurus cristatus*, *Phleum pratense*, *Loliums* annual and biennial, so called perennial, especially the Devon Evergreen Rye, various *Poas*, and many other kinds are valuable, and from my test culture, analysis, and feeding, their properties are all useful in their proper places, as are also the *Trifoliums* (clovers), and some others; but even yet more grasses are required to make up the deficiencies of all these, and it becomes necessary to discover and obtain other grasses and fodder plants that would supply these defects. Having therefore obtained and cultivated several hundred species of grasses during a space of fourteen years, and subjected them to various tests, it was found that some were very excellent, and others for divers reasons could be discarded, and their culture given up; while others being still under experiment a future verdict will have to be given upon their merits. The experience of graziers in most parts of the Colony of New Zealand is that in the spring and autumn, if not over-stocking their fields or pastures, feed or herbage is abundant, yet in the summers, and also in the winters the grasses, clovers, and other food plants do not grow quickly enough to supply the sheep or cattle with the necessary nutritious feed to keep up their condition for their owners' benefit. After the rains and dampness, with the increasing warmth of the spring, has caused the grasses and clovers on the best pastures to grow very rapidly for a few weeks, the drought and hot sun of summer too soon causes this rampant growth to cease, and the pastures become dry and brown looking, and cannot maintain the same amount of live stock in good condition as in the spring. According as the pastures have been more or less carefully sown with a larger or smaller number of various grasses, so is this state of barrenness sooner or later arrived at. For the pasture is better all through the year the greater the number of well-chosen grasses and clover sown upon it.

For while in some of the best pastures and fields of the grazing counties of England, over 40 kinds of grass and clover are to be found, it is unfortunately the case that, in many fields laid down to grass in New Zealand, only two or three kinds of grass and clover are sown as a mixture, and then not always of the best sorts. Some pastoralists think it sufficient to sow one of the *Loliums* and a clover; and, not knowing that the so-called Perennial Rye Grass will not last longer than two or three years if closely fed down, their fields soon cease to fatten enough live stock to give a profitable return for the capital invested. If they knew that the Rye Grass is naturally a biennial, but that by Pacey, Lawson, Sutton, Stickney, and others, it has been by careful growing and experiment so changed that it will live longer than its natural two years, if carefully treated, but, if not so treated, it will in no wise be perennial. In no case should this grass alone, or with a clover, be the only grass sown, or it will soon die out, and useless weeds will take its place. But as neither space nor opportunity will in this place permit me to go into the merits of the numerous useful grasses for sowing upon perennial pastures, I will confine myself to a short description of some of the grasses that could be introduced with advantage by graziers, and, without crowding too many into this space, a few may be now mentioned as of considerable value—some for summer, and others as winter herbage, being among others, *Elymus condensatus*, *Panicum spectabile*, *Panicum hispidulum*, *Stenotaphrum glabrum*, *Bromus secalinus*, *Festuca gigantea*, *Cynodon dactylon*, *Dactylis cæspitosa*, *Elymus cristatus*, *Gynerium argenteum*, *Milium multiflorum*, *Phalaris canariensis*, *Briza major*.

The Californian Lucerne, or Alfalfa, a *Melilotus* from Thibet, *Trifolium incarnatum*, *Pentzia virgata*. Among the more than 800 kinds of panic grass, there is one, the

Panicum spectabile, or Coapin Grass of Angola, that, if introduced into a mixture for permanent pasture, will be most desirable for its valuable property of growing very luxuriantly in the hottest and dryest summer weather. Having obtained the seed of *Panicum spectabile* from various places and persons—some from Mr. Phillips, some from Dr. Schomburgh, and others—the different lots of seed were sown in the month of October in several successive years. The seed vegetated, and came up readily in the drills where sown, and continued to grow all through the dryest and hottest weather, until the plants were four and five feet high, when it set its seed and ripened it, and continued to grow vigorously until stopped by the winter frost, when it ceased to grow during the winter; and in the month of October following, in each year, it again came up from the roots that had been dormant during the cold weather, and again grew each year as vigorously as at first. Its strong succulent herbage was much relished by stock, and when cut down quickly grew again without any irrigation or watering. It contains large quantities of nutriment, and is in every way valuable as a summer or hot-weather grass, no heat or drought seeming to stop its luxuriant growth, and in various kinds of soil it flourished. It was vigorously growing while the *Loliums* and other British grasses planted in its neighbourhood were dry and withered. It is therefore for these and other reasons one of the best summer grasses.

Panicum hispidulum is another good summer grass. It grows indigenously in Queensland. The seed I obtained was sown in October, and came up in November, and continued to grow rapidly during the hottest and dryest weather, stoling out and covering the ground between the drill, and when allowed to perfect its seed producing an abundance. It continued growing unceasingly all the time the hot weather lasted. It becomes dormant during the winter and cold weather, but appears again in the spring, and proves itself a valuable summer grass.

Milium multiflorum.—The seed of this grass should be sown in October. It comes up in about a month, grows rapidly, keeping green and abundant in the dryest season. If not fed or cut down, forms large tufts two feet six inches to three feet high ; all through the summer it is growing, and even at the latter end of May and June, when the cold wet weather sets in, it still continued to grow; therefore besides being an excellent summer grass it will be useful in the winter.

Elymus condensatus can also be highly recommended. It is the Bunch Grass of British Columbia, and in its native home it is thought more of than any other grass. The mules and horses of the travellers and packers will work and keep in excellent condition, getting quite fat, while working all day and turned out at night to feed on this grass, and in winter will scrape off the snow to get at the withered tufts. The seed of this grass I received from many places and persons, amongst others from Mr. Anderson Henry. It was sown in November, and came up immediately. During the first year it does not make much progress. In the second year it commences to grow in August, and grows quickly during the summer, and if not cut or grazed its herbage is two or three feet long, and if allowed to perfect its seed-stems they will be four to six feet high. It requires more moisture than the previous grasses, but with occasional moisture and heat is very luxuriant, nutritious, and fattening, and well worthy of extensive cultivation, and will prove one of the best grasses the pastoralists can sow to meet the demands of a large quantity of stock, as it will fatten them quickly.

The *Elymus cristatus* is also a good grass. The seed I sowed in April, soon came up, and kept green and healthy through the hottest weather. The foliage is from nine inches to a foot high ; seed stems about eighteen inches in height, and until the frost comes it continues to grow and keep the pastures green.

Cynodon dactylon, the Doobj Grass of India.—I found a little difficulty at first in acclimatising this grass, but it now seems to ripen its seed without difficulty, and kept green during a considerable portion of the winter, but is especially good as growing during the hot and dry season.

Stenotaphrum glabrum, Buffalo Grass, is an excellent grass for summer herbage. During the winter it remains stationary, but during the summer no weather appears too dry or too hot for it. It continues to spread over as large a space of ground as the stock feeding upon it will permit. It does not readily ripen its seeds, but is easily propagated by dividing its roots and planting them, each root sending out stems which form rootlets at every joint. It is also a useful grass for covering sandy lands and hill sides.

Briza major is a grass worthy of some introduction; for although in some places it is only an annual, yet in others it will appear year after year; but in all situations it makes such an abundance of seed that it is sure to drop enough down to perpetuate itself, and its great merit is that it begins growing very early in the winter and all through the spring, and gives an abundance of early herbage before other grasses begin to shoot. All stock are fond of it, and it is nutritious and useful for them, making feed before other grasses begin to grow.

Phalaris canariensis, although another annual, I believe to be a useful grass from its early habit, the readiness with which stock eat it, its fattening properties, and large amount of seed. I would not advise its use so much for permanent pastures as sowing it with Rape, or *Trifolium incarnatum* for one year's lay in alternate husbandry, the *Trifolium incarnatum* growing such an abundant crop for hay or herbage that a very large number of stock may be fed off the acreage so laid down, and, although these three latter plants are annuals, they will be found very serviceable to the farmer and to the grazier.

Bromus unioloides, Prairie Grass.—This useful perennial grass is of the utmost value in permanent pasture as a winter grass, and grows all the year, but most luxuriantly during the winter months. It produces a considerable quantity of sweet and succulent herbage. As soon as the wet weather sets in it rapidly throws up its nutritious foliage, growing through frost; and the stock relish it so much that they will even eat it out by the roots if allowed to stay on it too long at one time. It seeds abundantly, yielding large quantities, which are as good as corn for the stock that eat it. If cut for hay it makes an excellent kind, well filled with nutriment. When permitted to seed the stems are from three to four feet high. It contiuues to ripen its seeds all through the winter if kept free from stock.

Bromus schrœderi, Schrœder's Brome Grass, is even more permanent in pastures than the Prairie Grass, as, from its habit of growth, the crown of the root is not so near the surface of the ground, so stock cannot so soon kill it when it is overstocked. It stoles out, covering the ground rapidly, and seeds freely; seeds-stems about eighteen inches to two feet high. It is good for hay, for winter fodder, and for grazing.

Gynerium argenteum, Pampas Grass.—This is a noble grass, with seed-stems 10 feet high if allowed to seed, but, if within reach of stock, they will keep it low, being particularly fond of its rather coarse leaves. It contains a large amount of nutriment, grows through both winter and summer, no cold affecting it, and as the young leaves appear all cattle and sheep will quickly eat them, leaving more delicate herbage to feed on this.

Bromus seccalinus.—This valuable grass, described by Baron Von Muëller as being one of the best fattening grasses in cold damp lands, growing so rapidly that it supersedes all others, is one that, after considerable difficulty, I obtained from Germany. At present I have not permitted it to seed, with a view to gaining all the growth I can from it, and thus rendering the roots as permanent as possible. It is a grass that will eventually establish itself as one of the most valuable of our winter grasses, especially on damp lands, where other grasses are innutritious or valueless. This will not only supersede those of no value, but will be very fattening and nutritious, and will support a large number of sheep and cattle.

Dactylis cæspitosa, the Tussac Grass of the Falkland Islands, is another valuable winter grass; grows through the coldest and wettest weather, sending out abundant verdant leaves, and will eventually prove itself, to all grass-growers who fairly try it, a very superior winter grass for feeding and fattening stock. It is a pity that it is not more generally diffused, as it has been very difficult for many who are experimenting with grasses to obtain it. I believe I have been one of the first in this and the Australian Colonies who obtained the true seeds and got them to vegetate. Of this valuable fattening grass, from what I observe of its mode of growth, the readiness with which it is eaten by stock, and the nourishment it contains, I believe it will rank among the best of our winter grasses.

Festuca gigantea, the Giant Fescue, is amongst all the Fescues one that both summer and winter gives the largest amount of nutriment. So quickly does it grow after the first year that if the stock are removed from it a short time it shoots up above the neighbouring grasses, and quickly overtops them. Its seed-stems are between four and five feet high, and produce a large quantity of seed, which my experience proves to vegetate easily.

Pentzia virgata, the Sheep Bush of the Cape of Good Hope, is a valuable herbage or fodder plant for summer feeding where sheep are kept. Dr. Schomburg kindly sent me some seeds, a few of which vegetated, growing all through the dryest and hottest weather during summer, and by the autumn they had become nice little bushes between a foot and fifteen inches high. Cuttings were taken as soon as the first showers came. These struck readily, and grew into healthy little plants. From the manner in which it grows I am satisfied it is a very useful introduction into sheep pastures. The sheep like it, and it gives the mutton fine quality. This is even more useful than the *Achillea millefolium*, which latter is also a desirable addition to sheep runs as a condiment plant, as is also *Poterium sanguisorba* Burnet, which latter stands drought well, and grows all through the summer, and the sheep eat it greedily.

Californian Alfalfa, a species of Lucerne, cultivated in California.—Having obtained seed of this Alfalfa from several growers in California, and also a small packet from Dr. Hector, I have grown this plant from the several packets of seeds, and although some varieties grow much more vigorously than others, they all grow well in summer. Some of them had stems between three and four feet long, and those that were cut grew very fast during the hottest and dryest weather, seeming to luxuriate in heat, and not requiring any moisture. I think this plant well adapted for sowing in permanent pastures, as although it grows but slowly during winter it amply makes up for it during summer, and is greatly relished by stock of all kinds. I learn there are several varieties of this plant in cultivation in California, and there is another kind grown in Chili, the seed of which I obtained and am now experimenting with. This Chilian Alfalfa is said to be more vigorous and altogether better than the Californian, and it was from this Chilian species the Californian varieties were at first produced.

I obtained a *Melilotus* that is indigenous to Thibet. I sowed it, and during the spring, summer, and autumn it grew well. It does not appear to like frost if placed in a damp situation, yet in sheltered, warm spots it thrives in the winter as well as the summer. But it may be found a valuable summer herbage and fodder plant. It has a very fragrant scent, grows tall, is succulent and tender, grows a heavy crop, and is in some respects preferable to Alfalfa, and will make a full and very excellent crop of hay. Having thus briefly indicated what I believe are very valuable grasses and herbage, I will cease from enumerating others, although there are many that I have found will grow well in this Colony, and analytical tests for starch, salts, and other nutritive matters, as well as actual feeding of stock, experiments have proved are very valuable and desirable for culture, such as the *Festuca dives*, a magnificent grass said to grow ten feet high in Australia, also the Australian Kangaroo Grass, and very many others.

I have refrained from giving anything but results and conclusions, as details of analysis, feeding, experiments, modes of acclimatization, and mere cultural operations would have extended this paper to over-large dimensions. There are many plants that I might have referred to, but determined to only point out, to the pastoralist and others interested, those grasses that it will be well to bring into cultivation immediately. I might in passing, state, that the Sugar Beet, upon which, some years since, I wrote for the newspapers several articles, showing its advantages when grown for sugar-making and for other purposes, would be very useful if grown to feed and fatten cattle, pigs, etc., upon.

From time to time I shall be happy to give results of my experience, as my acclimatization experiments upon all kinds of economic or useful plants, etc., are still going on; and I am always trying the merits of new Grasses as well as other things sent me by my correspondents from all parts of the world.

I would add that those plants and grasses I have recommended for summer culture are well adapted for cultivation in Auckland and the North, and those growing in winter are all suitable for Otago and the South; but, for the places in this latitude, they are all adapted for summer and winter culture, and may with great advantage be introduced into the fields and pastures whereon the cattle, sheep, and horses feed.

Art. LXXVIII.—*Notes on some Otago Plants.* By G. M. Thomson.

[Read before the Otago Institute, 24th October, 1876.]

Since the publication in Vol. I. of the "Trans. N.Z. Institute" of Mr. Buchanan's excellent List of the Flowering Plants of Otago, no additions seem to have been made to our knowledge in this respect by local botanists. The following supplementary list of plants collected by Messrs. Petrie, Purdie, and myself, is intended as a small contribution in this direction. There is no doubt that if more information of this kind were obtainable it would be found that species hitherto considered to be very limited in their range would be found to be widely distributed. So much is this the case that Hooker's Flora is found to be of no use as an authority on the distribution of the species, most of those in the accompanying list being given as from the North Island only, and in some cases from only one locality. There are many agencies at work throughout the Colony, such as enclosing of land for grazing, burning, clearing of bush, etc., which greatly affect the indigenous flora. As instances of the above, and of the rapid appearance and disappearance of plants, the following facts are interesting. Three years ago *Gentiana montana* began to be noticed on the Town Belt of Dunedin. In the summer before last it had increased to such an extent that the sward in many parts was white with its flowers during the months of January, February, and March. Last season cattle were not permitted to graze on the belt, the grass got full freedom to grow, and as a result I sought in vain during the whole summer for a single *Gentian* flower. No doubt if the grass were once more kept down, this plant being bitter and untouched by cattle would again appear abundantly. In Stewart Island I found *Utricularia monanthos* on a tract of swampy ground not many feet above high-water mark, from which a thick scrubby bush had been burned off only a few months previously. In no other part did I meet with this plant, though it probably occurs in open marshy ground higher up the hills.

Again, *Euphrasia antarctica*, formerly occurring sparingly on Flagstaff Hill, has within the last year or two overrun the whole southern side of the hill; while the cutting down of the bush in the neighbourhood of Dunedin has been accompanied by a great increase in the number and variety of the species of *Erechtites*. The following plants are given by Mr Buchanan as occurring only in the western region of the Province, but are to be found also in the eastern.

Colobanthus acicularis; C. subulatus; Metrosideros lucida (Bluff, Nuggets and Stewart Island); *Ligusticum brevistyle; Angelica gingidium; Olearia hectori* (Saddle Hill); *Brachycome sinclarii* (Flagstaff Hill, etc.; *Cotula pyrethrifolia* (neighbourhood of Dunedin, not uncommon); *Raoulia tenuicaulis* (Otago Peninsula, Waitati, etc.); *R. glabra* (Flagstaff, etc.); *R. grandiflora* (summit of Maungatua); *Gnaphalium bellidioides; G. luteo-album; Senecio bellidioides; S. lautus;* and *S. rotundifolius* (Stewart Island).

Order.—VIOLACEÆ.

1. *Melicytus macrophyllus* (A. Cunn.)
2. *M. lanceolatus* (Hook., f.)
3. *M. lanceolatus*, var.

} Waikari Creek, near Dunedin.

Leaves, 2–4 inches long, ¾–1 inch broad; oblanceolate, acute, very closely serrate, slightly coriaceous, on stout petioles ¼–½ inch long. Flowers small, chocolate-brown, in fascicles of 2–5 on stoutish decurved peduncles, ¼–½ inch long, bracteate close to the flower. Stigma, 3-fid.

Waikari Creek and West Taieri Bush.

I have described the last at some length, as Mr Kirk, to whom I sent a specimen, referred it to *M. macrophyllus.* With due deference to his superior judgment, I consider that its general resemblance to *M. lanceolatus* —the shape and texture of its leaves, the appearance of its flowers, and its 3-fid stigma—warrant me in naming it as above.

(All the above were collected by Mr. A. Purdie.)

Mr. Purdie also informs me that *M. micranthus* occurs in the neighbourhood of Dunedin, but I have seen no specimens.

4. *Hymenanthera crassifolia* (Hook, f.), var.

A densely-branched, almost leafless, tortuous shrub, 2–3 feet high, with the habit of a *Discaria*, forming an impenetrable bush. Leaves very few, from ¼–1 inch long, spathulate, entire, or with one or two sinuous serrations, coriaceous, sessile. Flowers ⅛ of an inch long, very abundantly produced on the under side of the branches, solitary, or in fascicles of 2 or 3, almost sessile, minutely bracteate. Sepals triangular, thick, with scarious margins. Petals twice as long as sepals, oblong, recurved, yellowish-brown.

Taieri River, near the mouth.

Order.—Malvaceæ.

5. *Plagianthus divaricatus* (Forst.), salt marshes near Dunedin.

Order.—Leguminosæ.

6. *Swainsonia novæ-zealandiæ* (Hook., f.), Mount St. Bathans, 4–5,000 feet (D. Petrie).

Order.—Rosaceæ.

7. *Acæna novæ-zealandiæ* (Kirk), Hills to east of Taieri Plain, probably common.

Order.—Crassulaceæ.

8. *Tillæa sinclairii* (Hook., f.), Tomahawk Lagoon, near Dunedin.

9. *T. verticillaris* (D.C.), not uncommon on dry rocky ground.

Order.—Droseraceæ.

10. *Drosera binata* (Labill.), Kaikorai Lagoon, near Dunedin; Bluff; Stewart Island.

Order.—Halorageaceæ.

11. *Haloragis micrantha* (Br.), common on dry ground.

12. *H. tenuissima* (Kirk), Flagstaff Hill and Chain Hills.

13. *Myriophyllum variæfolium* (Hook., f.), common in marshes.

14. *Callitriche verna* (Linn.), common in swamps.

Order.—Onagrariæ.

15. *Epilobium nummularifolium* (A. Cunn.), var. γ. *brevipes*, Chain Hills, and other places near Dunedin.

Order.—Umbelliferæ.

16. *Hydrocotyle americana* (Linn.), Town-belt of Dunedin.

17. *Pozoa trifoliolata* (Hook., f.), Tomahawk Lagoon and Saddle Hill.

18. *P. trifoliolata*, var *tripartita*, Tomahawk Lagoon.

19. *P. hydrocotyloides* (Hook., f.), Mount St. Bathans, 3,500 feet. (D. Petrie).

20. *Crantzia lineata* (Nutt.), Tomahawk Lagoon (D. Petrie).

Order.—Araliaceæ.

21. *Stilbocarpa polaris* (Dene. and Planch.), Stewart Island.

22. *Panax longissimum* (Hook., f.), common, probably unintentionally omitted by Mr. Buchanan.

Order.—COMPOSITÆ.

23. *Cotula squalida* (Hook., f.), Bluff Hill, Stewart Island.

24. *Erechtites glabra* (Kirk), Nuggets, Catlin River.

25. *Senecio sciadophilus* (Raoul. Choix.), Otago Peninsula and Saddle Hill; probably not uncommon. Flowers late, February to March.

Order.—MYRSINEÆ.

26. *Myrsine chathamica* (F. Muëll)., I found a single tree of this beautiful species at the head of Wilson Bay, Stewart Island. It probably occurs sparingly in the south of that island.

Order.—CONVOLVULACEÆ.

27. *Cuscuta densiflora* (Hook., f.), growing on Fuchsia at Green Island (A. Purdie).

Order.—BORAGINEÆ.

28. *Myosotis spathulata* (Forst.), Lower Gorge of the Taieri, near the mouth.

Order.—SCROPHULARINEÆ.

29. *Mimulus repens* (Br.), Ocean Beach, Dunedin.

30. *Limosella aquatica*, var. *tenuifolia* (Linn.) Tomahawk Lagoon. (Both collected by Mr. Petrie.)

31. *Ourisia colensoi* (Hook., f.), moist ground in Stewart Island.

Order.—LENTIBULARIEÆ.

32. *Utricullaria monanthos* (Hook., f.), swamps at the Head of Paterson Inlet, Stewart Island.

Order.—VERBENACEÆ.

33. *Teucridium parvifolium* (Hook., f.) Mr. Purdie reports this plant from the neighbourhood of Dunedin. I have seen no specimens.

Order.—LABIATÆ.

34. *Scutellaria novæ-zealandiæ* (Hook., f.), Flagstaff Hill (A. Purdie).

Order.—CHENOPODIACEÆ.

35. *Chenopodium urbicum* (Linn.), roadsides near Dunedin.

36. *C. glaucum* (Linn.), var. *ambiguum*, Brighton.

37. *C. carinatum* (Br.), Manuherikia Valley (D. Petrie.)

38. *C. pusillum* (Hook., f.), Manuherikia Valley and Ida Valley, (D. Petrie.)

Order.—THYMELEÆ.

36. *Pimelea virgata* (Vahl.), sea coast near Dunedin.

Order.—POLYGONEÆ.

37. *Polygonum minus* (Huds.), var. *decipiens*, Long Bush, near Invercargill.

Order.—URTICEÆ.

38. *Parietaria debilis* (Forst,) Water of Leith, Dunedin (D. Petrie).

Order.—Orchideæ.

39. *Corysanthes rivularis* (Hook., f.), gullies near Dunedin and Stewart Island.

40. *Chiloglottis traversii* (F. Muëll.), Swampy Hill, 2,000 feet.

Order.—Liliaceæ.

41. *Dianella intermedia* (Endl.), Chain Hills (A. Purdie).

42. *Anthropodium candidum* (Raoul. Choix), common.

Order.—Cyperaceæ.

43. *Uncinia ferruginea* (Boott), damp ground near Dunedin.

44. *Carex raoulii* (Boott), Stewart Island.

45. *Carex lambertiana* (Boott), near Dunedin.

Art. LXXIX.—*On the Fertilization of* Selliera. By T. F. Cheeseman, F.L.S.

[*Read before the Auckland Institute, July 3rd, 1876.*]

The singular cup-shaped covering, generally known as the indusium, that surrounds the stigma in the *Goodeniaceæ* has long been recognised as playing an important and probably somewhat varied part in the fertilization of the plants composing the order; but nevertheless, so far as I am aware, no one has yet indicated the exact way in which this takes place in any one species. As one member of the order—*Selliera radicans*—is abundant near Auckland, I have been enabled to make a few observations that bear upon the subject, and consequently take this opportunity of placing a *resumé* of the results obtained before the Institute.

Selliera radicans is a common plant in salt marshes along the whole of our coast-line, but is rarely found inland. It has a stout creeping stem, thick and succulent dark green leaves, and small white flowers, that are abundantly produced during the whole of the summer months, often whitening a broad band near high-water mark at the head of many of our shallow bays and inlets. The corolla is split to the base at the back, the five lobes all turning to the front, thus giving the flower a peculiar one-sided or incomplete appearance by which the plant can be readily identified.

If a young flower-bud, some days before it is ready to expand, is examined it will be found that the corolla lobes cohere by their edges, that is, are valvate. The five stamens form a ring in the centre of the flower, closely surrounding the style, than which they are a little higher. The style, as is usual in the order, is terminated by the widely expanded cup-shaped indusium, in the base of which the stigma, as yet quite young and immature, is hidden. As the flower approaches expansion, the stamens, at first erect, arch over the indusium; each anther case splits along its inner face, and the contained pollen slowly drops into the gaping indusium immediately below. The corolla then ruptures at the back, and gradually opens, the five lobes, as stated above, all turning towards the front. At the same time the stamens elastically curve towards the back of the flower, and ultimately protrude, in a withered condition, out of the posterior slit of the corolla. Meanwhile the lips of the indusium have closed together, thus firmly shutting up the pollen as if it were in a box; and the style, instead of being, as before, perfectly erect, is now considerably bent down towards the front of the flower. It will now be noticed that the flowers are sweet-scented, and that a small drop of nectar always exists at the base of the style.

In the meantime the stigma has been slowly growing upwards, consequently pushing before it the whole of the pollen, and ultimately forcing it out, bit by bit, from between the closely appressed margins of the indusium. If the pollen were to drop directly to the bottom of the flower, it would be impossible for fertilization to take place, but as the margins and sides of the indusium are furnished with a few weak hairs a portion at least is detained on the outside of the indusium for a time. The stigma still continues its growth, and when mature and ready to receive the fertilizing pollen protrudes considerably beyond the indusium. It is then imperfectly two-lobed, and is plentifully covered with rather viscid cellular papillæ.

I think it will now be evident that self-fertilization cannot possibly take place; for, long before the stigma reaches maturity, the pollen has been thrust out of the indusium; and although, as we have seen, it may be detained for a time by the hairs on the outside of the latter organ, yet every vestige has disappeared before the stigma is in a fit condition to receive it. As the plant regularly produces an abundance of fruit, we are naturally led to the supposition that some means exist by which pollen is transferred from the younger flowers to the older ones.

I have already alluded to the presence of nectar, and to the odour exhaled by the flowers. Can we suppose that these attributes are of no purpose in the economy of the plant? Hardly. There is a well-known axiom, that there is no effect without its cause. In this instance the cause of the presence of both nectar and odour is, that insects require to be attracted to the flowers, in order that the pollen may be regularly and efficiently transferred. That the attraction held out is amply sufficient, is proved by the fact that it is only necessary to watch the flowers for a short space of time, on a bright and sunshiny day, to observe that they are visited by numerous insects, all busily engaged in feeding upon the nectar.

The insects are of various Orders, but I believe that fertilization is chiefly effected by a species of *Diptera*. The method pursued appears to be as follows:—The fly alights on the front of the corolla, which forms an excellent landing-place, and creeps a little way into the flower, at the same time bending down its head, so as to reach with its proboscis the nectar at the base of the style. If the visitor be of the right size (a species approaching the common house-fly in this respect seems to suit the requirements of the flower the best), it will inevitably strike its head against the bent summit of the indusium. Should the flower have been expanded for some time, probably nothing will be effected; but should it be one in which the stigma is thrusting the pollen out of the indusium, the insect cannot fail to get the back and front of its head plentifully dusted over with pollen. Let it now visit another and *older* flower, and it is evident that when occupying the same position as before, that the part of its head which had then rubbed against the extremity of the indusium, will now strike against the stigma, which, as we have seen, protrudes beyond the indusium when mature. In this case the pollen would adhere to the viscid papillæ with which the stigma is covered, and fertilization would be ensured.

If this view of the fertilization of the plant be accepted, we can readily see the meaning of several facts that would otherwise remain without explanation. For instance, the sudden and elastic movement which the stamens make to the back of the flower immediately after expansion, is probably of use by removing them from a position in which they would interfere with the attempts of insects to reach the nectar. Similarly, the bending of the upper part of the style—also taking just before or at the opening of the flower—evidently happens for the purpose of turning both the indusium and stigma towards that part of the flower on which insects most often alight; while the few weak hairs that are found on the outside of the indusium—a point of structure that might well at first sight appear to be of little or no use in the economy of the plant—are probably of importance as serving to detain some of the pollen after it has been pushed out of the indusium in the very best position for the visits of insects that it could possibly have occupied.

To any one possessing a better knowledge of entomology than I do, it would be an interesting study to catalogue the various insects that visit this plant. In Europe this has been done for several plants by the distinguished naturalist, Herman Müller, and with very surprising results, as many as 60 different species having been observed to visit one kind of flower, while others, to all appearance equally attractive, are restricted to a much smaller number of visitors. In the case of *Selliera*, *Diptera* seem to be most frequently seen about the flowers, some twelve or thirteen distinct species having been observed, some of which, however, are of small size, and but poorly fitted for the work of transporting the pollen. Two or three *Hymen-*

optera have been noticed, including the Hive-bee. The common Red Ant is often seen crawling over the leaves, but I have not observed it to enter the flowers. I believe that several nocturnal *Lepidoptera* are constant visitors. I once saw a Butterfly sucking the nectar, while the handsome day-flying Moth, *Leptosoma annulatum*, has often been seen similarly engaged. *Coleoptera* are scarce; but one species of the *Staphylinidæ* is not uncommon about the flowers. A species of Bug is often exceedingly abundant amongst the leaves, but I have been unable to determine whether it visits the flowers or not.

It is impossible to examine the fertilization of this plant without being impressed by the fertility of contrivance, and beautiful adaptation of means to an end everywhere displayed. Passing over it in review we see first of all the open indusium, with the anthers slowly arching over and discharging their load of pollen; then the closing of the indusium, and its curious change of position, placing it in the most advantageous situation for the visits of insects; afterwards the thrusting out of the pollen by the upward growth of the stigma, and its partial detention by the hairs on the outside of the indusium; then the visits of insects, attracted by the delicate odour and the copious supply of nectar; and, lastly, their departure, but not without conveying with them, for transportation to other flowers, some portion of the fertilizing pollen. Taken singly, any one of these contrivances would appear to be of little importance, but linked together they form a chain upon the proper arrangement and entirety of which depends the very existence of the plant itself.

ART. LXXX.—*On New Zealand Coffee.* By J. C. CRAWFORD.

[*Read before the Wellington Philosophical Society, 24th February, 1877.*]

IT is desirable that we should not overlook, as regards our sources of industry and wealth, the indigenous products of the country.

The *Coprosmas* of New Zealand are allied to the Coffee plant, and I have seen it stated that coffee of fine flavour has been produced from the Karamu, *Coprosma lucida*.

I wish to call attention to another plant of the same family, viz., the Taupata, *Coprosma baueriana*. I have for some years past planted this shrub extensively in my garden, chiefly as a nurse for other trees, and as it loves the sea breeze and an exposed situation, I have found it most useful for the purpose. The question to be solved is, can the seeds of this plant be profitably utilized as a coffee, and as such enter into the products of commerce? There is much to be said in favour of the Taupata. It is extremely hardy, and grows in the most exposed situations; it bears a great quantity of fruit and is easily grown either from seed or cuttings, it grows with rapidity to a moderate height, one quite sufficient for the purpose of supplying berries, and it is hardier than its allied plant, the Karamu.

As it is greedily eaten by horses, cattle, or sheep, it would require to be grown in enclosures, and when the berries are ripe, turkeys must not have access to them, as they are very fond of them and soon strip the branches.

I do not pretend to go into what the cost would be of preparing these berries for the market, as I am ignorant of the process of preparing the true coffee berry or bean, and removing the outer fruit. Then there is the expense of gathering to be considered, which could be easily done by children. There are two berries in each fruit, lying side by side, as in the true coffee. Whether or not the Taupata would grow well inland I cannot say. It appears to like the sea air and perhaps may not thrive beyond its reach.

I find that slight bruising and washing will remove the outer pulp very rapidly, and possibly this may be the best mode of cleaning the seeds. The seeds are small compared with those of the true coffee, but the trees bear much fruit and appear to do so every year. As there are plenty of Taupata shrubs in the Wellington gardens it would be easy to make experiments. I have to add that I have collected a quantity of the berries, the beans of which when roasted and ground have a splendid coffee aroma, and when made into coffee the result seems to be thoroughly satisfactory. I send a sample of the ground coffee for the inspection of the meeting. If members will apply their olfactory nerves to it, I think they will be satisfied that we have in the Taupata berry a great source of wealth, requiring but little capital to develop, and capable of almost unlimited extension.

It is not for me to dictate to professional men on the mode of raising the Taupata, but the plan I have adopted is simply to sow a small circle of seeds slightly covered, and put a stick in the middle to indicate the position. A bunch of plants comes up, these I plant out when convenient, probably the second year is about the best time for transplanting.

After being transplanted they generally grow with great rapidity, and I think have plenty of seed in the second or third year. I will not be positive about this, as I have not paid attention to the subject previously.

The Taupata evidently requires very little nourishment from the soil, for it may be seen growing vigorously on bare rocks standing in the sea, where it can be supported only by sending its roots deep into the clefts and fissures of the rock.

This plant also grows readily from cuttings, but for raising a number of plants it is far better to rear it from seed.

ART. LXXXI.—*Description of a New Species of* Pilularia. By T. KIRK, F.L.S.

[*Read before the Wellington Philosophical Society, 24th February, 1877.*]

Pilularia novæ zealandiæ, n. s.

Root-stock creeping. Leaves solitary, 1–2 inches long, erect, setaceous. Sporocarpium globose, 2-valved, 2-celled; carpopodium ¼ inch long, erect; raphe elongated; micro-sporangia numerous, pyriform, each containing 20–30 microspores; macro-sporangia 20–25, ovoid; macrospores globose, or globose-ovoid, regular, not constricted.

Hab.: South Island: Lake Lyndon and Lake Pearson, Canterbury. Alt., 2,800 feet. J. D. Enys and T. Kirk.

In general appearance our plant resembles *P. globulifera*, L., differing externally in the 2-valved sporocarp, the longer carpopodium, and essentially in the non-constricted macrospores. It appears to be closely allied to *P. novæ hollandiæ*, A. Br., from which it differs in the 2-valved sporocarp, erect carpopodium, and lesser number of macrospores.

A species of *Pilularia* was detected at Whangape Lake, Waikato, by Professor Hutton and myself, in 1869, but the specimens were too imperfect to admit of identification.

DESCRIPTION OF PLATE XXIX.

1. *Pilularia novæ zealandiæ*, natural size.
2. Dehiscing sporocarp.
3. Micro-sporangia.
4. Microspores.
5. Group of Micro-sporangia attached to a fragment of the placenta.
6. Macrospore surrounded by a mucilaginous coat.
7. Macrospore.

All magnified.

ART. LXXXII.—*Descriptions of New Plants.* By T. KIRK, F.L.S.

[*Read before the Wellington Philosophical Society, 24th February, 1877.*]

RANUNCULACEÆ.

Ranunculus trilobatus, n. s.

Stem weak, matted, procumbent and rooting at the joints. Lower leaves on long slender petioles, trifoliolate, leaflets 3-lobed, petioled, faintly toothed, with a few weak scattered hairs on both surfaces; upper leaves orbicular, 3-lobed or toothed. Flowers on short slender peduncles, axillary, or opposite the petioles, or below them, very small, sepals deciduous; petals, 5, narrow; stamens 5, carpels 5–7, stigmas spreading; achenes somewhat flattened, smooth, beak slightly recurved, slender.

Hab.: South Island: Catlin River. D. M. Petrie and T. Kirk.

Allied to *R. hirtus*, Banks and Sol., from which it differs in the procumbent habit, short slender peduncles, and small flowers with few carpels The flowers closely resemble those of *R. parviflorus*, L.

Rosaceæ.

Acæna depressa, n. s.

Stem matted, depressed, much branched, forming dense patches on the surface of the ground. Leaves 1–1½ inches long, villous below, leaflets in 3–5 pairs, decreasing in size towards the base of the petiole, ovate or orbicular, sharply toothed, strigillose above. Head sessile, almost hidden by the leaves; calyx 4-angled, villous, angles produced into four flexuous red spines, spreading, barbed; petals 4; achene 1, bony.

Hab.: South Island: Cardrona Valley; Lake Hawea, Otago.

A singular species. The heads are so closely hidden by the leaves that they would scarcely be observed except for the bright red, soft, flexuous spines, which project in all directions.

Halorageæ.

Haloragis uniflora, n. s.

Stem, creeping underground, wiry, much branched, 1 inch high. Leaves opposite, shortly petioled, ovate-lanceolate, acute, with one or two serratures on each side. Stem and leaves sparingly clothed with soft white hairs, not scabrid. Flowers solitary, terminal, shortly peduncled; sepals erect, triangular, obtuse; petals 4, with short hairs; stamens 4; stigmas 4, plumose. Fruit 4-costate, smooth.

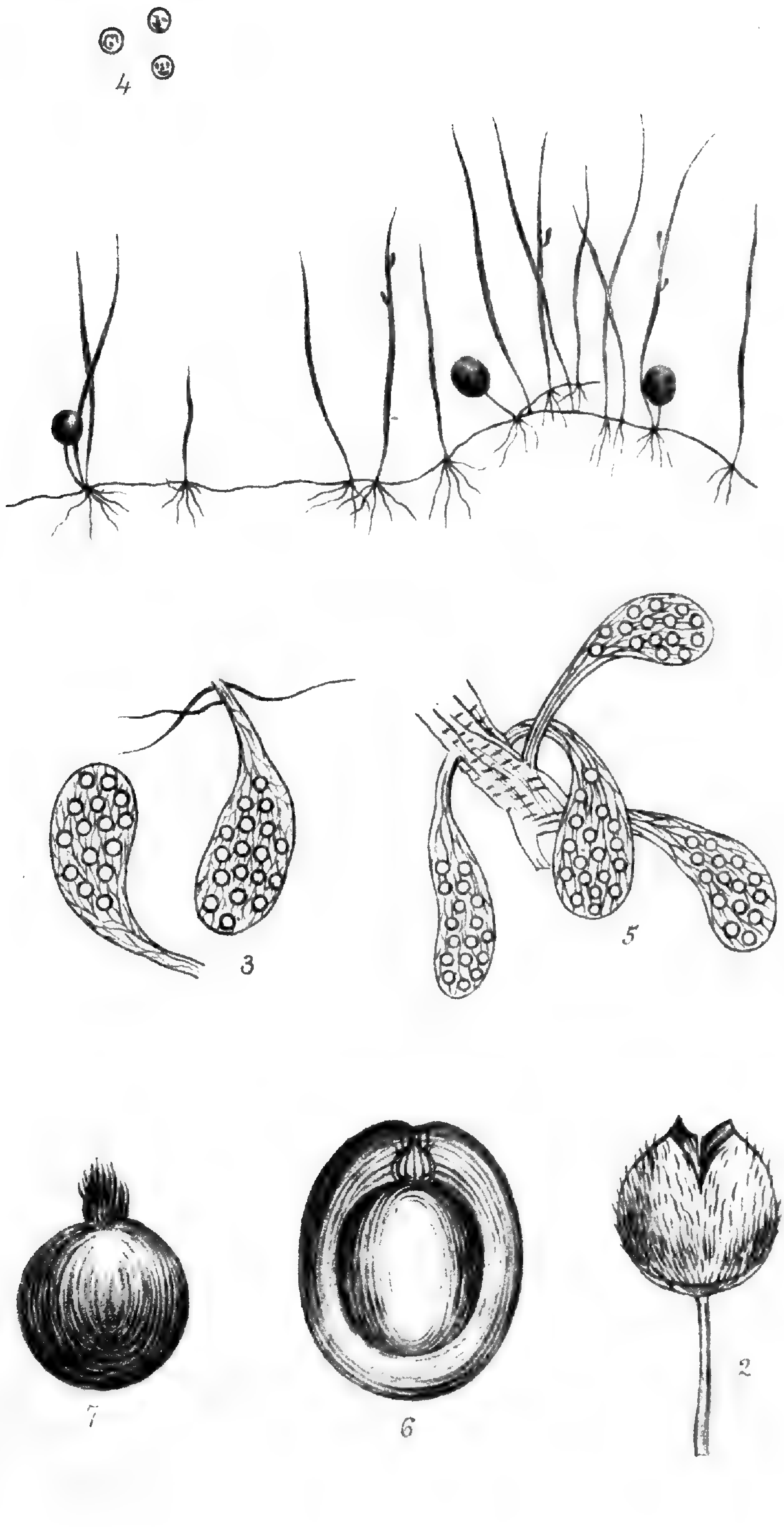
Hab.: South Island: the Bluff Hill, Southland.

Allied to *H. depressa*, Hook., f., from which it is distinguished by its peculiar habit, solitary terminal inflorescence, and narrower fruit. It forms a compact sward in boggy ground.

Umbelliferæ.

Ligusticum enysii, n. s.

Depressed, 2–4 inches high, solitary. Leaves few, spreading, when fresh excessively thick and glaucous, 2–3 inches long, linear, pinnate, leaflets in 3–6 pairs, sessile, ovate, or ovate-acuminate, lobed or deeply toothed, not piliferous. Stem decumbent, 2–4 inches high, simple, or with a single branch. Umbels of 3–5 unequal, spreading rays, springing from a cup-shaped involucre composed of 2 broadly ovate, apiculate, involucral leaves; partial umbels 3–6 flowered, flowers on slender pedicels. Fruit ovoid, carpels 5-winged.



PILULARIA NOVÆ-ZEALANDIÆ n.sp.

T. Kirk. del. J.B. lith.

CELMISIA WALKERI, *n. sp.*

J.B. del. et lith.

Hab.: South Island: Limestone Rocks, Broken River, Canterbury. J. D. Enys and T. Kirk.

Allied to *L. aromaticum*, Banks and Sol., from which it differs in its singular habit, excessively thick, glaucous leaves, connate involucre and broad fruit. The cauline leaves are not furnished with sheathing bases.

COMPOSITÆ.

Celmisia walkeri, n. s.

Plate XXX.

Stem woody, procumbent, stout, sparingly branched; branches ascending. Leaves crowded, linear, 1–1½ inches long, acute, patent, with broad imbricating bases, wider than the blade, slightly coriaceous, serrulate, clothed beneath with snow-white appressed tomentum, margins not revolute. Peduncles 5–8 inches long, solitary, axillary, one to three near the tips of the branches; very slender, with numerous linear bracts. Head 1½ inch in diameter. Involucral scales linear, tips recurved, glandular; ray florets 30–40, narrow.

Hab.: South Island: Dividing range above Lake Harris, Otago, 3,500 to 4,000 feet. Captain J. Campbell Walker and T. Kirk.

Stem clothed at the base with the persistent remains of dead leaves; whole plant slightly viscid, peduncles and involucre glandular.

A remarkable plant, which might with almost equal propriety be referred to *Olearia*, with which it agrees in having the lower part of the stem woody, in the spreading leaves, and lateral inflorescence. The broad membranous leaf bases, and the slender bracteate flower-heads are essentially those of *Celmisia*.

It is allied to *C. ramulosa*, Hook., f., from which it differs in its larger size, acute spreading leaves, which are never revolute, and in the long axillary peduncles. There can be no doubt that other species with woody stems will ultimately be discovered.

I have named this fine plant in compliment to my friend, Captain J. Campbell Walker, in whose company I had the pleasure of collecting it.

Raoulia petriensis, n. s.

A small, hard, densely tufted species; branches short, erect. Leaves loosely imbricate, $\frac{1}{10}$ inch broad, broadly spathulate, thickened at the tips, nerveless, clothed on the upper surface with appressed white hairs, greenish below; tips of old leaves recurved. Heads deeply immersed amongst the uppermost leaves; involucral scales about 20, rather stout, with membranous apex and margins; outer series linear oblong, obtuse; inner series linear obovate, narrow. Florets numerous. Pappus of few white hairs with thickened tips, finely serrulate. Achene faintly grooved, smooth.

Hab.: South Island: Mount St. Bathans, Otago. D. M. Petrie.

Allied to *R. hectori*, Hook., f., but differs in the peculiar leaves, larger flower heads, and faintly grooved achenes, which are never silky.

I have dedicated this interesting plant to its discoverer, to whom I am indebted for much valuable information on the botany of Otago.

Erechtites glabrescens, n. s.

Stem 1–3 feet high, soft, furrowed, simple or sparingly branched. Leaves 3–6 inches long, 1–2 inches broad, oblong, or lanceolate oblong, more or less pinnatifid, lobed and toothed, with sinuate dentate margins, sessile, with large toothed auricles at the base, glabrous, or with a few scattered cottony hairs, often purple beneath, extremely membranous when dry. Heads numerous, laxly corymbose; involucral scales, narrow, with scarious margins. Achenes faintly grooved, pappus scabrid.

Hab.: South Island: Roto-iti, Wairau Valley, T.K.; Wairau Valley, Nelson, W. T. L. Travers; Lake Hawea; Valley of the Dart, Otago, T.K.; Stewart Island, G. M. Thompson.

Originally discovered by Mr. W. T. L. Travers.

CHENOPODIACEÆ.

Chenopodium detestans, n. s.

A much-branched, prostrate or decumbent herb; stem and branches sometimes 2 feet long, wiry, terete; whole plant glandular. Leaves $\frac{1}{2}$–$\frac{3}{4}$ inch long, petioled, rhomboid, or rhomboid-hastate, or ovate, acute, entire, or with a tooth on each side. Spikes short, glomerate, axillary, leafy. Perianth 4–5 partite. Stamens 4. Seed horizontal, minutely punctate.

Hab.: South Island: Between Lake Lyndon and Lake Pearson, Canterbury. Outlet of Lake Hawea, Otago.

Originally discovered by Mr. J. D. Enys, who informs me that he has seen it in several localities in Canterbury.

The whole plant emits a pungent and highly offensive odour, resembling that of decaying fish. It is the "Fish-guts plant" of the shepherds.

JUNCEÆ.

Juncus involucratus, n. s.

Culms erect, 1–1$\frac{1}{2}$ inches high, leafy at the base, striated, pith jointed. Leaves grassy, narrow, flat, sheathing at the base, finely striate, sheaths with a narrow membranous margin. Panicle terminal, surrounded by the long involucral leaves, effuse or close, pale, branches short, involucral leaves 3–6, slender, drooping. Flowers 2 or 3-fascicled, rarely solitary. Perianth segments lanceolate, acuminate, or apiculate, with membranous margins, strongly nerved. Stamens 3. Capsule (immature) shorter than the perianth, ovoid, prismatic.

Hab.: South Island: Amuri; 3,000 feet. Easily distinguished from all other New Zealand species by its long involucral leaves.

Allied to *J. planifolius*, Hook., f., and *J. bufonius*, L.

Juncus pauciflorus, n. s.

A small densely tufted species. Leaves ½–1 inch long, with broad sheathing bases, linear acuminate, flat, shorter than the culms. Culms simple, 1–2 inches high, leafy at the base only, 1–5 flowered; involucral leaves ovate, perianth segments lanceolate, acuminate, with membranous margins. Stamens 3; stigmas 3. Fruit ovate, prismatic, equalling the perianth, faintly 3-angled.

Hab.: South Island: Broken River, Canterbury, 2,000 feet.

The peculiar habit at once distinguishes this from all other New Zealand species. The capsule resembles *J. novæ zealandiæ*, Hook., f., from which it differs in the flat radical leaves and simple culms.

CYPERACEÆ.

Cladium huttoni, n. s.

Culms slender, 3–5 feet high, glabrous, terete, wiry, striate, pith continuous. Leaves terete, subulate, with broad sheathing bases, finely striated. Panicle elongated, 10–18 inches long, drooping, lower branches distant, with spathaceous, membranous, acuminate bracts; spikelets sessile in rather loose fascicles, ⅛ inch long; glumes ovate-lanceolate, membranous, acute. Nut ovoid, 3-ribbed, smooth.

Hab.: North Island: Whangape, Waikare, and Wahi Lakes, Lower Waikato; Tikitapu Lake, Taupo.

Allied to *C. glomeratum*, Br., but at once distinguished by its drooping habit, open panicle, and small florets.

Gahnia rigida, n. s.

Densely tufted, culms leafy at base, harsh and rigid, erect, 3 feet high. Leaves 2–3 feet long, convolute, with drooping points and cutting margins, lower surface excessively scabrid. Panicle erect, branches numerous, short, strict, erect, spikelets crowded. Glumes coriaceous, outer longer than the spikelets, awned, margins membranous; upper glumes lanceolate, acute, with a stout nerve serrated at the back. Stamens 5. Nut ovate, brown, or slightly mottled, narrowed at both ends, with 4 furrows on the outside, transversely grooved within.

Hab.: South Island: Between Ross and Hokitika; near the Junction Hotel on the Christchurch-road; between Hokitika and Marsden; near Greymouth, Westland; Valley of the Grey; near Square-town; Nelson.

Allied to *G. setifolia*, Hook, f., from which it is distinguished by its erect panicle, and larger furrowed nuts, transversely grooved within. The nut resembles that of *G. procera*, Forst., from which it is separated by its habit, densely branched panicle, and smaller glumes.

Gahnia hectori, n. s.

Culms 2–3 feet high, sparingly leafy, leaves flat, panicle slender, drooping, branches distant, slender, 2–6 feet long. Leaves convolute, scabrid above and beneath, and with cutting edges. Spikelets not crowded, sessile or shortly pedicelled ; outer glumes coriaceous, ovate lanceolate, awned, shorter than the spikelet ; upper glumes obtuse, with finely ciliated margins ; stamens 4, filaments elongating slightly after flowering. Nut ovoid, obscurely trigonous, deeply furrowed on one side, acute, orange-brown, shining, transversely furrowed within.

Hab.: North Island; not unfrequent: Auckland, Wellington, etc. South Island: Westland, Buller Valley, etc.

Allied to *G. procera*, Forst., but differs in the slender, drooping panicle, elongated branches, short lower glumes, obtuse upper glumes, shorter filaments, and nut.

This species is the *G. pauciflora* of my list of Auckland plants,* and the *G. procera* of Mr. Buchanan's list of Wellington plants.† That species, however, is restricted to the South Island, and at present has not been found north of Hokitika.

G. hectori is the most elegant of all the New Zealand species.

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* "Trans. N.Z. Inst.," Vol. III., p. 156. † "Trans. N.Z. Inst.," Vol. VI., p. 225..

IV.—CHEMISTRY.

Art. LXXXIII.—*On a modification of the Mercuro-iodide test for the detection of Alkaloidal or Albumenous matters.* By William Skey, Analyst to the Geological Survey of New Zealand.

[*Read before the Wellington Philosophical Society, 24th February, 1877.*]

While engaged in making an exhaustive research into the causes which prevent the proper action of the mercuro-iodide test when applied to weak solution of certain alkaloids, I found that a number of salts are able to dissolve certain of the mercuro-iodides of these alkaloids, and thus prevent the formation of those precipitates, which are the indications (unto this test) of their presence. Among the salts which have notable effects of this kind are potassic iodide and mercuric chloride, and it was therefore found to be a matter of great importance that in the preparation of the mercuro-iodide of potassium an excess of either be avoided. This is readily accomplished by adding the solution of the alkaline iodide to the bichloride of mercury until a small quantity of the red precipitate which forms is seen to be permanent, even when well shaken about through the liquid.

The test liquid prepared in this manner generally has two or three times the delicacy of that prepared in the usual way, that is by mixing the necessary salts in the supposed ratio of their equivalents, this ratio being in practise not easy to observe.

Prosecuting this subject further I found that several of the alkaloids and two or three of the albuminoids do not respond to this test, even as thus prepared, except they are present in quantity comparatively large, and I then ascertained that by the application of this test in a still more modified form, even such alkaloids and albuminoids can be indicated, though present only in minute quantity. This modification is a very simple one, and consists in just following up the addition of the mercuric iodide to the suspected liquid with one of mercuric chloride in successively minute quantities until the liquid is permanently turbid, when in case either of these substances is present the precipitate which ultimately forms is of a *pale yellow colour*, instead of a *brilliant red*, as when alkaloidal or albuminous matters are absent.

A good way to apply the mercuric chloride is to take a little of its weak solution (aqueous) up by a thin glass rod, and dip the rod, with attached liquid, into the solution to be tested. Usually the precipitate thus made will at first dissolve. In such cases more of the test liquid is added until the precipitate or turbidity ensuing is permanent.

The instances to which this modifiation of the mercuro-iodide test has been found to be applicable are aconite, atrophia, colchicum, morphia, and veratria, among the alkaloids; caseine and gelatine among the albuminoids. It is also applicable to solutions of digitalin and urea. Those to which I have ascertained it to be unapplicable are codea, narcotina, nicotina, quinine, strychnia and albumen, this last group forming such insoluble compounds with iodide of mercury, prepared as first indicated, that mercuric chloride is not needed with them; strychnia, for instance, giving a distinct cloudiness with it when present in a solution as but $\frac{1}{480\cdot000}$ part of it, quinine affecting this when only in a $\frac{1}{500\cdot000}$ part, narcotina as $\frac{1}{1\cdot000\cdot007}$ part; and albumen, hydrous as it exists in eggs, reacting in a similar way when present in only the $\frac{1}{120\cdot000}$ part.

I append a few approximate determinations as to the degree of delicacy this test (the mercuric iodide and chloride conjoined) admits of in the case of a few of the substances cited in the first group.

Atrophine	$\frac{1}{30\cdot000}$	a distinct cloudiness.
Morphia	$\frac{1}{200\cdot000}$	,,
Veratria	$\frac{1}{250\cdot000}$	,,

For comparison of this test with the best of those hitherto used I may state that morphia and gelatine do not give a decided precipitate with these, except it is present in not less than the $\frac{1}{5\cdot000}$ part of the liquid to which the test is applied.

I should state that the liquid suspected to contain an alkaloid should be made neutral, or care should be taken that no free mineral acid is present; this is readily accomplished by adding thereto sufficient acetate of soda.

The exact composition of the various precipitates formed in this way has not yet been ascertained; they of course mainly, if not altogether, consist of the alkaloid or albuminoid used together with iodine and mercury, but whether in any case chlorine forms a part, I do not yet know, but I believe it does not. Various useful and interesting facts in connection with this subject have been ascertained in the course of this investigation, and which I will shortly state.

In the first place, I find that the compounds of the alkaloids generally with iodine and mercury are readily soluble in ether, and to such an extent that they can be removed from their aqueous solution acidified with acetic acid, by this liquid, as in "Stas's process," and the etherial solution leaves the triple compound in a granular form; this, dissolved in alcohol, and allowed to stand a few hours with thin strips of copper, or agitated a short time with mercury, is decomposed, the organic base present being dissolved in a pure or nearly pure state by the alcohol, and the remainder of the compound precipitated in an insoluble state.

The mercuro-iodide of strychnia is, I observe, readily decomposed by cold concentrated sulphuric acid, and the addition of the proper oxidizing agents to this solution develope the chromatic reaction of strychnine.

The mercuro-iodide of morphia, when recently formed, gives the morphia reaction with ferric chloride, that is, a blue colouration, and what is remarkable, this colour is not evanescent as is that which is got by operating with this test upon a solution of morphia, the colour being maintained for several days, but it is destroyed by bi-chloride of mercury; that it is destroyed in this way explains in part the reason why solutions of morphia so weak as to require the aid of mercuric chloride in conjunction with mercuric iodide of potassium give a precipitate which does not colour blue in presence of ferric chloride.

The mercuro-iodide of digitalin, which I believe I have produced, was especially sought for as an insoluble substance, because tannic acid is known to form an insoluble compound with this principle; this mercuro-salt has a great tendency to pass through filter paper; it is easily and completely soluble in alcohol, also in ether and iodide of potassium, and manifests a distinct pink colouration when placed in contact with cold strong sulphuric acid.

Adverting to particulars in the case of the behaviour of potassic iodide with the alkaloids, I have to state that the strychnia and narcotina compounds with mercury and iodine are but feebly soluble in it. I should state that albuminous compounds of this nature are readily distinguished from alkaloidal ones by their insolubility in alcohol or ether, only the mercury and iodine dissolving, a viscid mass being left, as the albumen, etc.

I have now to relate a few facts which, as being connected with the subject in hand, and arrived at collaterally with its prosecution, I think I am at liberty to do.

The remarkable aptitude to form insoluble compounds with iodides of the alkaloids which mercuric iodide displayed to me during my pursuit of the subject of this paper, led me to seek substitutes for these organic iodides among our metallic ones, and this under the hope that the exact position of the alkaloids themselves, in regard to the metallic bases, might, in the case of success, be easier to define than it is now. In this I believe I have been successful; at any rate, I find that the iodides of silver, thallium, and lead, combine with iodide of mercury. The thallium and lead compounds of this kind do not manifest any great or notable difference in colour from that of their simple iodides. A careful comparison however, of the salts side by side, shows the more complex ones are of a distinct yellower shade of colour than the others.

In the case of silver iodide, however, the change which ensues when mercuric iodide combines with it is so striking, that it seems very remarkable this combination has not before been proved to be possible. The iodide of silver is, as you are aware, of a very pale yellow colour, and the effect of a solution of mercuric iodide upon it is to heighten its colour instantly to a very deep good yellow. As in the case of the detection of alkaloidal matter, however, by the mercuric iodide test, it is necessary to avoid excess of either potassic iodide or mercuric chloride in this reagent when we wish to prepare these double metallic iodides, a circumstance which may account for the fact that they have not hitherto been formed.

Art. LXXXIV.—*On the Composition of the Silver Ore of Richmond Hill* By William Skey, Analyst to the Geological Survey of New Zealand.

[Read before the Wellington Philosophical Society, 24th February, 1877.]

This ore was discovered in the year 1875, by Mr. James Washbourne, and a sample of it (No. 1692) was forwarded to the Colonial Laboratory as an iron ore, with the request that its richness in this metal might be ascertained, but upon being examined by me it proved to be more of a lead than an iron one, and besides, argentiferous to a remarkable extent, no less than 185 ounces of silver being present in it, as calculated upon the ton. This interesting fact was duly announced, and, in consequence, numerous other samples of ore from this locality were transmitted here for assay, and the results of these, though varying greatly, (from 32 ozs. 15 dwts., to 596 ozs. per ton,) showed unmistakeably that silver exists in the Richmond Hill district in considerable quantity, and that by careful selections from the several lodes now opened, silver-mining should pay there, and pay well. The precise position of the lode, from which the first sample was taken, is, according to the prospectors of it, one mile above Richmond Hill, five miles more or less bearing S.S.W., crossing the Parapara River three miles south of Collingwood. The lode from which the specimen was taken, that yielded at the rate of 596 ozs. of silver per ton, is about seven inches thick, and the specimen itself weighed upwards of nine pounds, and upon this I have, in accordance with instructions, performed the complete quantitative analysis, which forms the leading subject of my paper; this ore, of all the specimens to this time received here from Richmond Hill, being supposed to best represent the mineralogical character of the silver-bearing ore of the lodes there to this time opened out. The following are its principal mineralogical characters :—

Massive, nearly homogeneous, cleavage irregular; brittle; structure confusedly crystalline; colour black generally, but in some parts reddish; has the lustre of molybdenite; hardness about 4·5; specific gravity, 4·317.

At a low heat (a little under that of redness) it fuses readily in parts, and with much intumescence.

The sample analyzed contained 15·4 per cent. of siliceous matter, principally quartz, also a little oxy-sulphide of antimony, both of which are thrown out in the analytical results stated below.

ANALYSIS.

Sulphide of Lead	36·12
" Antimony	22·20
" Bismuth	Traces.
" Copper	19·31
" Iron	13·59
" Zinc	5·87
" Silver	2·39
" Manganese	·52
	100·00

The proportion of antimony sulphide to the other sulphides is about as 2 to 7, and its formula appears to be $Sb^2 S^3 + 6$ (Pb. Cu. Zn. Fe. Ag. S.), that of Tetrahedrite is $Sb^2 S^3 + 4$ (Pb. Cu. Fe. Zn. Ag. S.)

After comparing it with the Tetrahedrites very carefully I am led to look upon it as belonging to this group of minerals, although it diverges from any variety of it heretofore announced, and this to such an extent that I have no hesitation in making a new variety of it, to which I would give the name of Richmondite, after the hill in which it occurs, this being in accordance with Dr. Hector's suggestion to me on the subject. It is distinguished from other varieties of this very variable mineral by containing a low proportion of copper, for which lead appears to be substituted.

ART. LXXXV.—*On a useful modification of common Writing Ink.* By WILLIAM SKEY, Analyist to the Geological Survey of New Zealand.

[*Read before the Wellington Philosophical Society, 24th February, 1877.*]

THE subject of the improvement of our common Writing Ink *(ferro-gallic ink)* has lately been forced upon me by the proceedings here of a certain gentleman, a vendor of pens. These pens were alleged by him to be, at least as to their exterior parts, of aluminium, and, in consequence of this, to be incorrodible by ink of this kind. Large numbers of them had been sold by him to various Governments and private persons under these representations; but, in an unpropitious hour, he was moved to attempt a sale of them to our Colonial Government, and under the same representations on their behalf as had been hitherto so successful. A sample of them was therefore handed for examination to the Department to which I belong, when their true character as steel pens was for the first time ascertained and publicly announced.

The fact that there had been such a rush after pens supposed to be incorrodible, showed the great necessity there is for a cheap pen which is proof against the corrosive action of our common writing inks, or of a good cheap writing ink which will not corrode our steel pens; and I accordingly thought the matter over, when it occurred to me that the ink might at any rate be modified so as to afford us this great desideratum. The way in which such an ink should be modified for this purpose will at once suggest itself to you when the specific cause of its corrosive effect upon steel is considered. This is, as you are aware, the combination of oxygen with the iron of the pen, and a partial solution of the compound thus formed in the acids (gallic, tannic, carbonic acid, etc.) of which the ink in part consists, the rest of the compound combining with these acids to form adherent flocks or laminæ upon the pen.

Now it is a well-known fact that all these processes—in short this corrosion, or indeed any corrosion of iron or steel—can only go on when the surrounding liquid is in an *acid* or possibly neutral condition; at least to speak guardedly and in mind of the easy superficial oxidizement of even the noble metals which I have before this shown to you,* it can but go on to a very limited, indeed an imperceptible extent as regards vision. It will therefore occur to you, as it occurred to me, that by alkalizing our common ink, a product would be obtained having no visible effect upon steel pens, the only question to determine being this—whether we can so radically change the character of the ink without rendering it useless? In regard to this question, I believe that I have, after several experiments, settled it quite favourably by using bi-carbonate of ammonia as the alkalizing agent. Any other bi-carbonate will do too, as also borax, or alkaline phosphates; but the first salt is on the whole the best, as any notable excess of it does not, on account of its volatility, long incommode one.

Ammonia, or common soda, cannot safely be used for this purpose, as matters so caustic as these change the color of the ink to a weak pink or purple.

* Vol. VIII. "Trans. N-Z. Institute," p. 332.

A lump of carbonate of ammonia the size of a walnut will generally be found sufficient to add to three or four ounces of ink, and, as soon as effervescence has ceased, the ink is ready for use.

Ink of this description is slightly paler than that not thus modified, and, in drying, does not show quite so black. It is, besides, a little more liable to be washed off in part by water, but, to compensate for this, it neither corrodes nor clogs steel pens; it flows more readily, and is not so much affected by any greasy matter with which it may get in contact as in the unmodified variety.

This kind of ink when dried in hot weather so as to be unusable, can be easily recovered by adding water thereto with or without carbonate of ammonia as may be required. Being an anti-corrosive ink, any pens which have been used with it may afterwards be left therein with very good effect.

V.—GEOLOGY.

ART. LXXXVI.—*An attempt at an explanation of the origin of Mineral Veins, particularly those of Gold and Silver.* By J. C. CRAWFORD, F.G.S.

[*Read before the Wellington Philosophical Society, 29th July, 1876.*]

NUMEROUS theories which have been propounded with regard to the origin of mineral veins are generally acknowledged to be by no means satisfactory or convincing, and it may be said that the world is in the dark upon this subject.

It is extremely improbable that I shall be able to throw any light upon a subject in which so many have failed, but I have got hold of an idea, and it may as well be ventilated to see if there is anything in it.

It may be said that for all practical purposes mineral veins are only found in the palæozoic rocks, and chiefly in that range of those rocks called "silurian." They may be found in small quantities in newer rocks, but in that case they are apt to prove treacherous to the miners.

Now there must be some good and sufficient reason for the locality of minerals being in the palæozoic rocks in question, and if we find out this reason we may have solved the difficulty.

Late researches in deep sea soundings have established this fact, that in the deeper parts of the ocean, below the depth of 2,500 fathoms, the water is strongly charged with carbonic acid, which is supposed to produce a rapid solvent or decomposing effect upon most substances brought within its influence.

It is, I believe, an established fact that silver can always be detected in sea water. Now, supposing this silver, in whatever combination it may be, to come within the influence of carbonic acid at great depths, might it not be, as it were, brought together and condensed by the action of the acid? If silver is always present in salt water may not gold be present also, although from its greater rarity more difficult to detect, and may it not be precipitated in the same way in which I have supposed silver may be affected.

On the other hand, supposing the rocks composing the floor of the ocean to be fractured, the fissures may be penetrated with warm water or gases from below, containing metals in solution, which coming in contact with the carbonic acid may be precipated as carbonates or otherwise; or the waters of the ocean entering, the fissures may be the medium by which metals contained in sea water may be precipitated and retained within the fissures or veins.

If the theory is correct, then the fact is established that silurian rocks have been formed in very deep seas at a greater depth than 2,000 fathoms. The point which seems to me to be most in favour of the theory is this: We find that the chalk formation goes on at a depth of 2,000 fathoms. We find no mineral veins in that part of this formation which has been raised into dry land. To raise an extended stratum from a depth of 2,000 fathoms to a height of some hundreds or thousands of feet above the sea, seems necessarily to involve many fractures, therefore, *prima faciæ*, we might expect to find mineral veins. As we do not find any, I think we are entitled to draw this conclusion, viz., that the depth of 2,000 fathoms is insufficient for the production of mineral veins, inasmuch as it does not produce the required hollow for the collection of carbonic acid. Similar remarks to those made with regard to the chalk may be made of the nummulitic limestone, which occupies so large an area in Africa and Asia, and also with regard to other rocks, both secondary and tertiary.

The theory therefore stands thus: That the filling of veins or fractures by metallic minerals has chiefly taken place at a depth of about 2,500 fathoms or over; that the precipitating agent has been the carbonic acid always present at those depths; and that precipitation may have proceeded either from metals present in the waters of the ocean, or in gases or heated water rising from below.

We may therefore suppose that the formation of mineral veins may be always proceeding at the depth already pointed out; possibly collecting fresh stores for a time, when the present mines are worked out and the present continents have passed away. I have not sufficient chemical knowledge to be able to work out this theory in detail, therefore only give it as a general idea of the probabilities. It may be objected that metamorphism is a necessary preliminary or adjunct to the presence of metallic veins, but as a matter of fact the most highly metamorphosed rocks are not the most abundant in metallic minerals.

ART. LXXXVII.—*On probable reasons why few Fossils are found in the Upper Palæozoic, and possible Triassic Rocks of New Zealand.* By J. C. CRAWFORD, F.G.S.

[*Read before the Wellington Philosophical Society, 16th September, 1876.*]

THE Upper Palæozoic Rocks occupy a great area in New Zealand. In Wellington and Hawke Bay they form the whole of the true mountain ranges, Tararua, Rimutaka, Ruahine, etc.; and in Auckland these ranges are continued to the N.N.E. to the sea in the vicinity of the East Cape, that Cape, however, being of newer formation, either upper mesozoic or cretaceo-tertiary. The Kaimanawa range is formed of the same palæozoic rocks, which also crop out in many other parts of Auckland. It is supposed by Dr. Hector that triassic rocks are mixed with these palæozoic rocks, but for the purposes of the present argument it may be as well to consider them as being all palæozoic.

In the South Island these rocks attain equal or greater development, forming the eastern part of the great mountain chain of that island. Of these rocks the Kaikouras are formed, also the mountains skirting the Canterbury Plain, and parts of the eastern mountains of Otago.

I have searched diligently for fossils in these rocks in the mountains of Wellington, and have found nothing except some impressions of plants, chiefly in two places, viz., near Pauatahanui, and at Oriental Bay, within the limits of the City of Wellington. These impressions were too indistinct to make anything of. I may say that it could hardly be decided whether they were of terrestrial or marine origin. One point, however, I may mention. I took their line of strike from Pauatahanui, and went on this bearing to Oriental Bay, some twelve miles distant, and there found them at once.

I have also found some vermiform casts of indistinct character.

I believe that nothing of more decided character has been found in these rocks in Canterbury or other parts.

Now in the older palæozoic rocks of Nelson and Otago, distinctive fossils have been found of a similar character to the graptolites and other fossils of the lower palæozoic rocks of Europe, and therefore it seems curious why the upper palæozoic rocks should be wanting in the remains of ancient life. The rocks above this series are full of fossils.

The first idea which no doubt may be brought forward is, that from the mineral character of these rocks the fossils which they contained have been removed by chemical destruction or otherwise; but when we consider the immense area which they occupy, it seems unaccountable that the destruction should have extended over so large a space.

I think I can give a more satisfactory reason, viz., in the mode of deposition of the rocks themselves.

If we examine the older palæozoic rocks of New Zealand we find them to have been deposited in regular parallel strata of great thickness. The mesozoic and tertiary strata are also deposited with the usual regularity; but, when we come to examine the upper palæozoic rocks, we find the rule to be extreme irregularity. Sandstones and slates run in and out of each other, thin out, enlarge, and mix together in a remarkable way. There is very little solid rock within the whole area that can be used for building purposes, because the rock is so much jointed that it readily breaks into angular fragments.

Now what does this extreme irregularity indicate? I should say deposition in a sea agitated by rapid, conflicting, and changing currents. This would indicate a state of things unfavourable to the growth of animal life; and destructive, during the process of deposition, to such life as might exist.

It seems to me that this is the most probable theory to account for the remarkable absence of fossils in the upper palæozoic rocks of this country.

I only throw out this theory, however, in a tentative manner. I can see that, in certain localities where the tides and currents are rapid, conflicting and changing deposits are no doubt going on, well filled with the remains of organic life. Thus in the British Channel, and the great fishing-grounds of the North Sea, there are no doubt great quantities of the shells of molluscs, and of the bones and teeth of fishes, deposited with the detritus brought down by rivers, or re-arranged by the changing currents. Therefore there may have been other causes at work than those above indicated. The depth at which the deposition took place may have to be taken into account, as also possible changes in the direction of currents. We may suppose that if, from changes in the sea-bottom, an equatorial current were diverted into one from the poles, or *vice versa*, from a polar to an equatorial current, a complete destruction of animal life within the area might take place, and a long time might elapse before new forms of life spread from the nearest parts then presenting a similar temperature.

I would by no means, however, discourage attempts to find fossils within the area of the newer palæozoic rocks. When we consider for how long a period the slates, sandstones, and limestones of the older palæozoic rocks of Wales were considered to be azoic, but were afterwards found, by Sir Roderick Murchison and others, to be rich in fossils, we need not despair, for a long time to come, of finding fossils in the ranges of Tararua, Ruahine, etc. Whoever shall make this discovery will have reason to congratulate himself on having added another link to the chain of New Zealand Geology.

When I speak of these rocks as upper palæozoic, I refer to their relative position to the schists of the older silurian rocks of Otago, and other parts of the Middle Island, and therefore conclude that they are probably upper silurian. The term of upper palæozoic might otherwise be held to mean carboniferous or devonian rocks.

Against this idea, however, it may be stated that the composition of the sandstones and slates more resembles that of carboniferous, or devonian, rocks than of the upper silurian rocks of Europe, and the few remains of organic life yet discovered being of vegetable origin, may it not be possible that here we have the representatives of the carboniferous rocks? If this be the case, it is to be regretted that the coal seams appear to be absent.

On the other side, however, it may be argued that it is unusual, and, as far as I am aware, unknown, to find the rocks of the carboniferous period contorted and folded so that the position of the strata is practically vertical; but, in New Zealand we have, on the east coast of Wellington, rocks of much later date—upper mesozoic, or cretaceo-tertiary—with their strata standing vertical.

A few fossils would resolve our doubts. One thing is certain, which is the extreme irregularity of deposition of these rocks.

As to what I have above remarked on the matter of folding of the strata, it is, I suppose, generally held that, during the palæozoic period there was a great shrinking of the crust of the earth, from the results of secular cooling, which produced the result of great fracture and folding of the strata of the crust. It may, I think, be taken as a general rule that the folding of the strata of the palæozoic rocks of the age of silurian, and beneath, is far greater than can be found in rocks above that age. The superior rocks are fractured and faulted, but seldom folded to the same extent.

May not another theory be adduced? If rocks are formed at a great depth in the ocean bed, say from 2,500 to 3,000 fathoms, forming in the curve between two continents an inverted arch; and the sea-bottom is gradually raised from this great depth to higher than the ocean level: will not this movement fully account for the fractures and folding, without the necessity of calling in the theory of shrinking? No doubt the arch may be one of small curve, but rocks must have room to expand under pressure, otherwise they must break, and, if the lateral pressure is very great, they must fold also.

I have seen fossils in the Museum from rocks of a somewhat similar lithological character to those above described, from the Wairoa, at Nelson, and from the Nuggets, in Otago. These rocks may belong to the same series, in which case, being of triassic age, our supposed upper palæozoic rocks would of course prove to be triassic also; but a lithological resemblance is not a positive proof, but only an inference, and supposing the triassic age of the series to be proved, we still have the remarkable fact of the non-discovery of fossils in the great mountain ranges in both islands, composed of these rocks, for the Wairoa and the Nuggets are, at the best, only outlyers. Therefore, the reason why fossils are not found in these mountain ranges is still a question for argument.

ART. LXXXVIII.—*Sketch of the Geology of the northern portion of the Hawke Bay.* By S. PERCY SMITH.

Plates XXII., XXIII.

[*Read before the Auckland Institute, 27th November, 1876.*]

THE following notes have reference to the country lying to the northwards of the town of Napier, extending along the coast of Hawke Bay to the Mahia Peninsula, and inland for a distance of from 15 to 25 miles, as is shown upon the accompanying map.

The geology of this part of the North Island is tolerably simple. It forms part of a large elongated basin occupied by rocks of the tertiary age, called by Dr. Hochstetter the "Hawke Bay series," but now I believe included in the Ahuriri formation of Captain Hutton,* and includes also rocks of an older date, all of which have been deposited on the flanks of the slate mountains found a few miles further inland. The greater part of the eastern edge of this basin has been gradually eaten away and removed by the action of the sea, but in the northern part of the district the westerly dip of the beds shows that part of the ancient margin is here preserved. This may also be seen a little further south, near Cape Kidnappers, where the strata all dip towards and under the Ahuriri Plains. A line drawn from near Napier in a north-easterly direction to the falls at Te Reinga on the Wairoa River, will very nearly coincide with the synclinal axis of the basin, towards which the strata on either side regularly dip, Scinde Island being part of the youngest formation present.

I very much regret that owing to want of time I was unable to carry my sections a few miles further westwards, so as to show the relation between the rocks here described and the old slate rocks forming the axis of the island, and which extend uninterruptedly from Wellington to the East Cape, forming the Tararua, Ruahine, and Urewera mountains. To anyone accustomed to the shapes presented by mountains of this class of rock, however, there is no mistaking their appearance as seen even from a distance of several miles. Their positions therefore will be indicated on the accompanying sections with tolerable accuracy.

That an extensive series of stratified argillaceous and sandstone rocks exists between the lowest beds shown on Section No. 1, Plate XXIII., and the slate ranges at Huiarau is evident from the appearance of the country looking westward from the high mountains surrounding Lake Waikaremoana, where every here and there the white surface of the rock has been exposed on the hill sides by land slips.

* See introduction to "Catalogue of Tertiary Mollusca," Wellington, 1873.

The upper part of this formation is the lowest and oldest shown on the sections. It crops out on the shores of Lake Waikaremoana, forming low white cliffs, and partaking of the same dip as the superincumbent sandstones and gritstones. In its lithological characters it somewhat resembles the Papa Rocks, to be described further on, but is much harder and whiter, and contains in places peculiarly-shaped cement stones or septaria, which, owing to the weathering of the clay in which they are embedded, often stand out in grotesque forms.

I only saw fossils in one spot, and regret that I was unable to procure any of them.

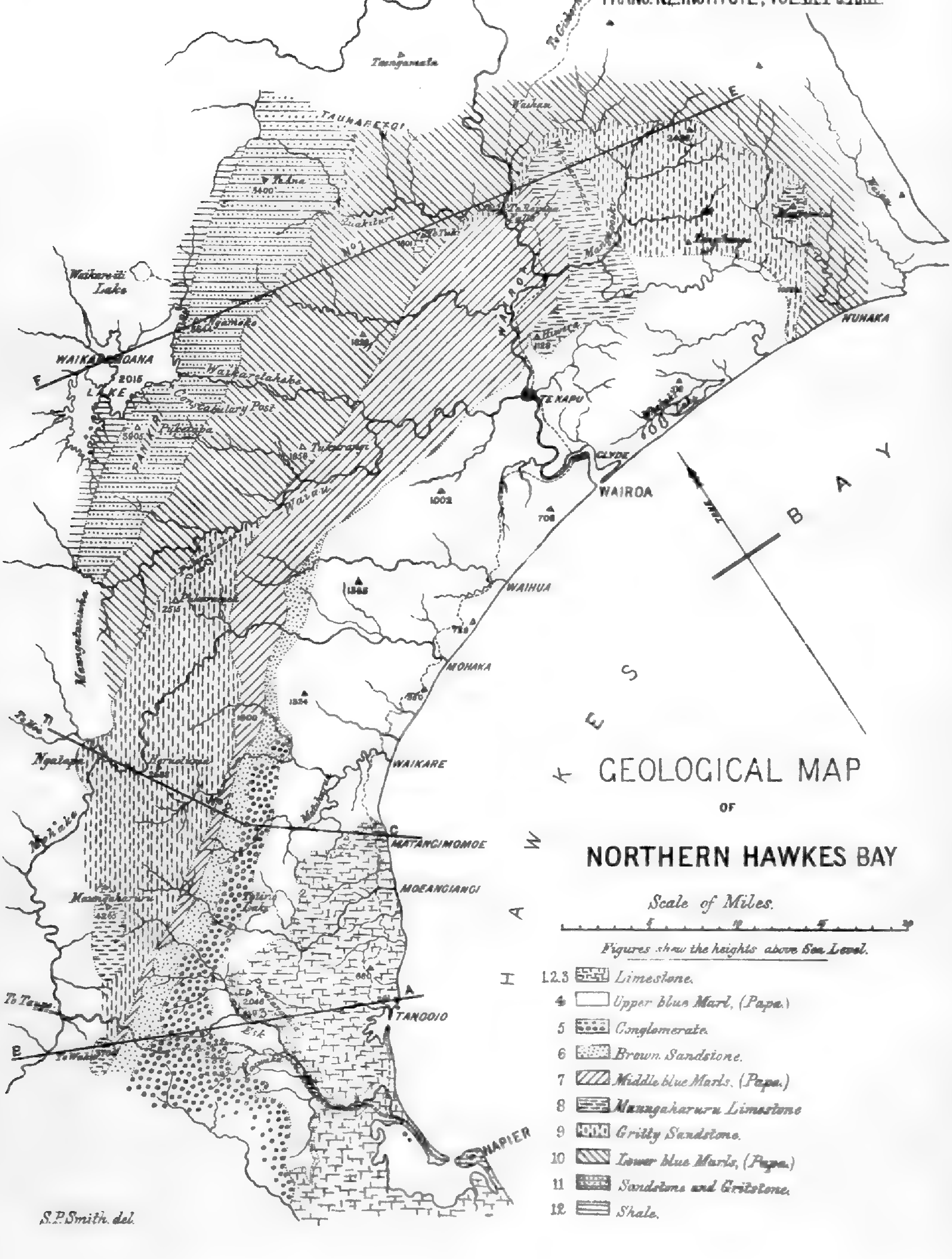
Waikaremoana Sandstones.

Lying conformably on these clayey strata are a series of very hard sandstones and gritstones, having a probable thickness of over 2,000 feet. These sandstones form the Panikiri and Matakuhia ranges, most prominent features, rising in one long slope of 20° from the east, to a maximum height of 3,905 feet above the sea, and then suddenly descending on the western face 1,900 feet, nearly perpendicularly, to the shores of the Lake. The prevailing colour is greyish-white where exposed to the action of the weather, but when in the form of boulders, as seen in the river beds, it is a rich dark brown. The stratification is well marked, the beds dipping to the south-east at angle of 20°. The hardness and sharpness of these sandstones is such, that they will probably be used at some future date as grindstones and sharpening-stones, and also for the purpose of flagging, for which they are well adapted, as slabs may be obtained often of ten feet square and from six to eight inches in thickness.

They form most picturesque groups on the shores of the Lake, where broken by joints and fissures, which are generally filled with a rank growth of vegetation, conspicuous amongst which is the graceful Beech tree *(Fagus)*, which in the higher parts of the mountains forms large open forests. In the month of February on these trees is often to be seen a very handsome Scarlet Mistletoe, which I have seen nowhere else.

The western line of outcrop of the sandstones may be traced for many miles to the north-east of Waikaremoana in a succession of bold precipitous bluffs facing the north-west.

The Lake itself lies at the foot of these mountains, and is about eleven miles long, with an average width of two miles, its greatest breadth being opposite the Constabulary Station of Onepoto, where it is four miles across. It is acknowledged by all who have seen it to be by far the most beautiful of all the Lakes of the North Island. The grandeur of the bluffs of the eastern side, rising as they do at Ohiringi 1,100 feet perpendicularly out of the water, is unsurpassed by any cliff scenery I am acquainted with; whilst


GEOLOGICAL MAP
OF
NORTHERN HAWKES BAY
Scale of Miles.
Figures show the heights above Sea Level.
1.2.3 Limestone.
4 Upper blue Marl, (Papa.)
5 Conglomerate.
6 Brown Sandstone.
7 Middle blue Marls. (Papa.)
8 Maungaharuru Limestone
9 Gritty Sandstone.
10 Lower blue Marls, (Papa.)
11 Sandstone and Gritstone.
12 Shale.
HAWKES BAY
WAIKAREMOANA LAKE
Waikareiti Lake
TE KAPU
CLYDE
WAIROA
WAIHUA
MOHAKA
WAIKARE
MATANGIMOMOE
MOEANGIANGI
TANGOIO
NAPIER
NUHAKA
Tutira Lake
Wairau
Mohaka
2015
5905
1002
706
1365
S. P. Smith. del.

the innumerable long narrow arms, charming little bays, and rocky islets of the southern and western shores, are equally beautiful in their way. The Aniwhaniwha Waterfall, at the north-east end of the Lake, is well worthy of a visit; a boat can be taken right up to the deep pool at its foot, and from there the double Fall can be seen to great advantage as it tumbles over the sandstone cliffs. The shores of the Lake are everywhere very steep, and, with a few exceptions, covered by forest right to the water's edge, the most common tree being the beautiful Beech.

The surplus waters are carried off by the Waikaritaheke River, though in ordinary weather the outlet is not visible, being subterraneous. On descending the dry watercourse of the river some little way, however, it is seen bursting forth from a crevice in the rock, and thence descends in a series of rapids to join the Wairoa, falling in the first three miles as much as 1,500 feet. There are several of these underground outlets, which are sufficient under ordinary circumstances; but after very heavy rains, or a westerly gale, the lake rises sufficiently to overflow the rocky bar at the mouth of the river, and then the water descends as a flood. The height of the lake above the sea is 2,015 feet, and that of Waikare-iti, a small lake situated a few miles to the north, is 3,122 feet, being probably the highest sheet of water in the island.

Lower Papa.

Resting on these Waikaremoana sandstones, the next formation, is a a great thickness of calcareous clayey marls, known universally on the East Coast by the name of "Papa Rock." This papa rock occupies probably the largest surface area of any rock met with between the East Cape and Napier. It is not, however, a continuous formation. I believe it to be of several different ages. At the line of junction between this and the underlying sandstone there is evidence of a break in the continuity of deposit, as may be seen in the valleys of the Waikaretaheke and Ruakituri, where the Papa contains embedded in it large boulders of the sandstones, showing that an elevation of the sandstone must have taken place sufficient to have formed a coast line upon which the denuding powers of the sea had been exercised in the formation of these boulders. The dip of the two formations is, however, very nearly the same. These beds are generally distinctly stratified, with here and there bands of a much harder and more sandy rock. At the point where the Waiau River first enters them, are to be seen embedded in the Papa large boulders of exceedingly hard yellowish cement stones or septaria. They are best seen under the Pukaramea Bluff, where the beds of the streams are often filled with them. Fossils are apparently scarce, though no doubt a proper search would reveal a great many more than I saw.

Maungaharuru Sandstones.

Lying on the lower Papa is found a vast series of hard sandstones and gritstones, with thin strata of limestone composed of rolled fragments of shells and interbedded bands of Papa. This sandstone bears a great resemblance to that of Waikaremoana, being equally hard, and generally of the same colour, although it is sometimes varied by bluish and yellowish varieties, more especially in its upper parts, where it is also much softer. They extend from Maungaharuru to the Waiau river, where they are lost to view, having apparently suffered great denudation, and are covered by the next formation, until some 25 miles to the north-east they again occur at Te Reinga, the point where the Wairoa River precipitates itself over their outcrop in a magnificent fall. Continuing on to the east they compose the lower part of the Whakapunake range, attaining an altitude above the sea of 3,198 feet, and forming some grand perpendicular cliffs facing the east or seaward side of the basin. From here they tend to the south-east and south, finally reaching the sea coast near Nuhaka, where however the uppermost beds only are seen, composed of soft yellowish sandstone containing many fossils. At Nuhaka, the Papa is seen immediately to the east of these sandstones, but there is some doubt as to whether it belongs to that formation already described or to the middle Papa, which overlies the sandstones to the south-east. It contains some of the same cement stones. The question will ultimately depend upon the presence of the same fossils, but as I obtained none, either here or in the southern part of the lower Papa, the matter must at present remain an open question. The bands of limestone occurring with these sandstones are composed almost entirely of broken and rolled fragments of shells, principally of the genera *Pecten*, *Ostrea*, and *Waldheimia*. The dip of the beds varies from 17° to 29° 30′, being greatest on the slopes of Maungaharuru. Here the surface of the country is broken up into deep gorges with perpendicular sides of grey sandstone, the bottoms of which are occupied by streams, ponds, patches of bush, and numerous waterfalls, forming altogether a most picturesque country.

Pohue Papa.

We have now arrived, in our upward course, at a point where a considerable break occurs in the sequence of the beds, which is plainly seen where the two formations meet. Section 2, Plate XXIII., exhibits the unconformability of the beds as seen on the Upper Waikare stream, where the Papa, dipping at about 10°, abuts against the steep face of the sandstones, dipping under them at an angle of 29° 30′. This unconformability is a marked feature in viewing the country anywhere near the line of strike of the beds, where the older strata, even in places where the sandstone (as I suppose) has been

SECTIONS OF GEOLOGICAL MAP OF NORTHERN HAWKES BAY.

Horizontal Scale—4 miles to the inch. Vertical Scale—5000 ft. to the inch.

S. P. Smith del.

denuded off, are seen dipping at a considerable angle, forming hills which are quite characteristic and different in shape to the Papa hills of the overlying formation. I have termed these beds the "Middle Papa," to distinguish them from those of the same lithological characters both above and below them. They are composed of the same bluish marly clays, with intercalated seams of harder, more sandy Papa. Their general dip is about 10°, varying in direction from south-east, near Maungaharuru, to south and south-west as their northern termination is reached. Fossils are plentiful, but, as is usually the case when embedded in Papa, are of so fragile a nature that it is very difficult to preserve them. I obtained eighteen different species of *Testacea* from these beds in different parts. In this formation we first see signs of local disturbance, which is not continued, as far as I am aware, into the overlying one. We must therefore suppose that the movement took place before the deposition of the later ones, and was confined to a small area; this being very near the axis of the synclinal basin. As a general rule, the uniformity in amount and direction of the dip in each formation, over large areas, is very remarkable, and shows, I imagine, that the last elevation which brought the beds into their present position must have been on a large scale, and extending over a protracted period. It is probable that this Middle Papa thins out considerably towards the south, as is shown on the map. It is, however, I think, present at Pohue, a point on the Taupo road, although I did not actually see the rock itself, but a large *Dentalium*, which is a characteristic fossil of the beds, was brought to me there, and described to me as having been found in blue clay at the foot of the Titiokura Pass.

Brown Sandstone and Conglomerate.

Lying conformably on the Middle Papa is found a considerable thickness of brown soft sandstone, overlaid by beds of conglomerate formed of slaty pebbles cemented together by ferruginous matter. The best section of them is seen along the Taupo road from Rangimaipapa Hill to Te Pohue Lake. Both beds thin out and gradually disappear to the north. The conglomerate itself is very easily traced across country by the steep escarpments it presents, especially towards the west or uptilted side. I saw no fossils in either of these beds.

Esk or Upper Papa.

We next come to the Upper Papa, which there is every reason to believe is not conformable to the conglomerate underneath. Of this, however, I cannot be certain, as I had not time to search in positions which would show their line of junction. This Papa is wonderfully full of fossils, of which I brought away 21 different species, many other larger ones being much too fragile to get out of their matrix. The nature of this rock is much like the two formations of the same name already described, but there are certain differences in its characters by which it may generally be recognized in the field; and these are, first, the perpendicularity with which it stands up in cliffs, its greater homogeneity, and a peculiar form that the fracture of the rock takes as it weathers and falls, which is conchoidal, like the fracture of flint, only on an immensely larger scale. It seems also more liable to small slips. Standing on the Purohutangihia range, and looking northwards towards the Wairoa, these beds may be distinguished from the Middle Papa (on which they rest, beyond the limits of the brown sandstone) by the enormous number of land-slips which dot the surface of the country, giving it an appearance of great barrenness: this is far from being the case, however, for whenever the soil is derived from the Papa rock, it is very rich indeed.

The quantity of material which is yearly precipitated into the beds of the streams off the surface of these Papa hills in this district is something incredible, and will ever be a constant source of heavy expense in keeping the roads open. During the heavy and continued rain of last January, many of the roads were simply impassable by horses for weeks, and many millions of tons of clay must have fallen. Some of the slips were of large extent. I saw one myself which was three-quarters of a mile long and a a quarter of a mile wide, which had slid down the side of a mountain into a gully, carrying everything before it. Large trees were uprooted and left, many of them with their heads buried deep in the ground and their roots high in the air; and large Rimu trees, six feet in diameter, were broken short off in a manner that would scarcely be believed, whilst enormous masses of rock as large as cottages were piled up pell-mell on the tops of the trees. Another slip is described by one of the Surveyors as over a mile long, which fell into the Waiau River, damming up its course and causing a long narrow lake to form, three miles long.

I have already spoken of the fertility of the Papa soil. This is proved by the readiness with which the grass takes on the surface of the newly-formed slips.

Brown Papa and Calcareous Sands.

Above this Upper Papa another bed of conglomerate is seen in the Esk Valley, but it is of no great extent; and above that again are a series of calcareous clays, which have a very small surface exposed horizontally, owing to the ease with which they disintegrate and are carried away by water. They are generally fossiliferous, and range upwards for about 500 feet, and are then overlaid by a hard calcareous sandstone, also containing numerous fossils, the most common ones being species of *Arachnoids* and *Placunanomia.* It is this sandstone which forms the lowest strata seen at Scinde

Island, Napier, where it occurs at the sea level, and is there overlaid by the Napier limestones, which have a thickness of about 300 feet.

Napier Limestone.

A little further to the north at Tangoio it is somewhat less, and is divided by strata of dark grey clays and softer yellowish limestone. Further inland it again increases in thickness, being probably 300 feet deep along the bluffs of Purotangihia range. These limestones and associated beds form to the north of Napier a high broken plateau, rising at Purohutangihia to 2,046 feet, and thence sloping gradually to the sea near Tangoio, where the cliffs are 250 feet high, but rising again towards the north at Matangimoe-moe, where the cliffs are 1,200 feet in height above the sea. The limestone generally has steep escarpments bounding it, often quite inaccessible. It is full of fossils, generally rolled and worn, principally *Pecten* and *Ostrea*. In some places, however, the shells are perfect, as in a branch of the Manga-pikopiko stream, where the bottom of the valley is strewn with large oyster shells in incredible quantities.

This limestone (if we except the much later formed deposits of shingle, pumice, and river terraces) is the youngest of the rocks in the district of which this paper treats. It has a very considerable extension to the south of Napier, reaching as far as the upper end of the Wairarapa Valley, and is probably of the same age as the limestones found on the southern flanks of the Kaimanawa Ranges on the other side of the Ruahine Mountains. That it has suffered very great denudation I have not the slightest doubt, as it gradually rose from the sea by the action of running streams, and I may add by the wind, which as a denuding agent is by no means to be despised, at all events in this part of the country. An inspection of the map (Pl. XXII.) will show that several out-lying patches are scattered over the district, extending inland to Maungaharuru, and northwards to Whakapunake and the Mahia Peninsula. All these isolated portions dip regularly towards the centre line of the Hawke Bay basin, and with one exception the fossils are the same, as far as my imperfect knowledge of the subject goes. This exception is the mass of limestone capping the hills to the east of the Wairoa River, and extending to Whakapunake. Here the rock is composed almost entirely of *Waldheimia* shells, giving it in places a peculiar botryoidal appearance. Whether the other fossils common to the rock in other places are present also, I am unable to say, but I saw none in the few places I was able to examine. The dip of the underlying strata is also hidden in this part, excepting on the bluffs of Whakapunake, where the limestone appears to rest on the Maungaharuru sandstones, but a little to the north of Te Hiwera, the Papa is seen dipping south-south-west, whilst the Waldheimia beds dip nearly west. At Moumoukai, on the Nuhaka River, is another patch of limestone, containing the usual fossils, and dipping to the west at about 10°, whilst at Te Tuhi a few large blocks are left capping the hill, also with the same fossils. It will be seen from an inspection of Section 3, Plate XXIII., that if the limestone there shown were continued westwards with the same dip, that it would cut the Maungaharuru Range, both at its highest point, 4,265 feet above the sea, and also at Te Waka, in the positions where we actually find it capping the range. This shows, I think, that the intro-vening space was at one time occupied by continuous sheets of limestones, which would have rested unconformably on the lower strata of conglome-rate, etc., and which have been denuded off; in the first place by the action of the sea as the country generally rose, and later by sub-ærial agencies.

I have mentioned above the occurrence of pumice in this district. It is found nearly everywhere: on the river terraces, the hill sides, and on top of the highest mountains, covering the surface with a deposit of sand more or less deep, and in larger or smaller particles. During the course of the last five years it has been my duty to visit the tops of most of the higher mountains lying between Napier and Tongariro, and thence north-ward to the country under consideration, and in every case a deposit of pumice sand has been found, sometimes plainly showing, at others covered by vegetation. On the Panikiri and neighbouring ranges around Waikare-moana, it is found of a considerable thickness, whilst the lower lands along the lake are covered by it sometimes to a depth of three feet. On the eastern side of the Maungaharuru Range it is very thickly deposited, being often, in the gullies, six to eight feet thick. The extensive terraces of the Lower Mohaka River (which contain as large a quantity of level land as is to be found in the district) are thickly covered with it, thereby rendering them unfit for cultivation.

Towards the east the deposit gradually thins out, until, approaching the vicinity of Poverty Bay, very little is seen. The only spots that are free from it are the lowest terraces of the rivers and the surface of the slips, and, as the country lying along the coast is the most subject to these slips as mentioned above, it is here that the pumice has in a great measure disap-peared, thus allowing the grasses to spread.

The general opinion appears to be that this pumice was ejected from Tongariro and the adjacent volcanoes, and was spread over the surface of the country by the wind; and there are certain considerations which favour this view, such for instance as finding the greatest thickness of the sand on the lee sides of the high ranges, where it would naturally accumulate; and also from the fact that the size of the articles appears to diminish as we recede from the supposed centre of distribution; but at the same time this will not account for all the facts. An examination of the sand seems to show that all the particles are waterworn or abraded, and that many of them are too large to be carried by an ordinary wind, being sometimes as large as walnuts, though the average size would be about an eighth of an inch in diameter. The only other hypothesis which would account for the presence of pumice over such an extent of country is, that it has been carried into its present position by water. No doubt many of the extensive pumice drifts of the North Island do owe their origin to that cause, notably the pumice plains of Kaingaroa, near Taupo, which in places are regularly stratified, and often contain the trunks of trees, lying in a horizontal position, converted into charcoal; but there is a great deal of difference between the pumice deposits of Taupo, the Waikato, and the inland portion of Taranaki and those of Northern Hawke Bay. The former invariably occupy level plains or depressions, which no doubt were at one time lakes. To my mind, a deposit of a light substance like pumice, which ordinarily floats on the surface of the water, is only possible in enclosed sheets of water, which would not allow of its escape. If it once reached the open sea it would be carried far and wide by the winds and currents. There is one thing, however, which should not be forgotten, and that is, that the enclosed air, to which pumice owes its buoyancy, might under pressure be driven out, in which case, of course, it would become water-logged and sink, and would then form regular aqueous deposits like sand or clay. That such deposits are sometimes met with, I think every one must allow who has seen the Kaingaroa Plains, or the beds of coarse white sandstone found near the Miranda Redoubt, which is, I think, without doubt, formed of coarse pumice sand, consolidated under pressure; and the deep pumice strata found in the Tauranga District.

I observe in the last volume of the "Transactions of the New Zealand Institute," that Mr. J. C. Crawford, of Wellington, in his paper on "The Old Lake System of New Zealand," has touched upon this subject, and comes to the conclusion that the great central pumice drifts are lake deposits. In this I entirely concur, as far as relates to the country described by Mr. Crawford, but I think that the lake theory cannot be applied in this district. The large extent, and great height of the country over which the pumice is scattered precludes the idea that it is entirely due to the action of water, whilst the fact that the thickest deposit seems to be confined (in this district at least), to the northward of a line drawn in a true east direction from Ruapehu, would add force to the argument, that it was spread out by the prevailing westerly winds; and the water-worn appearance may be explicable on the supposition that it is due either to decomposition or to the attrition of the particles as they were ejected from the volcano. The amount of evidence, however, is not sufficient to come to a conclusion either way; nor are we justified in ascribing to Tongariro and its adjacent volcanoes the origin of the whole of this pumice, until a thorough exploration of the mountainous Urewera country shall have proved that it did not emanate from some nearer source. That volcanic rocks exist somewhere in that direction is proved by the finding of volcanic pebbles in the bed of the Wairoa River, which must have come down the Hangarou, one of its main branches, and which has its source somewhere in the neighbourhood of Maungapohatu, a lofty mountain some 20 miles to the north and east of Waikaremoana.

Of other recent formations present there are the river terraces, sand dunes, lagoons along the coast, caves in the limestone, and the fine gravel along the beach. The course of the Mohaka River presents some fine examples of the first. Near its mouth I have counted as many as eleven separate and distinct terraces, some high, some of only a few feet. These are all cut out of the solid Papa rock, and in the case of the higher one of all (which forms the true valley of the river) this has been spread over with a deposit of shingle derived from the slate mountains of the interior, of from six to eight feet thick. It forms a plain about ten miles long by a varying width of from one to two miles. It is covered thickly with pumice, as before mentioned. Its general level is from 200 to 300 feet above the present river, which has cut for itself a deep precipitous channel, the sides of which afford an excellent section of the various beds through which it passes. The terraces of the Wairoa River are not so well developed. There is one large one, however, which extends up both the main branches at a general height of from 50 to 150 feet above the river level. This is also generally covered with pumice, but not to so great an extent as those of Mohaka, whilst the recent and lower ones are nearly free from it. Of sand dunes there are not many, the coast being generally bold and precipitous. They are found at the low narrow neck of land connecting the Mahia Peninsula with the main (and which narrow neck, I may here observe, would, by a depression of 20 feet, again be submerged, thus making the Mahia an island), and also about the Whakeki Lagoon, which owes its origin to the banking up of the sand and gravel from the beach. A regular gradation may be observed in the sizes of the gravel on the beaches, which at Petane is small shingle, but sets smaller and smaller until at Nuhaka it has become ground down into coarse sand.

The caves of the limestone formation are numerous, but I never had time to visit them.

The Natives relate stories of most wonderful caves, grottos, and fissures as existing in the Whakapunake Mountain. They also stated that in one of these caves, the last of the Moas had his residence, and that their ancestors used to collect the feathers found near its entrance, as ornaments. My informant could not tell how long ago this occurred, and seemed rather inclined to set the whole story down as "*he korero parau na nga tupuna,*" or old men's tales. It is, however, strange that I had heard, many years before, from a Northern Native, that the last Moa was seen on the East Coast, at a place called Whakapuna, evidently indicating this same mountain, though the last syllable of the name had been dropped.

There are several interesting physiographical questions, which a study of this district would illustrate, such as the origin of Lake Waikaremoana and other smaller lakes, most of which occupy true rock basins *not* scooped out by glaciers; the course taken by the present rivers, which are not always along the natural water-courses; the encroachment of the sea; and the alternations in the level of the land; but they would prolong this paper to an undue length, and moreover require to be dealt with by an abler observer than myself.

Appended hereto is a list of the fossils seen, as far as they can be identified, an estimate of the probable thickness of each group, and a map and sections.

List of Fossil Shells from Hawke Bay, deposited in the Auckland Museum.

	Upper.			Middle.			Lower.				
	Limestone.	Calcareous Sands, &c.	Upper or Esk Papa.	Conglomerate.	Brown Sandstone.	Pohue or Middle Papa.	Maungaharuru Sandstone.	Lower or Waiau Papa.	Waikaremoana Sandstone.	Shale and Sandstone.	
Dentalium, sp.	...	...	...	...	...	*	...	...	...	...	
" "	...	...	*	...	...	...	...	...	...	...	
" "	...	...	...	...	...	*	...	...	...	...	
" "	...	...	...	...	...	*	...	...	...	...	
" "	...	...	*	...	...	...	...	...	...	...	
Murex zealandicus	...	*	*	...	...	...	...	...	...	...	
Fusus, sp.	...	*	*	...	...	...	...	...	...	...	
" "	...	*	*	...	...	...	...	...	...	...	
" " (large)	...	...	*	...	...	...	...	...	...	...	No Specimen.
" *stangeri*	*	*	...	...	...	...	...	...	...	...	
" *plebeius*	...	...	*	...	...	...	...	...	...	...	
" *sp.*	...	...	...	...	...	...	...	*	...	...	No Specimen.
Pleurotoma buchanani ...	...	*	*	...	...	...	...	...	...	...	
" *sp., ind.* ...	...	...	...	...	...	*	...	...	...	...	
" "	...	...	...	...	...	...	...	...	...	...	
Turritella tricincta ...	...	*	...	...	...	...	...	...	...	...	
" *sp.*	...	...	*	...	...	...	...	...	...	...	
" "	...	...	*	...	...	...	...	*	...	...	
" " (prominent rib)	...	...	...	...	...	*	*	...	...	...	
Crypta contorta ?	*	...	...	...	...	...	...	...	...	...	
" *profunda ?*	*	...	...	...	...	...	...	...	...	...	
Zizyphinus, sp., indes ...	...	...	...	...	...	...	*	...	...	...	
Purpura, sp.	...	*	...	...	...	...	...	...	...	...	No Specimen.
Ancillaria, sp. (large) ...	...	*	*	...	...	...	...	...	...	...	
" " (small) ...	...	*	*	...	...	...	...	...	...	...	
Voluta pacifica ?	...	...	*	...	...	...	...	...	...	...	No Specimen.
" *sp.*	...	...	...	...	...	...	*	...	...	...	No Specimen.
" " *(subplicata ?)* ...	...	*	*	...	...	...	...	...	...	...	
Natica, sp. (vitrea ?) ...	...	*	*	...	...	...	...	...	...	...	
" " *(callosa ?)* ...	...	...	...	...	...	*	...	...	...	...	
Corbula zealandica ? ...	...	...	*	...	...	...	...	...	...	...	
Venus zealandia	...	*	*	...	...	...	?	?	...	...	
" *mesodesma*	...	*	...	...	...	...	...	...	...	...	
Dosinea anus ?	...	...	...	...	...	*	...	...	...	...	
" *sp. (cyclina ?)* ...	*	*	...	...	...	...	...	...	...	...	
" " " ...	...	*	...	...	...	...	...	...	...	...	
Venericardia australis ...	*	...	*	...	...	...	...	...	...	...	
" *zealandia* ...	...	...	*	...	...	...	...	...	...	...	
Mysia ?	...	...	*	...	...	...	...	...	...	...	
Mytilus, sp. (large)	*	*	*	...	...	?	...	...	...	...	No Specimen.
" " (very small) ...	*	*	*	...	...	*	...	...	...	...	
Pinna, sp.	...	*	...	...	...	...	...	...	...	...	No Specimen.
Pectunculus globosus ? ...	*	...	...	...	...	...	...	...	...	...	
Solenella australis ? ...	...	...	...	...	...	*	...	...	...	...	
" *cumingi ?*	...	...	...	...	...	*	...	...	...	...	
Pecten triphooki	*	...	...	...	...	*	*	...	...	...	
" *williamsoni*	...	*	...	...	...	...	...	...	...	...	
" *zealandiæ*	...	*	...	...	...	...	...	...	...	...	
" *sp.* (small)	...	*	*	...	...	...	...	...	...	...	
" *villicatus ?*	...	...	...	...	...	*	*	...	...	...	
Placunanomia, sp.	...	*	...	...	...	...	...	...	...	...	
" "	...	*	...	...	...	...	...	...	...	...	
Ostrea, sp. (large)	*	...	...	...	...	...	?	...	...	...	No Specimen.
" " (very small) ...	*	*	...	...	...	...	...	...	...	...	
" " " ...	...	*	*	...	...	...	...	...	...	...	
Balanus, sp.	...	*	*	...	...	*	...	...	...	...	
Lucina divaricata ? ...	...	*	*	...	...	...	...	...	...	...	
Mya ? sp.	...	*	...	...	...	...	...	...	...	...	
Leda ? sp.	...	...	*	...	...	...	...	...	...	...	
" "	...	...	...	...	...	*	...	...	...	...	
Waldheimia triangulare ? ...	*	*	...	...	...	*	*	...	...	...	
Rhynchonella, sp. (like *R. nigricans*) ...	...	*	...	...	...	...	...	...	...	...	
" *sp., indes* (small)	...	*	...	...	...	...	...	...	...	...	
Terebratella gaulteri ? ...	...	*	*	...	...	...	...	...	...	...	
Fish Vertebræ	...	...	*	...	...	...	...	...	...	...	
Arachnoides zealandiæ ...	*	*	...	...	...	...	...	...	...	...	
Probable Thickness of each Group in Feet ...	300′	700′	1,000′	300′	1,200′	1,000′	6,000′	7,000′	2,000′		
	2,000′			2,500′			15,000′				

Art. LXXXIX.—*Notes on the Valley System on the Western Flanks of Mount Cook.* By S. Herbert Cox, F.C.S., F.G.S.

[*Read before the Wellington Philosophical Society, 30th September, 1876.*]

The following observations were made by me during a trip in January last to the West Coast, south of Hokitika, on work connected with the Geological Survey, and are placed before the Society with the permission of Dr. Hector.

The points to which I wish to call attention in this paper are more specially connected with the West Coast Glaciers rising in the vicinity of Mount Cook, pointing out the position of the snow-fields from which these derive their origin; this being of special interest, as showing the disconnection which exists between the older crystalline range and Mount Cook proper.

I intend on a future occasion to read a paper before this Society on the glaciation generally of the West Coast, and simply bring the present facts before the notice of the members as a ground-work for further remarks in the future.

Mr. McKay and I arrived at Gillespie Beach on the 22nd January, having come up overland from the Abbey Rocks, where we had been landed by the "*Waipara*" on its way from Jackson Bay.

We had previously settled in our own minds that we would go inland from this point to the Fox Glacier, and endeavour to get back on to the main range, and also see with what prospect of success an attempt to ascend Mount Cook from the West Coast was likely to be attended. I do not think we were ever sanguine enough to fancy that we could ascend the mountain ourselves under the circumstances in which we were placed, and if we ever did indulge such an idea for a moment we had abandoned it before reaching Gillespie Beach.

However, we wished to get as far back as possible, our object being, if practicable, to reach the junction between the older crystalline rocks and the overlying Maitai slates; and accordingly having hired a pack-horse, and prevailed upon a man who had been to the glacier often before, and knew the fords of the river well, to accompany us, we started on the morning of January 25th, arriving at the foot of the glacier the same night.

When Mr. Fox visited this glacier, and indeed until comparatively recently, the river headed from the northern side, and the passage from one side to the other was readily accomplished. Now, however, the river heads from almost the southernmost boundary of the terminal face, and to cross the glacier is a matter of considerable time and difficulty, the result being that, having been obliged to leave the pack-horse a mile or so below the glacier, and having had to swag our things from this point, we arrived too late, and were too heavily laden to make any attempt to get to the southern side to camp as had been our original intention, so we pitched our tent at the foot of the northern spur.

The elevation of the terminal face of the glacier above the sea by aneroid measurement I found to be 660 feet.

From the northern edge of the Fox Glacier a spur rises very abruptly to an elevation of about 5,000 feet, and separates the Francis Joseph Glacier from the Fox, the summit of this spur in the summer time being only capped with patches of snow.

On the southern side of the Fox there is another spur-range, which attains a somewhat greater elevation than that to the north, the highest point being, by aneroid measurement, about 6,500 feet above the level of the sea, the general elevation of the spur being about 5,500 feet.

The next morning we started on our way across, and found considerable difficulty in getting over owing to the manner in which it is crevassed, involving many journeys backwards and forwards up the glacier, in addition to which, in three separate cases, we had to cut steps in the ice to ascend or descend as occasion required.

We got across eventually, and spent the day in examining the rocks which occur in the Conical Hill and in travelling for a distance of perhaps two miles up the southern lateral moraine.

On the southern side of the terminal face of the glacier is a hill called the Conical Hill, on the southern side of which a stream runs, delivering its waters into the Cook River and rising from the glacier about a mile above its terminal face, also deriving a good deal of its water from mountain torrents which fall from the spur-range to the south of the glacier.

Up this creek we went until getting into the lateral moraine; and at a point about 1½ miles up the glacier came to one of the before-mentioned mountain torrents.

We went some little distance up this, and found that, although rough climbing, it was quite practicable to ascend it, at least as far as we could see, so we decided to try this direction for our ascent of the hills next day. We returned to our camp that night, and the next morning started with daylight, having by this time become more familiar with the way across the glacier, which we crossed in about half-an-hour, and then pushed on to the before-mentioned stream. Up this we started, and made pretty good travelling for some time, ascending along the bed of the creek to an altitude of 4,000 feet, a considerable amount of the travelling requiring the use of our hands far more than feet. When we reached this elevation we left the bed of the creek, and, after a rough scramble, got on to a slope covered with alpine plants, which were at this time in full flower, and by eleven o'clock we were on the summit of the range.

On the northern slopes of this spur little or no snow rests, but on crossing the crest of it a large snow-field is seen at an elevation of 5,300 feet above the level of the sea, and *sloping eastwards.*

This field is surrounded on all sides by turretted peaks, which rise as bare patches above the snow, and at one point only could we see an outlet, viz., at the S.E. edge, from which point the Balfour Glacier is fed.

The Fox Glacier trends away to the N.E., at a point about two miles above its foot, to an extension of this snow-field, lying to the westward of a dome-shaped mountain, which we took at this point for the dome of Mount Cook, but whether correctly or not, I am unable to say. The Francis Joseph glacier heads from the northern part of the same snow-field.

The ridge of the spur to the south of the Fox Glacier follows the trend of the Fox Glacier itself; that part of the snow-field, from which the Balfour is fed, thus widening out to considerable proportions, as shown on the diagram, but I had neither the means nor the time to determine the exact extent of this accurately, and am only able to shew it relatively to other points, which have been fixed by topographical surveyors; however, it extends continuously over the dome.

Beyond this snow-field, in a S.E. direction, there is a deep valley separating it from the main range, which, as far as I could determine, is the valley of the Balfour Glacier, and its elevation above sea level cannot be more than from 2,000 to 3,000 feet, a dense bush being seen on the western flank of the main range, which rises abruptly from this valley.

The northern branch of the Weheka or Cook River rises from the Fox Glacier, the middle branch from the Balfour Glacier, and the southern branch—which, according to all accounts, is not an ice river—in all probability has one of its sources in a valley at the foot of the main range in the direction of Mount Cook; the main source, however, heading from Mount Sefton, as is evidenced by an account I got from a digger at Gillespie Beach. It appears that this man wished to get from Gillespie to the Mackenzie country, and thought he could effect a pass at the head of the southern branch of the Cook River, the elevation of the main range there being considerably less than at most points, but very broken and rough. With this end in view, he went up to the head of the south branch, and, as he says, completely lost himself. However, he kept on rising till he got, as he imagined, to the summit of the main range, and then commenced to descend, ultimately finding himself in the bed of the Karangarua River, which brought him out at its mouth, about ten miles from where he started, showing that the southern branch of the Cook River saddles with the Karangarua, at a point to the Mount westward of Sefton.

It will be seen then from the above:—

(1.) That the principal drainage of Mount Cook is to the S.E., by way of the Hooker and Great Tasman glacier; but at the same time it is highly probable that a large quantity of snow from the main range is carried down to the West Coast by the Wataroha, which falls into the sea north of Okarito.

(2.) That a snow-field of very considerable proportions lies to the westward of Mount Cook, not, however, having any immediate connection with it.

(3.) That this snow-field stretches back to the Dome, to the eastward of which the River Wataroha, in all probability, takes its rise from an, as yet, unknown glacier, and consequently that, from Mount Cook, the line of water-shed must retreat to the eastward.

It will further be seen that the Francis Joseph and Fox Glaciers are fed from this snow-field irrespective of Mount Cook, and that the Balfour Glacier derives the greater portion of its ice, at all events, from the same source, but that it may also, to some extent, be fed by avalanches from Mount Cook, which mountain would also perform, in a large measure, the function of condenser for the whole field.

We spent some hours on the snow-field, and then commenced our descent, and, not being satisfied with the way we had come up, thought it better to try the spur for some distance, and then to get into another creek, which, from our point of observation, appeared to rise by easier gradients. We were decidedly unlucky in our choice, having great difficulty in ever getting to the creek at all, and, after reaching it, I counted 36 waterfalls that we had to descend before reaching the edge of the glacier, and we only arrived at our camp when it was quite dark, having had to cross the glacier with very little more light than that afforded by the moon, and having had considerable experience of what Mr. McKay described as the "Boulder Hornpipe."

Before closing this paper, I wish to call attention to a few points of interest, which have come under my notice, with respect to the present glaciers.

In the year 1870, Dr. Haast made the height above the sea of the terminal face of the Francis Joseph Glacier, 705 feet, and of the Fox Glacier, 702 feet.

In 1868, Mr. J. R. Hackett made the height of the Francis Joseph Glacier 640 feet above sea level; and when at the Fox Glacier last January, I found the elevation of the terminal face to be only 660 feet above the level of the sea.

Dr. Haast, in describing his topographical map of the Southern Alps for the Royal Geographical Society, mentions the fact that the Tasman Glacier had advanced about half a mile during the time which had elapsed between his visits there in 1862 and 1870; and in an earlier report on the West Coast, he has also given the height of the Francis Joseph Glacier above the sea at 750 feet. These variations appear to point to the advance of the glacier during the past few years; and the absence, at the foot of the Fox Glacier at least, of any terminal moraine of consequence, adds further proof of the truth of this hypothesis.

Art. XC.—*On the Reptilian Beds of New Zealand.* By A. McKay.

[Read before the Wellington Philosophical Society, 4th November, 1876.]

In March last, I received instructions to proceed to the Amuri Bluff for the purpose of making further collections and a measured section of the north-east face of the bluff. In my official report I confined myself to a statement of the facts observed by me; and now, with the permission of Dr. Hector, I contribute my views in the form of a paper to the Society.

Before doing so I propose to shortly sketch the progress of the geological exploration of the Waipara and Amuri Bluff beds, as the views held as to the age of these vary considerably.

In 1861 a notice of the first discovery of saurian remains, at the Waipara, by Mr. T. H. Cockburn Hood, was given by Professor Owen in a paper read before the British Association, from which it is to be inferred that he considered the fossils to indicate a jurassic age for the formation period.*

In 1864 Dr. Haast, in a paper dated, June, 1869, states that he examined the Waipara beds, at which time he considered the saurian beds to be of lower tertiary age.† In the same year Mr. John Buchanan, of the Geological Survey Department, examined and made collections from the Amuri Bluff beds, considering the Amuri limestone and overlying marls at that place as lower tertiary.‡

In the same report, from an examination of Mr. Buchanan's collections, Dr. Hector was enabled to classify the beds as below :—

Cretaceo-tertiary formation.

A—Chalk marls, the upper parts of which are now known as the grey marls; the lower as the Amuri limestone.

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* Proceedings of the British Association, 1861.

† "Trans. N.Z. Inst.," Vol. II., p. 189, 1866.

‡ "Geol. Reports," 1866-7, p. 39.

B—Ferruginous clays, with septaria and leda marls, containing upper secondary fossils (the greensand group and saurian beds of later classification).

C—Sandstone and grit, with plants representing the West Coast coal-field. Now known as the Amuri group. *

This, the first proposed, will, there is no doubt, prove to be the true classification of the beds, and may be applied equally to the Amuri Bluff and the Waipara sections, minor sub-divisions being in places adopted with advantage.

In 1867 Dr. Hector examined the Waipara section, and, as remarked by Dr. Haast, was the first to point out the true relation of the saurian beds to the overlying Weka Pass limestone.†

In 1868 Mr. Hood made a second collection from the Waipara, and during the same season Mr. R. L. Holmes made in this district a collection for the Colonial Museum. During the same year Dr. Haast made a survey of the Waipara district, and in his report argues at considerable length the question of the age of the saurian beds; considering the whole series, including the coal beds of the Waipara and Malvern Hills, to be of lower tertiary age.‡

During the latter part of the year 1869 and in the beginning of 1870, Dr. Haast, for the New Zealand Geological Survey Department, examined the Amuri Bluff and surrounding district. In his report he describes the Amuri Bluff beds as being altogether distinct from the saurian beds at the Waipara, and notes a total disagreement between the fossils of the two localities.§

In 1871 Mr. H. H. Travers made a collection for the Colonial Museum, at Amuri Bluff; and in 1872 the writer made a large collection from the Waipara for the Canterbury Museum; and in 1873, at Amuri Bluff, another collection for the Colonial Museum, but none of these visits had any reference to the stratigraphical relations of the beds.

During December, 1872, and in the early part of 1873, Captain Hutton, as assistant to the Geological Survey Department, made an examination of the north-east part of the South Island, with a special view to the relations of the saurian beds.

In his report he considers the Amuri limestone, and underlying beds of the same series, as belonging to the very uppermost part of the cretaceous formation. The overlying beds at Amuri Bluff he refers to the upper

* "Geol. Reports," 1866-7, p. 17.

† "Trans. N.Z. Inst.," Vol. II., p. 189. See also "Geol. Reports," 1868-9, Progress Report, p. 11.

‡ "Geol. Report.," 1870-1, p. 5-19.

§ "Geol. Reports," 1870-1, pp. 25-46.

miocene period. The same beds at the Weka Pass and upper part of the Waipara section are by him considered to be of upper eocene age. *

In 1874 I made an examination, for the New Zealand Geological Survey Department, of a part of the Waipara district, with the object of ascertaining the extension of the lower beds of the series in a westerly direction, the collection of fossils, and to determine the relation of Weka Pass calcareous greensand to the underlying Amuri limestone and the overlying grey marls.

During April, May, and June of 1876, I made the collections and examinations already alluded to, the results tending to confirm the view that the entire series as seen at the Amuri Bluff follow in unbroken sequence, of which, with the Waipara beds, the following is a comparative statement:—

Waipara.	Amuri Bluff.
1. Mount Brown Limestone.	1. Wanting.
2. Grey Marl.	2. Grey Marls.
3. Weka Pass Calcareous Sandstone.	3. Weka Pass Calcareous Sandstone.
4. Greensand Conglomerate.	4. Greensand Conglomerate.
5. Amuri Limestone, embracing	5. Amuri Limestone.
a. Tucoidal Limestone.	*a.* ,,
b. Flaggy ,,	*b.* ,,
c. Flinty ,, ; and	*c.* ,,
d. Chalk Marl or Leda Beds.	*d.* ,,
6. Teredo Limestone wanting, or merged in 7.	6. Teredo Limestone.
7. Concretionary Greensand.	7. Concretionery Greensand.
8. Boulder Sands, Saurian Beds.	8. Boulder Sands, Saurian Beds.
9. Glance Sandstone.	9. Black Grit.
10. Conchothyra Beds.	10. Aporrhais Beds.
11. Trigonia Beds.	11. Trigonia Beds.
12. Grey and Rusty Sands.	12. Belemnite Beds.†

In the section at Amuri Bluff the grey marls are not overlaid, as in the Waipara section, by the Mount Brown limestones; these beds, if ever present at Amuri Bluff, having been removed by denudation. The grey marls are here the highest beds, and have partially been removed by denudation. They are present both to the east and west of the older rocks, which divide the two wings of the cretaco-tertiary formation at Amuri Bluff. On the eastern wing, Dr. Haast calls them Leda beds; on the

* "Geol. Reports," 1872-3, p. 47, and Sec. 5.

† The three last beds are distinguished by the abundance of the fossils from which they take their names.

western, Scalaria beds—these latter being, according to him, uncomformable to the Amuri limestone. Captain Hutton, on the other hand, describes the beds on the eastern wing as unconformable to the Amuri limestone, but makes no mention of the scalaria beds of Dr. Haast. These same beds in the Waipara section are referred by Dr. Haast to the Awatere formation, and by Captain Hutton to the trelissaic group of his Oamaru formation. None of these arrangements agreeing with the classification here adopted, which regards the grey marls as the higher beds of the cretaceo-tertiary formation, leaving for future determination the relation of the Mount Brown limestone. That these beds, as seen at Amuri Bluff, belong to the chalk group, there can be no doubt, their conformable sequence to the Amuri limestone, and the contained fossils alike being evidence in this direction. In the upper part they are unfossiliferous, but in the middle and lower part they contain a few bivalve shells, besides abundance of *Foramenifera* shells, which characterise the same marls in other localities. The lower part is also characterized by the great abundance and beauty of the fucoidal impressions contained therein. Downwards, they pass into a calcareous greensand, harder, but presenting the same composition as do the same beds at the Weka Pass and at the Waipara Gorge. These beds are parted from the Amuri limestone by a rubbly bed of calcareous greensand occurring as nodules in a greenstone matrix, which, according to Captain Hutton, contains, at the Weka Pass, rolled pebbles of Amuri limestone.

When I examined the Weka Pass section, in 1874, I observed the pebble-like pieces of limestone, but doubted the evidence of their shape, as proving that they were water-worn.

While yet undecided how to account for them in the position in which they occur, I discovered, in the upper part of Weka Creek, where it breaks through the limestone range and in the underlying greensands, pebbles of Amuri limestone in every way resembling those which occur in the higher greensand parting the Amuri limestone from the Weka Pass stone. I concluded, therefore, that these pebbles are of a concretionary character, as those in the underlying greensands could not possibly be the proceeds of the denudation of the Amuri limestone.

This greensand conglomerate, though never more than two feet thick, generally about ten or twelve inches, is of great importance, as from it fossils have been obtained which have an important bearing on the view here taken of the general sequence. I have not obtained any fossils from this bed at the Waipara or in the Weka Pass section, but at Amuri Bluff it contains in places abundance of fossil bones, and of these there seems to be a considerable variety, but on account of the peculiar character of the matrix they are very difficult of extraction. Some of these I believe to be saurian, but as the bones only appear when the surface of the bed has been long exposed to the action of the sea, they are necessarily much eroded.

From this bed I succeeded in securing two or three recognizable fragments of the fossil Penguin (*Palæeudyptes antarcticus*, Huxley), found in the limestone of Fortification Hill, Oamaru, and at Brighton, on the West Coast of the South Island.

North of Amuri Bluff, at Kaikoura, and in the Clarence District, this horizon is represented as beds of greensand, interstratified with the upper part of the Amuri limestone; and further north, in the vicinity of Cape Campbell, this and the overlying Weka Pass stone is wholly represented by beds of greensand, with which the Amuri limestone itself is frequently interbedded.

In the Amuri limestone itself the fossils of the higher beds are found, and notable amongst these is a well known form of *Pecten zettelii*, which has never yet been found outside the chalk group of the cretaceo-tertiary formation in New Zealand. From the same bed whence the above comes I obtained *Inoceramus*, sharks' teeth, and other remains of fishes, which are equally to be had in the marls above the underlying teredo limestone. In the lower part of the teredo limestone, fossils are met with which characterize the upper beds of the Amuri group, for which reason it is separated from the leda marls and Amuri limestone, and classed as the highest member of the greensand group. It is followed by the concretionary greensands, which, together with the boulder sands, and sulphur or gypseous sands, make up the saurian beds. Although abounding with saurian remains, these beds have not yielded fossil shells to the extent which might have been anticipated, although boulders containing shells frequently occur in the higher beds, and, invariably yield highly characteristic forms. In the Waipara District, the saurian beds are far more productive of fossil shells than the same beds at Amuri Bluff.

The Amuri group, or lower division of the series, has for its highest member the black grit or pebble bed, rich in fossil remains, of which the greater number are found in the lower beds of this group. Yet many shells and most of the saurians are also to be had in the overlying greensand group. A considerable thickness of green and grey sands follows, in the lower beds of which small and irregular concretions, abounding in fossils, are to be had; from which point, to the lowest beds of this section, fossils are extremely abundant and in great variety. The very lowest beds, seen only on the western wing, are brown or grey sands, with abundance of silicified wood, fragments of trees 18 or 20 inches in diameter. The upper beds of this group are represented at Boby Creek, Waipara River, by the calcareous semi-crystalline sandstone, with *Conchothyra parasiticum*, and other fossils, and in like manner the occurrence of the black oyster of the Waipara in the trigonia beds at Amuri Bluff affords us the means of comparing the very lowest beds in the two localities. Both the Amuri group and the saurian beds are much more indurated as they are followed north, and at Flaxbourne their lithological characters are very different to what they are either at Amuri Bluff or the Waipara ; heavy beds of volcanic rocks, with beds of indurated green sandstone, playing a prominent part in the composition of the beds which underly the Amuri limestone.

Having reviewed the opinions entertained by former workers in this field, and in part given a description of the beds in localities where they have come under my own observation, I now venture to place before you the views held by myself as to the age and conditions under which they have been deposited, and the after movements to which the beds have been subjected.

As regards the question of their age, my labours in the field as collector to the Geological Survey Department have accumulated abundant evidence in the shape of fossil remains to prove the synchronism of the beds throughout, and also to indicate by means of highly characteristic forms, that all the rocks here specially treated of are of young secondary age ; and if, as has been contended, some of the fossils obtained from the higher beds are also to be had in decidedly tertiary rocks, these beds thus objected to on account of their perfect conformity to the underlying and decidedly cretaceous rocks, cannot be considered as other than passage beds between it and the very lowest tertiaries ; and hence the classification of whole series of beds under the term "cretaceo-tertiary," as proposed by Dr. Hector, even in the objections of dissenters, receives its fullest verification.*

The middle and lower beds of the series have generally been considered as of secondary age. Although Dr. Haast is not alone in assigning a tertiary age to these beds, in certain localities where the more characteristic secondary fossils are less abundant than at Amuri Bluff; as Captain Hutton considers the Saddle Hill and Green Island coal beds near Dunedin to be of tertiary age, although many of the fossils from these beds are to be found associated with saurian remains at the Waipara and other localities, one or two cretaceous *Cephalopods* being common both to the Amuri Bluff and Otago deposits. As to the synchronism of the Waipara and Amuri Bluff beds, which Dr. Haast considers to be of different ages, at Amuri Bluff I obtained besides saurians of the same species many fossils common both to the Waipara and Malvern Hills ; and at Flaxbourne and near Cape Campbell in beds that co-relate with the belemnite and trigonia

* Although I here make use of the term "passage beds" it is used in a palæontological sense only, a break occurring between these and our oldest tertiary rocks.

beds at Amuri Bluff, the lower sands of the Waipara and the coal beds of the Malvern Hills; *Belemnites, Inoceramus*, and other characteristic shells, besides saurian remains closely associated with volcanic rocks, occurring under like conditions as the trachitic conglomerate described by Dr. Haast as interbedded with coal seams in the Malvern Hills.

It might be gathered from the authorities I have already cited that this series has already been traced to its very lowest beds. With this conclusion in the main I agree, but am still prepared for the discovery in the South Island of local deposits of still older date; and in the North Island, along the east coast, of a large development of rocks conformably underlying the saurian beds.

At all points where seen, the Amuri group lies highly unconformable on what appears to have been a very uneven surface, and this character of the old land seems to have been but little modified during the depression of the area over which the younger beds have been deposited.

The consequence is that the lower beds often appear as though deposited in bay-like indentations, a fact which appears to have been particularly noticeable to Dr. Haast during his earlier examinations of the Waipara district. A larger acquaintance with the beds in the adjoining district showed him that the Waipara beds could not have been so deposited, and this difficulty is overcome in his later reports by gradually increasing the dimensions of this imaginary bay, till eventually what, in the first instance, was of very moderate size, now, according to him, extended from the Looker-on Mountains in the Marlborough district to Otago Peninsula.

Captain Hutton seems to lay considerable stress on the apparent fact that "many of our vallies were formed in jurassic times." And in support of this view, points to the occurrence of outliers of the Waipara beds in the Upper Waipara, Waimakariri, and Rakaia Rivers.

The occurrence of cretaceous rocks in the localities indicated, I do not consider as at all proving that the vallies in which they are now found were then excavated.

It might as well be contended that, because these same rocks are to be found at an elevation of over 4,000 feet on the neighbouring ranges, that the mountains in question are thus proved to date back to jurassic times.

Dr. Haast, with a reasoning similar to that of Captain Hutton, would place the excavation of some of our vallies at a period long prior to jurassic times, as the following extract from his Amuri report will show:—"It may be truly said that after the mostly sub-ærial denudation of these mountains, probably after the deposition of the triassic beds in New Zealand, the skeleton form of this portion of the South Island was already fixed, and that subsequent volcanic action, and the deposition of extensive younger beds, changed little the characteristic features the country had then assumed. In any case, it is apparent that the country had already received its present orographical main configuration, in so far that the broad valley of the present Kahutara and its connection with the Upper Conway already existed, through which an arm of the sea flowed to the south before the marl stones and the succeeding beds were deposited."*

The marl stones here mentioned as being deposited after the excavation of this valley belong to the Mataura series, which, in the South, Captain Hutton finds to be conformable to the Kahiku series. Are we then to consider this valley as having been formed prior to the deposition of the Kahiku beds?

In his paper "On the Kaikoura District" † Mr. Buchanan notices the anticlinal arrangement of the young secondary rocks, and clearly shows that the movements whereby this was effected was not confined to the younger beds, but extended over a very large district, and involved in its action all the older rocks.

My attention thus attracted, I consulted the reports of Dr. Haast and Captain Hutton on this subject, but, further than that they note the beds as frequently standing at high angles, and occasionally forming synclines, no mention is made of the greater movements in which these beds have participated; wrapping round spurs, deposits in bays and vallies between mountain ranges, being the favourable theories advocated by them.

Not seeing my way clear to accept these as the true explanations, I submit some further evidence in support of Mr. Buchanan's theory, convinced that it alone fully explains the scattered occurrence of the Waipara beds from Southern Canterbury to Cape Campbell.

CONCLUDING REMARKS.

From the mouth of the Waiau River, and running parallel to the coast, the Hawkeswood Range is continuous until the Conway River is reached, north of which it loses the character of a range, and an assemblage of rocky peaks of inconsiderable elevation form the older rocks between the Conway and the north-east face of the Amuri Bluff. The line of higher elevation is yet, however, to be traced as far as Kais Hill, and fully a mile out to sea at the Hapuka Rocks.

The same line continued cuts the Kaikoura Peninsula at the centre of the anticline, where the older unconformable beds are exposed. Continuing this line to the north, the coast range south of the Clarence River is reached, consisting also of older rocks.

Thus from the mouth of the Waiau to the south bank of the Clarence

* "Geol. Reports," 1870-71, p. 28.

† "Geol. Reports," 1866.

River, we have a well-marked line of elevation, to the east and west of which, at intervals, outliers of the Waipara beds are to be found. For example, to the west, in the Valley of the Eden, and in the Lower Conway, and thence extending a few miles inland from the Amuri Bluff to the coast at the mouth of Oaro Creek.

Though at considerable distances, the limestones and saurian beds in the Kaikoura Peninsula west of the anticline, and the Waipara formation as exposed near the source of the Hapuka River, are evidently a continuation of this western division.

At the Amuri Bluff only are any portions of the Waipara beds continuous, so as to connect the eastern and western wings of the anticline. On the east side none of the Waipara rocks appear south of the Conway River, while at the Kaikoura Peninsula the whole have been removed on the crown of the anticline to the underlying beds, while east of the source of the Hapuka River the Waipara beds are not present, the older rocks reaching to the sea level. They are, however, to be found on the right bank of the Clarence River, extending some distance south along the coast.

To the east of this line of elevation the Waipara beds are nowhere observed to form a syncline (the Kaikoura Peninsula excepted), but on the west or inland side, this is invariably the rule.

From the point where it crosses the Waiau, this same line of elevation may be traced south (a slight interruption occurring at Cheviot Hills), and still dividing the younger beds, as in the north, into an east and west division, the easterly seldom presenting a synclinal arrangement, the westerly invariably doing so.

Further west, another belt of these younger rocks, often accompanied by tertiary beds, may be traced from Kaikoura up the valley of the Kahautara River, to the Upper Conway, thence across the Whale's Back to the Waiau Township, and at intervals along the borders of the Hurunui Plains, till, at the upper end of the Weka Pass, the two westerly divisions join. Tracing these south, they are found covering a considerable area in the vicinity of Heathstock, occurring as patches on the high ground dividing the south branch of the Waipara from the Okuku River, reported as occurring in the Upper Ashley, present in the Waimakariri basin west of Mount Torlesse, forming the coal basin west of the Big Ben Range, present in the Rakaia Valley near the mouth of the Acheron, crossing which at Redcliff they are next seen on the Smythe River, and at Clent Hills near Lake Heron. They are next seen in the Moorhouse Range on the north bank of the Rangitata, crossing which they appear in Coal Creek, and at Raincliff, west of Mount Four Peaks, uniting with the eastern division in the low country between Burke Pass and Timaru. These western divisions, in most cases, stand at high angles, and in two places present the phenomena of an overturned section. The first in the country, between the Clarence and Kaikoura, where the whole series, including the leda marls, are overturned 20° beyond vertical. The second, near Heathstock, where the Awatere beds are also involved; the beds here are for the most part nearly vertical, and it is only the greensand group which, in the section seen, is overturned.

And thus, when these facts are taken into consideration, it does not appear to me that, at the time when these beds were being deposited, the outlines of the present configuration of the area within which their remnants are now found, was then determined; or that this series, at least the higher beds of it, were deposited in a large bay, with inlets penetrating the mountain ranges, wherever these rocks are now found. I rather think that the evidence points to the subsidence of a very wide area until deep-sea deposits were formed and a subsequent upheaval of mountain chains, between which, and in the folds of which, the younger beds have been preserved to the present day.

Art. XCII.—*On the relation between the Pareora and Ahuriri Formations.* By Captain F. W. Hutton, Director of the Otago Museum.

[*Read before the Otago Institute, 24th October, 1876.*]

In 1873, in my "Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand, in the Colonial Museum," I separated the tertiary rocks at Awatere, Kanieri, Pareora, Awamoa, etc., from those of Napier, East Coast of Wellington, Broken River (upper bed), etc., under the names of the Pareora and Ahuriri formation respectively. During the last two years, however, I have been gradually led to doubt the correctness of this division, and to consider it probable that both ought to be regarded as one and the same formation. This view was first forced upon my notice during my survey of Otago, by finding that, although both the Oamaru and Pareora formations were largely developed, I could find no trace of the supposed intermediate Ahuriri formation. At the time of writing my report, however, I did not consider myself justified in making the change, nor was a discussion of this nature suitable to a report on the geology of Otago. But since then the Otago Museum has received collections of fossils from Pareora and the Wairarapa, which have enabled me to go more closely into the question, and the results of that investigation I have now the honour to lay before you.

In the first place the argument against the two formations being considered the same is that out of 154 species of mollusca found in the Pareora formation, 98 have not yet been found in the Ahuriri formation ; while out of 63 species of mollusca found in the Ahuriri formation, 29 have not yet been found in the Pareora formation. This is the reason that originally led me to distinguish between the two, but although of considerable weight the difference in the fossils may perhaps admit of another explanation than that of difference in age.

On the other hand, the proportion of living to recent species is nearly the same in both formations, being 37½ per cent. in the Pareora formation, and 35 per cent. in the Ahuriri formation.* This is, I think, a very strong argument in favour of the synchronism of the beds, and it is further strengthened by the fact, that at no locality are the two formations found together,† and that several of what were formerly supposed to be characteristic fossils of the Oamaru formation, such as *Pecten hochstetteri*, have been lately found by Dr Haast in beds belonging to the Pareora formation, although they are unknown in the supposed intermediate Ahuriri formation.

Now, while the similar percentage of recent to extinct forms can only be explained by similarity in age, the difference between the fossils found in the two groups of beds may perhaps admit of explanation by either difference in habitat, that is to say, by difference in the geographical positions of the beds constituting the two groups ; or by difference in station, that is to say, by a difference in the conditions of the sea bottom ; or, what comes to the same thing, in the difference in the deposits taking place in different localities at the same time. It is therefore necessary that we should examine both these causes in detail.

Difference in habitat.—If we look at the geographical distribution of the two formations as at present recognized, we find that the Pareora formation is extensively developed in Otago from Riverton and Te Anau Lake to the Waitaki, and is found in places all along the eastern side of the South Island, through Waipara, Motanau, Mount Cookson, River Conway to Cape Campbell and the Awatere. On the west coast of the South Island it also extends from Hokitika to Nelson. In the North Island it has only been

* These numbers are of course always altering as our knowledge increases. At present they stand :—

	Total Number of species.	Recent.	Extinct.	P.C. of recent species.
Pareora formation	154	58	96	37½
Ahuriri formation	63	18	45	35

† When the geology of the interior of Wellington is known, this statement may possibly be proved to be incorrect.

recognized at the White Cliffs, Taranaki, the upper end of the Manawatu Gorge, and doubtfully in the upper parts of the Wanganui and Rangitikei Rivers. In Hawke Bay and Auckland it is unknown. On the other hand, the Ahuriri formation is largely developed in the north from Cape Rodney and the Kawau, to Auckland and the Waikato. It occurs again largely between the East Cape and Napier, and all down the east coast of Wellington to the Wairarapa, and is found again on the west coast at Waitotara. In the South Island, on the contrary, it is only known in two limited localities, viz., the Hurunui Mound in the Nelson district, and the upper beds of Castle Hill Station on the Broken River, a branch of the Waimakariri. It would thus appear that the Pareora formation is almost entirely confined to the South Island, and the Ahuriri formation to the North Island, the two, as I have already stated, never yet having been observed in contact. Let us now see if this difference in geographical distribution will in any way account for the difference in the fossils of the two groups of beds.

Up to the present date 300 species of marine mollusca are known to inhabit our seas, and of these, 122, or 41 per cent., are only found north of latitude 42° S.; 40, or 13 per cent., are only found south of that latitude; while 138, or 46 per cent., are found both in the north and the south. The number common to both would, however, be much smaller if those species had been omitted that are so rare either in the north or the south, that we could hardly expect that they would be found as fossils when the present sea bed becomes dry land. Nevertheless, we see that there is a considerable difference at present between the marine shells of the north and south of New Zealand.

If, now, we arrange in the same way, the 179 species of fossil shells found in the Ahuriri and Pareora formations, we find that 41, or 23 per cent., are found only in the north; 82, or 46 per cent., are found only in the south; while 56, or 31 per cent., are common to both north and south. We see, therefore, that the difference in the Ahuriri and Pareora formations is considerably greater than the present difference, and we should not, I think, be justified in supposing that the difference between the fossils of the Ahuriri and Pareora formations was caused altogether by their different geographical distribution, although probably a certain amount of influence may be attached to it.

Difference in station.—Turning now to the other possible cause, we find that in all the localities for Ahuriri fossils the rocks are more or less calcareous, while in all the localities for Pareora fossils the rocks are either clay or sandy clay, with the exception of Mount Caverhill, Lyndon, and Mount Cookson in the southern part of the district of Nelson. Here, then, we have a reason quite sufficient, apparently, to account for the difference between the fossils of the two formations; but we still have to account for the calcareous rocks of Lyndon, Mount Cookson, and Mount Caverhill having been classed with the clays of the Pareora formation, rather than with the calcareous rocks of the Ahuriri formation. Only nineteen species of shells are known from these localities. Of these eight are common to both the Ahuriri and Pareora formations in other localities, nine are found only in the Pareora or Wanganui formations, while two are found only in the Ahuriri formation. We thus see that, while the fossils of these localities are more nearly related to those of the Pareora than to those of the Ahuriri formation, still the percentage of species common to both is above the average. The percentage, however, is nearly the same at Motanau, and even equal to it at Napier, so that this explanation is not altogether satisfactory.

But although neither difference of habitat nor difference of station appear to be quite capable of explaining the great difference between the fossils of the Ahuriri and Pareora formations, I think that the objections that can be urged against them are of little weight in comparison with the almost identical percentage of extinct forms in both, and it will be better to consider both formations as one until decisive proof can be got to the contrary. When the geology of the Wellington district is better known, proof one way or the other will probably be obtained; for the rocks in the Manawatu Gorge and the Upper Wanganui belong probably to the Pareora formation, while those on the East Coast and also at Waitotara belong to the Ahuriri formation.

Dr. Hector, in his recently published Geological Sketch Map of New Zealand, places his Kanieri series with the Hawke Bay series, and in this I think he is right; but he places the Awatere series with the Wanganui series of Shakespeare Cliff, and this I cannot agree to; for the fossils of the Awatere series are closely related to those from Motanau and Kanieri, and only 42½ per cent. of them are recent, while the fossils from Shakespeare Cliff are very distinct, and 75½ per cent. of them are recent.

Art. XCII.—*Descriptions of some new Tertiary Mollusca from Canterbury.*

By Captain F. W. Hutton, Director of the Otago Museum.

[*Read before the Otago Institute, September 5th, 1876.*]

Last year Dr. J. von Haast sent a collection of Canterbury tertiary fossils to the Otago Museum, with the request that I would describe the new species. The collection contained about 68 species from four localities, viz., White Rock River; Mount Harris; Point Hill, Waitaki; and from the green sands at Waiho. Of these 22 are additions to our tertiary fauna. The remainder are species already described as found in our tertiary rocks, and from them I judge that the whole collection belongs to the Pareora formation, I am the more confident of this determination as six of the species here described as new are also found in the Pareora formation at Awamoa and other places in Otago. It is worthy of notice that *Pecten hochstetteri* was in the collection from Waiho, showing that this speciesis not exclusively characteristic of the Oamaru formation.

TYPHIS HEBETATUS, sp. nov.

Plate XVI., Fig 1.

Ovato-fusiform. Whorls, seven, irregular, smooth. Varices four in a whorl, rounded, spines obsolete. Tube for excurrent canal, short, conical. Aperture, oval. Anterior canal, closed, short, flattened. Axis, 1·1. Breadth, ·75.

Locality: Mount Harris.

FUSUS DENTATUS, sp. nov.

Elongato-fusiform. Whorls, eight or nine, sub-carinated, with distant, low, spiral ridges, crossed by low, rounded, transverse ribs, which on the keel are produced into flattened sharp teeth. On the body whorl there are three of the low spiral ridges posterior to the keel, while anterior to the keel the second or third ridge is rather larger than the others, and is followed by about 20 more on the produced canal. Aperture, broadly ovate, suddenly narrowed into the canal, which is much produced, narrow, quite straight, and as long as the spire. Axis, 1·45. Breadth, ·5.

Locality: Mount Harris.

Allied to *F. cumingi*, from China, but much narrower, and without the fold on the inner lip.

FUSUS TEGENS, sp. nov.

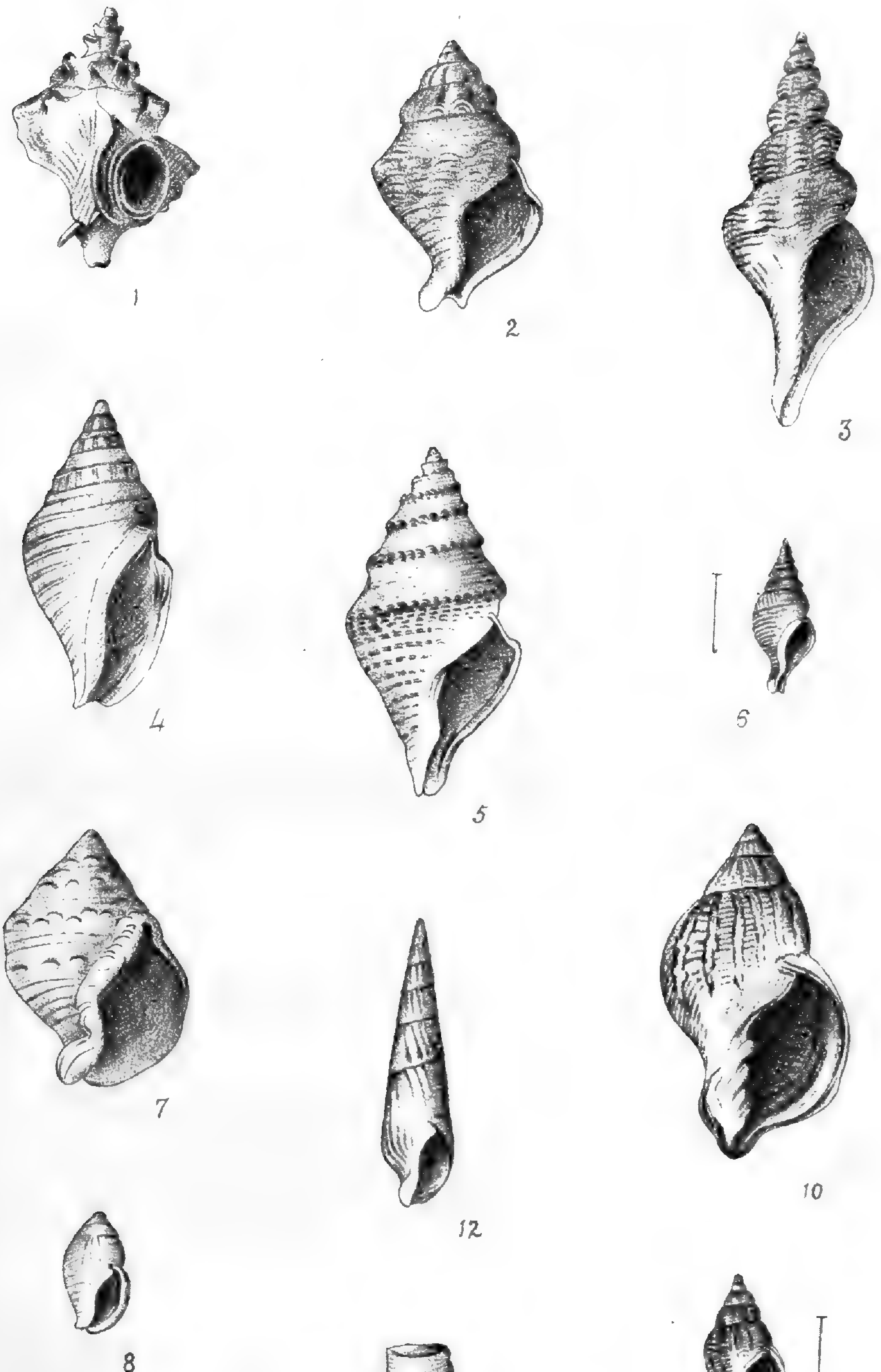
Small, elongato-fusiform. Whorls, seven, carinated, and with a row of tubercles on the keel; about eleven tubercles on the body whorl. Spire whorls and posterior portion of body whorl, smooth, shining, but slightly marked with oblique lines of growth. Anterior portion of body whorl with eight or ten low, rounded, spiral ribs, crossed by about ten sub-obsolete varices. Anterior portion of canal, smooth. Aperture ovate, gradually tapering into the long narrow canal, which inclines to the left and very slightly backward. Axis, ·4. Breadth, ·17.

Locality: White Rock River.

NEPTUNÆA (SIPHO) COSTATUS, sp. nov.

Plate XVI., Fig. 2.

Broadly fusiform. Whorls, seven, strongly spirally striated, and with



F.W. Hutton, del.

TERTIARY SHELLS.

J.B. lith.

rounded transverse ribs. Eleven or twelve ribs on the body whorl. Suture, closed over. Aperture, with a small posterior sinus. Canal, rather long, strongly twisted to the left, and slightly recurved. Axis, 1·2; breadth, ·75.

Localities: Mount Harris and White Rock River.

Closely allied to *Buccinum modificatum*, Reeve, but the canal is more twisted.

DRILLIA FUSIFORMIS, sp. nov.

Plate XVI., Fig. 3.

Elongato-fusiform. Whorls, nine, rounded, with rather oblique transverse ribs on the central portion. There are ten ribs on the body whorl. Anterior portion of the whorls with spiral sub-moniliform striæ. Spire, acute, nearly as long as the body whorl. Aperture, oval, rather suddenly contracted into the canal, which is short and nearly straight. Sinus, broad. Axis, 1·0. Breadth, ·7.

Locality: Mount Harris.

Somewhat approaching *D. flavidula*, Lam., from China and Japan, but the transverse ribs are not knobby, and the spire is much shorter.

BELA (?) ROBUSTA, sp. nov.

Plate XVI., Fig. 4.

Ovato-fusiform. Whorls, seven, concave and finely spirally striated posteriorly, and with low, rather distant, rounded, spiral ribs anteriorly. There are from ten to fifteen of these spiral ribs on the body whorl, and they are crossed by oblique lines of growth. Aperture, elongated. Outer lip slightly angled posteriorly. Columella, smooth, rounded. Canal, short, slightly twisted, and recurved. Axis, 1·45. Breadth, ·7.

Locality: White Rock River.

Similar in form to *B. decussata*, from Britain, but very differently marked.

CLAVATULA HAASTI, sp. nov.

Plate XVI., Fig. 5.

Broadly fusiform. Spire, acute. Whorls, eight, concave and spirally striated posteriorly, sharply keeled, and with rather distant spiral moniliform lines, crossed by oblique lines of growth anteriorly. There are about twenty of these lines on the anterior portion of the body whorl, in front of the keel. Aperture, elongated. Outer lip, angled posteriorly. Columella, with a slight swelling in the middle. Axis, 1·55. Breadth, ·78.

Localities: White Rock River and Mount Harris.

The nearest ally of this very distinct species is *C. mystica*, Reeve, but our shell has no nodules.

DEFRANCHIA EXCAVATA, sp. nov.

Plate XVI., Fig. 6.

Small, fusiform, turreted. Whorls, seven or eight, sharply keeled, and spirally striated. Striæ rounded, narrower than the grooves. Interstices crossed by oblique lines of growth. Aperture, ovate. Outer lip, simple. Canal, moderate, slightly recurved. Body whorl rather longer than the spire. Axis, ·37. Breadth, ·15.

Locality: White Rock River.

The sharp keel of the spire whorls gives the appearance of the sutures being excavated.

COMINELLA SUBNODOSA, sp. nov.

Plate XVI., Fig. 7.

Ovate, conical. Whorls, five, flattened, distantly spirally ribbed; the intervening grooves much broader than the ribs. Suture, covered. Spire whorls with one, and body whorls with two rows of low, rounded, tubercles, of which there are about twelve in each row on the body whorl. Plait over the suture sub-nodose. Aperture, ovate, with a distinct posterior sinus. Interior of outer lip, grooved. Inner lip with a broad callus. Canal, short, bent strongly to the left, and recurved. Axis, 1·3. Breadth, 1·0.

Locality: White Rock River.

COMINELLA ORDINATIS, sp. nov.

Plate XVI., Fig. 8.

Small, ovate. Whorls, five or six, smooth, finely spirally striated, slightly convex; those of the spire with some obsolete transverse ribs. Aperture, rather narrow, posterior sinus nearly obsolete. Canal, short, broad, recurved, not much bent on one side. Axis, ·5. Breadth, ·27.

Locality: White Rock River.

Like *Buccinum citrinum*, Reeve, in shape.

NASSA (UZITA) COMPTA, sp. nov.

Plate XVI., Fig. 9.

Small, ovate. Whorls, six, rounded, strongly spirally grooved, and crossed by low, rounded, transverse ribs. Aperture, broadly ovate, suddenly contracted to form the short oblique canal. Inner lip, well marked; a tooth near the posterior end. Outer lip, varicated, thick, dentate internally. Canal, short, inclined to the left, and recurved. Axis, ·43. Breadth, ·18.

Locality: White Rock River.

These shells still retain some of their colour, which was brown. The interior was white with brown lips. The nearest ally of the species is *Nassa striata*, Adams, from Panama.

TURBINELLA BREVIROSTRIS, sp. nov.

Plate XVI., Fig. 10.

Broadly fusiform. Spire, pointed. Whorls, five; those of the spire, flattened, with low, rounded, transverse ribs, of which there are about fifteen on the body whorl. These are crossed by spiral striæ of unequal size. The transverse ribs on the body whorl reach to the anterior portion of the shell.

Aperture, sub-ovate, suddenly narrowed to form the short straight anterior canal. Columella, with three oblique folds on the anterior end. Axis, 1·45. Breadth, .93.

Locality: White Rock River.

LUNATIA SUTURALIS, sp. nov.

Plate XVI., Fig. 11.

Globose, smooth. Whorls, three to five. Suture, excavated. Umbilicus, rather narow, not funiculate, but with a shallow spiral groove running to the anterior end of the inner lip. Aperture, semi-lunar. Inner lip, with a slight callus. Axis, ·65. Breadth, ·6.

Locality: Waiho.

In the young the umbilical groove is more strongly marked, giving the shell the appearance of a *Natica.*

SIGARETUS CARINATUS, sp. nov.

Small, depressed, smooth. Spire, immersed. Whorls, two and a half. Body whorl, sharply keeled, and margined along the keel. Aperture, oblique, very wide. Inner lip, curved posteriorly. Umbilicus, wide, partly covered by the posterior fold of the inner lip. Axis, ·07. Breadth, ·25.

Locality: White Rock River.

Somewhat similar in shape to *S. incisus*, Reeve, but widely umbilicated and keeled.

ACUS (ABRETIA) NITIDA, Hinds.

Plate XVI., Fig. 12.

Hinds, "Pro. Zool. Soc.," 1843.

Locality: White Rock River. Found living in Tasmania and the Marquesas Islands.

EULIMA ACICULATA, Pease.

Pease, "Pro. Zool. Soc.," 1860.

Locality: White Rock River. Found living in the Sandwich Islands.

TURRITELLA HAUSTATOR CONCAVA, sp. nov.

Large. Whorls, concave; the anterior half, finely spirally striated; the posterior half, smooth, or marked with oblique lines of growth only. Suture, closed over. Aperture, sub-quadrate. Axis, 3·5. Breadth, 1·4. Angle of spire, 15°.

Localities: White Rock River, Point Hill.

This species is readily distinguished from *T. gigantea*, by the spiral striæ being fine and numerous, and, in the larger whorls, confined to the anterior half; while in *T. gigantea* the striæ are larger (eight or ten in a whorl), and extend throughout its whole breadth.

CLADOPODA DIRECTA, sp. nov.

Plate XVI., Fig. 13.

Smooth, polished, not much curved; section, circular. Diameter, ·3.

CYCLOSTREMA HELICOIDES, sp. nov.

Small, depressed. Whorls, four; smooth, spirally striated, flattened posteriorly and exteriorly, and with a narrow spiral rib on the anterior part of the flattened exterior. Umbilicus wide. Aperture nearly circular. Peristome continuous (?). Axis, ·05. Breadth, ·15.

Locality: White Rock River.

This species approaches *C. biporcata*, Adams, but the upper keel is obsolete. The only specimen that I have seen has its aperture broken, consequently I am not sure whether the peristome is continuous or not. If it is not continuous, the shell will belong to the genus *Adeorbis.*

CORBULA SULCATA, sp. nov.

Plate XVI., Fig. 14.

Trigonal, gibbous, nearly as high as long. Deeply longitudinally grooved. Very slightly angulated behind, and rounded in front. Height, ·32. Length, ·35.

Locality, Mount Harris.

LEDA SEMITERES, sp. nov.

Rather compressed, rounded in front, and produced to a blunt point behind. Posterior dorsal margin, very slightly concave. Ventral margin, regularly rounded. The whole shell regularly and strongly concentrically striated. There are between 40 and 50 striæ between the umbo and the ventral margin. Height, ·25. Length, ·5. Breadth, ·18.

Locality: Waiho.

Similar in shape to *L. lata*, Hinds, from New Guinea and Borneo, but easily distinguished by the stronger striæ.

ANOMIA TRIGONOPSIS, sp. nov.

Sub-trigonal. Lower valve (?). Upper valve, gibbous, solid, rather smooth. Muscular impressions, three; the upper one the largest, nearly round, but flattened below. Middle impression, immediately below the upper one, trigonal, the apex angular and pointing downward, the angles of the base rounded. Lower impression, placed diagonally below and posterior to the middle one; of the same size and shape as the middle impression, but the apex pointing upward.

Locality: White Rock River.

ART. XCIII.—*A new fossil bird*, Anas finschi, *from the Earnscleugh Caves, Otago, New Zealand.* By P. J. VAN BENEDEN.

(Abridged from "Annales de la Soc. Geol. de Belg.," Vol. II., p. 123.)

[*Read before the Wellington Philosophical Society, 9th December, 1876.*]

Communicated by Dr. Hector.

Plate XXVIII.

EXCAVATIONS recently made in the above caves have revealed the existence of several new kinds of birds, amongst which there is one that deserves special notice.

It was submitted by Dr. Finsch, of Bremen, one of the most distinguished ornithologists of the present day, and one who has specially interested himself in the birds of New Zealand. He has compared these remains with the existing species of that country, and has easily been able to convince himself that these bones do not come from any bird known there at the present day.

Among the nine species of ducks described, there are only two to which these bones bear any resemblance. These are *Dendrocygna eytoni*, Gould, and *Querquedula gibberifrons*, S. Mull., two birds accidentally observed as stragglers in New Zealand, being quite peculiar to the Australian continent.

Dr. Finsch adds to these accounts the table of measurements which he has taken from these two species, after some stuffed specimens in the Bremen Museum. These measurements are herewith appended :—

—	—	*Anas chlorotis* (Gray).	*Anas gibbosifrons* (Mull).	*Dendrocygna eytoni* (Gould).
	Mill.	Mill.	Mill.	Mill.
Length of head	69	95	87	97
,, of beak from the frontal ..	..	40	55	41
,, of beak from edge behind nasal holes	27	39	33	40
,, from anterior edge	..	29	24	29
Width of beak in front	..	11	15	16
Length of fore-arm	..	63	60	..
,, of tarsi	53	40	37	58

Dr. Finsch remarks :—"If the bones of the head and of the beak resemble the *Querquedula*, the length of the legs removes them considerably from it. On the other hand the legs are not so long as in *Denrdrocygna eytoni*, also he thinks that these remains proceed from a duck which has affinities rather with the *Dendrocygna* than with the other division.

Among the true ducks of this country (New Zealand) there is only the *Anas chlorotis*, Gray, which can be compared to it, says Dr. Finsch, and he adds the measurement of this species as given above.

The following is a list of the bones forwarded by Dr. Finsch, from which the bird has been described :—

2 heads almost complete, with a large portion of the inferior maxillary.
2 pelves.
2 clavicles.
4 shoulder blades.
4 coracoids.
2 humerus.
4 radius and as many ulna.
4 metacarpus.
1 phalange.
12 ribs.
4 femurs.
4 tibias and fibulas.
4 tarso-metatarsus.
Several joints of the toes.

These bones came chiefly from two specimens, and probably from male and female. There are some pieces which indicate a third species.

The head most resembles our *Anas clangula* in shape as well as in proportions. In comparing it with a skeleton that we have received from Greenland we only find the beak a little wider, the nostrils more elongated, the sockets of the eyes not quite so large, and the whole of the skull more regularly rounded off. The part about the back of the head is still more alike in these two species than in the part round the face. Above the hole at the back of the head one sees in both the bone pierced to the right and to the left, and the boundary well established by ridges between the back of the head and the temples, but these parts are even better distinguished in the *Anas clangula* than in the *Anas* from New Zealand.

The two fossil heads show a certain difference, which does not exceed the difference that is found between the two sexes.

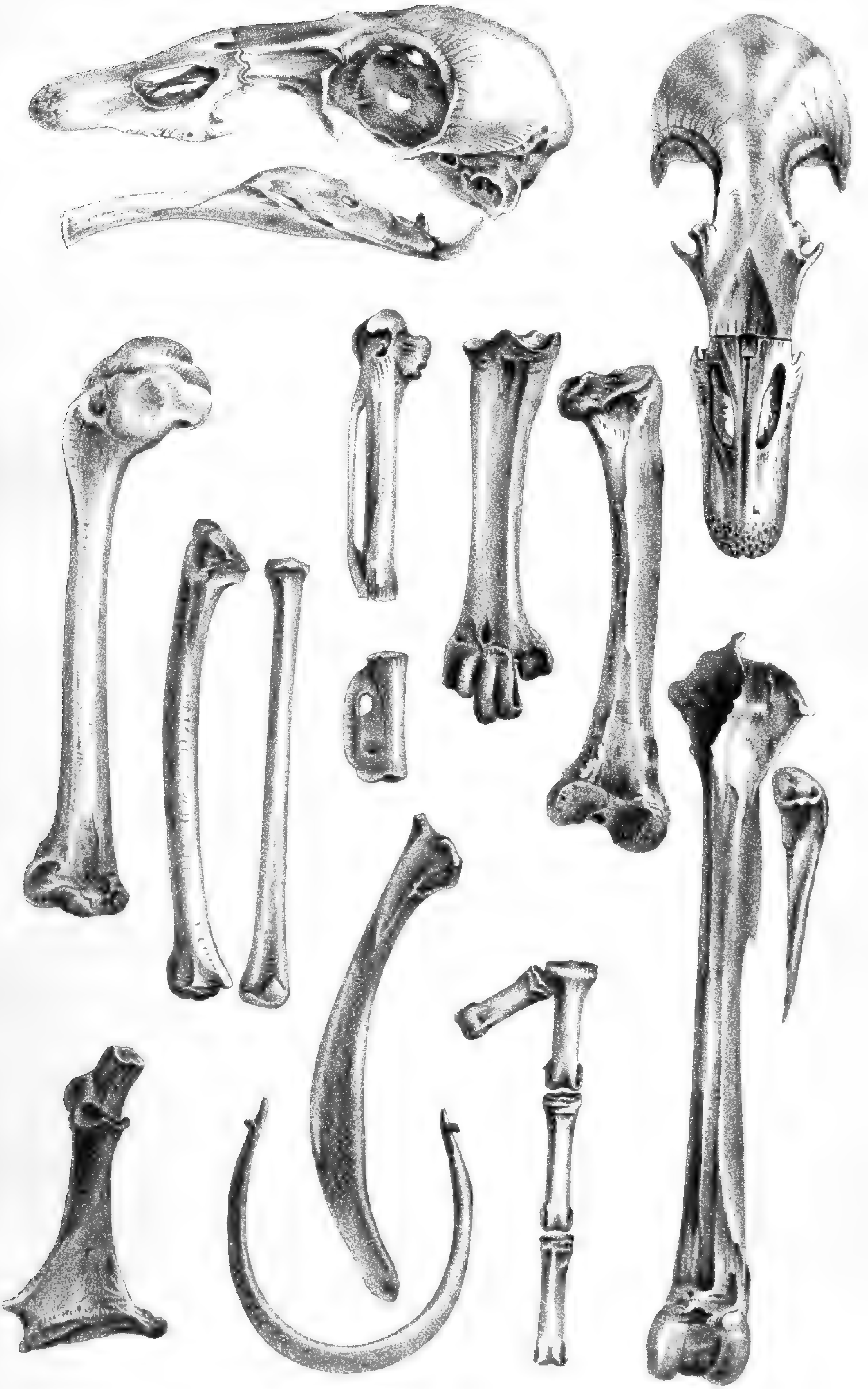
The inferior maxillary is more delicately terminated behind than in the living species of our hemisphere.

The sternum very much resembles that of *Anas clangula ;* it has the same dimensions and the same outline, only the notch is not so high, more faint at the back, and shorter in front, so that everything in this bird shows less power of flight than in our *Anas clangula.*

The differences which are observed in the two New Zealand sternums are, no doubt, as in the head, sexual differences.

The clavicle is considerably larger, stronger, and with the two parts more separate than in the Marila Duck.

The pelvis is in proportion much larger and stronger than in the living



J.B. lith.

species of the North, and what especially distinguishes it is the width of the sacrum and the height of the cotyloid cavities. The shoulder blade is also stronger, wider, and longer.

We have two entire coracoids, and their resemblance to the coracoid of the Marila is so great that we had some difficulty at first to distinguish them.

The humerus is larger and stronger than that of *Anas clangula* and *Anas marila.*

The radius and ulna are alike in size as in diameter. The metacarpals are stronger as well as the following segments. If the humerus is stronger than in the two living species, *A. clangula* and *A. fuligula*, more especially is a similar difference seen in the bones of the feet.

The femur is almost double in length and thickness. We can say as much, at least, of the tibia and tarsus, and the joints of the fingers are alike incomparably stronger in the new species from New Zealand.

The tarso-metatarsus bones show in addition differences we believe to be sexual. We have also a dozen ribs, and if we find any differences it is that the central apophyses, instead of being recurved from the lower part upwards, are on the contrary extended from the upper part downwards, uniting with the bone in the whole width.

From all this we may conclude with Dr. Finsch, that the bones of the duck from the Earnscleugh caves belong to a new bird, which has probably disappeared at the same time as the *Dinornis*, and to which we propose to give the name of the learned naturalist of Bremen—*Anas finschi.*

In comparing these bones with the two species known in Europe, we have been quite struck with their resemblance to the fossil species, which inhabited in great numbers the shores of lakes, the bottoms of which at the present day constitute a considerable portion of the department of Allier, and to which M. Alphonse Milne-Edwards has given the name of *Anas blanchardi.*

The principal difference between these and *Anas finschi* is that the head is not so long in the New Zealand species; and if there is but a slight difference in the size of the head, there is on the other hand a remarkable difference in the size of the bones of the limbs. The wings as well as the feet are stronger in the New Zealand species; the clavicle is wider, but it is with difficulty one discovers differences between the sternums or plastron.

That which is especially surprising in comparing these bones of a New Zealand form with the European species is, that one finds so faithfully reproduced all the characters peculiar to the birds of the family.

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EXPLANATION OF PLATE XXVIII.

ALL FIGURES ARE OF NATURAL SIZE.

Fig. 1.—Head seen in profile with inferior maxillary.
Fig. 2.—Same, seen from above.
Fig. 3.—Clavicle.
Fig. 4.—Shoulder blade.
Fig. 5.—Coracoid.
Fig. 6.—Humerus.
Fig. 7.—Radius and ulna.
Fig. 8.—Metacarpus and phalange.
Fig. 9.—Femur.
Fig. 10.—Tibia and fibula.
Fig. 11.—Tarso-metatarsus.
Fig. 12.—Phalanges.

Art. XCV.—*On a new Trilobite* (Homalonotus expansus).

By James Hector.

Plate XXVII., fig. 2, p. 474.

[*Read before the Wellington Philosophical Society, 9th December, 1876.*]

Homalonotus expansus, sp. nov.

Distinguished from *H. delphinocephalus*, Green (Hall, "Palæontology of New York," p. 309), and from *H. harrisoni*, McCoy, ("Pal. of Victoria," Pt. III.), by its great proportionate width, and particularly by the middle lobe being only half the width of the lateral anas of the caudal portion of the buckler.

From the Spirifier slates associated with Madripore limestone and quartzites on which the auriferous slates of Reefton rest unconformably. Probable age, upper silurian, being the upper part of the group of strata mapped as the "Mount Arthur Series."

Tail segments only; width of largest specimen, 3 inches.

NEW ZEALAND INSTITUTE.

NEW ZEALAND INSTITUTE.

EIGHTH ANNUAL REPORT, 1875-76.

The Board of Governors met during the past year, on the 11th October, 1875; 5th January, 14th February, 9th March, 22nd March, 17th June, and 12th July, 1876.

The three members of the Board who retired in conformity with the sixth clause of the Act have been re-appointed by His Excellency the Governor—viz., the Hon. G. M. Waterhouse, James Hector, M.D., C.M.G., F.R.S., and W. T. L. Travers, F.L.S.; and the Ven. Archdeacon Stock has been appointed in the room of Alfred Ludlam, Esq., resigned.

The elected Governors are—J. C. Crawford, F.G.S., His Honour J. A. Bonar, and Thomas Kirk, F.L.S.

The honorary members elected in conformity with Statute IV. of the Rules of the Institute are—Philip Sutley Sclater, Ph.D., F.R.S., Professor George Rolleston, D.M., F.R.S., and Dr. Filhol.

The number of members now on the roll of the Institute is as follows:—

Honorary members	22
Ordinary Members.	
Auckland Institute	219
Wellington Philosophical Society	180
Hawke Bay Philosophical Institute	59
Westland Institute	48
Nelson Association	54
Canterbury Philosophical Institute	93
Otago Institute	200
Total	875

From the above, it will be seen that two new societies have been incorporated since last report—viz., the Hawke Bay Philosophical Institute, and the Westland Institute, making in all seven societies now affiliated with the New Zealand Institute.

Copies of the last volume of Transactions (VIII.) have been distributed to all the members, and also 112 copies to the persons and societies whose names are on the free list.

The publication of the volume for 1875 was commenced in January, and finished at the latter end of May, occupying a period of five months; the edition has been increased to 1,000 volumes, and, owing to the increasing popularity of the various incorporated societies, it may be necessary to still further enlarge the edition.

Volume VIII. is somewhat smaller than the previous year's, the difference arising chiefly from the Proceedings of the societies being less voluminous. As compared with last year's issue, the sections of the work are as under :—

	1875.	1874.
Miscellaneous	179 pages.	195 pages.
Zoology	131 ,,	137 ,,
Botany...	31 ,,	46 ,,
Chemistry	20 ,,	30 ,,
Geology	39 ,,	57 ,,
Proceedings	50 ,,	101 ,,

The Appendix contained important tables relating to the climate of New Zealand, compiled under the direction of the Meteorological Inspector (in anticipation of the Annual Report), from returns furnished from the various meteorological stations throughout New Zealand, with accompanying notes on the weather for 1875; and also a paper on New Zealand Surveys, which was ordered to be printed after the miscellaneous portion of the work was completed.

The attention of Secretaries of incorporated Societies is again directed to the necessity of forwarding manuscript in an easily readable form, because, owing to the impossibility of referring questions of doubt as to the particular rendering of words and sentences to the authors, in some cases it is very difficult to arrive at an author's meaning, and the publishers cannot keep the type standing for any length of time without being subject to considerable loss. It must be borne in mind that a work of a scientific character, treating of so many different subjects, and in the present Volume consisting of fifty-seven different articles (in few cases revised by the authors), is far more likely to contain errors than a work by one person, who is also generally his own editor. It is desired that all papers for the present year, 1876, should be forwarded to the Manager, before the 31st December, if it is wished that they should appear in the next Volume.

The number of Volumes now on hand is as follows :—Vol. I., second edition, 560 copies ; Vol. II., 13 copies ; Vol. III., 10 copies ; Vol. IV., 14 copies ; Vol. V., 87 copies ; Vol. VI., 78 copies ; Vol. VII., 221 copies ; Vol. VIII., 30 copies.

The statement of the accounts of the Institute by the Honorary Treasurer is herewith appended, in which is shown a balance in hand of £218 4s. 4d.

The Governors have received applications from large numbers of scientific bodies in Europe and America for the exchange of the "Transactions of the Institute" for their own publications, and are of opinion that it would be advantageous to the Colony that such applications should, if possible, be acceded to. But as the funds at the disposal of the Governors render it difficult to carry this out, they venture to suggest that the annual grant should be increased by the sum of £100, which would enable them to comply with the requests made to them.

Museum.

The new building was open to the public on 3rd January, and, up to the end of 8th July, 8,776 names have been entered in the visitor's book. The arrangement of the contents, however, is only provisional, as show-cases and other furniture ordered from England have not yet arrived.

The total number of specimens received into the Museum during 1875–76 is 14,525 ; this includes about 13,090 specimens collected in the field by the officers of the Geological Survey Department. (*See* remarks under the head of Palæontology.)

The packing and re-arrangement of the collections during the erection of the building occupied much time ; but, notwithstanding, material progress has been made with the draft catalogues of the contents of the Museum, and a large series of new preparations are ready to be exhibited as soon as the cases can be arranged. Among these are 331 bird skins, which have been stuffed and mounted by the Taxidermist. The former collections have also been cleaned and re-mounted.

Herbarium.—The collection of New Zealand and Foreign plants, estimated to comprise 5,000 species, has been thoroughly re-arranged on a convenient system for reference. An addition to the Herbarium of about 10,000 species, presented by the Trustees of the British Museum, has been shipped from England. The Herbarium is entirely in charge of the Draftsman, whose work in this branch comprises 40 lithographed plates, 50 manuscript maps for the Geological Survey, besides a large number of Natural History drawings for the Department.

Mammalia.—The most important addition under this head has been a type collection of 95 stuffed animals and 102 skeletons, received from the British Museum in exchange.

Birds.—The skins and skeletons from the British Museum, noted in the list of donations, are the most interesting of those received. An increase in the duplicate specimens of New Zealand birds in the Museum has been made during the past year. A fine series of 911 North American birds' eggs has been obtained by exchange with Mr. Buckley, of Birmingham.

Reptilia.—Several fine specimens of the Tuatara lizard (*Sphænodon punctatus*) have been presented by Mr. L. B. Wilson, of the Marine Department, who obtained them from the Brother Islands during the survey for the new lighthouse.

Fishes.—From the British Museum we have also the most important addition under this head—viz., 100 species, part of which are stuffed, and the rest in spirit.

Invertebrata.—A fine collection of New Zealand insects, *Coleoptera*, presented by Mr. C. M. Wakefield, and those received from the British Museum.

The collection of land shells (354 species) from the British Museum is also an important addition to the Museum.

Palæontology.—During the present year a further examination has been undertaken of the Reefton district. This work went to confirm what was previously almost settled—viz., that the fossiliferous slates and madrepore limestones of Devonian age which occur in this district are overlaid unconformably by the auriferous slates (Maitai series ?)

No new fossils were discovered in these beds, but portions of two large *Trilobites* were secured.

The auriferous slates are still, as ever, devoid of fossils; they have been traced from Reefton south as far as the Grey, and are also seen as isolated patches at Ross and still further south, no fossils, however, showing in them.

From the slates occurring to the eastward of the belt of crystalline rocks, which strike through the island from north to south, an indistinct fossil *Annelid* is obtained, the character of which has not as yet been determined; it is, however, identical with one which occurs in similar rocks near Nelson, and similar to a fossil in the slates of Mount Torlesse and in the Ashley Gorge.

It is probable that these slates are identical with the auriferous slates of Reefton before mentioned; and it is in them that the gold-bearing reefs of the Taipo Ranges occur.

At Callaghan Hill, Westland, and at the Waimea Township, collections were made from the calcareous and greensand beds of the Kanieri series; and these collections, together with one made at Redman Creek, near Ross, may be taken as typical of the beds throughout the vast extent of country over which they occur.

At the Abbey Rocks a development of the coal measures occurs, in the shales of which fossil ferns, etc., have been found; and from certain beds of greensand, overlying the coal measures, a somewhat indistinct collection of fossils was obtained, but sufficient to identify the horizon as that of the Middle Amuri greensands, overlaid by the Amuri limestone.

It is in connection with these latter beds that the deposits of lithographic stone occur, which have recently been commanding a certain amount of attention.

The argentiferous lodes of Richmond Hill and Mount Rangitoto have been examined and reported upon.

Part of the east coast of the North Island has also been run over somewhat hurriedly, and collections made from the extensions of the Castle Point beds north of Napier, and also from the cretaceo-tertiary beds (Leda marls, etc.) which cover a large area of the country surveyed.

From the coal measures of the Buller coal field, immediately associated with the coal, some large oysters have been obtained, identical with those which are found in the sandstone overlying the brown coal at the Nine-Mile Bluff, north of the Grey.

In consequence of the great interest attached to the study of our Upper Mesozoic formations, it was considered desirable to make exhaustive collections of fossil remains from the Amuri series, and these comprise by far the greatest bulk of the addition to the Museum during the past year.

Mr. McKay, who was employed on this work, reports that he has collected approximately as many as 10,000 specimens of shells from the various horizons, in addition to which portions of not less than 150 Saurians have been secured, which will, it is hoped, tend to throw considerable light upon points in the anatomy of known species which have hitherto been of a doubtful character, in addition to which the number of species will, in all probability, be augmented.

As the collections are at present being unpacked, it is impossible to give any further information concerning them.

Advices have been received of a large shipment of fossils, obtained as exchanges and donations from correspondents in England.

Laboratory.

The number of analyses made in the laboratory during the past year is 133—viz., coal, 18; minerals, 49; metals and ores, 36; gold, 5; miscellaneous, 25.

A full report of these analyses is given in the Annual Report by the analyst.

James Hector, Manager.

19th September, 1876.

Accounts of the New Zealand Institute for 1875–6.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
Balance in hand, October, 1875	48	19	11	Expenses of Printing Volume VIII.	370	11	1
Vote for 1875-6	500	0	0	Binding Volumes for Library	3	14	0
Contribution from Wellington Philosophical Society ..	29	15	0	Miscellaneous items	3	1	6
Sale of Transactions	16	16	0	Balance	218	4	4
	£595	10	11		£595	10	11

Arthur Stock, Hon. Treasurer.

Wellington, 19th September, 1876.

APPENDIX.

THE CLIMATE OF NEW ZEALAND.

METEOROLOGICAL STATISTICS.

The following Tables, etc., are published in anticipation of the Report of the Inspector of Meteorological Stations for 1876:—

TABLE I.—Temperature of the Air, in shade, recorded at the Chief Towns in the North and South Islands of New Zealand, for the Year 1876.

Place.	Mean Annual Temp.	Mean Temp. for (Spring) Sep., Oct., Nov.	Mean Temp. for (Summer) Dec., Jan. Feb.	Mean Temp. for (Autumn) Mar., Apl. May.	Mean Temp. for (Winter, June, July Aug.	Mean Daily range of Temp. for Year.	Extreme range of Temp. for Year.
North Island.	Degs.	Degs.	Degs.	Degs.	Degs.	Degs.	Degs.
Mongonui	61·9	61·2	68·5	63·4	54·5	15·8	53·0
Auckland	60·0	58·8	66·5	61·8	52·9	14·4	48·5
Taranaki	58·2	57·4	64·6	60·1	50·8	17·1	53·5
Napier	59·4	59·1	65·6	61·7	51·3	14·1	54·0
Wanganui	56·8	56·2	64·4	58·1	48·6	19·8	56·0
Wellington	56·1	56·5	63·0	57·5	47·3	12·9	46·6
Means, etc., for North Island	58·7	58·2	65·4	60·4	50·9	15·7	56·0
South Island.							
Nelson	55·9	55·9	64·2	56·5	47·2	21·7	56·0
Cape Campbell ..	58·5	57·5	65·1	60·6	51·0	12·5	42·7
Christchurch ..	53·2	53·6	61·7	54·4	43·2	17·0	59·2
Hokitika	54·0	54·2	62·0	54·9	45·1	14·4	47·3
Dunedin	51·5	52·2	58·6	52·6	42·7	14·8	50·0
Queenstown ..	51·0	52·2	61·2	51·3	39·3	16·8	66 0
Southland	—	—	—	—	—	—	—
Means, etc., for South Island	54·0	54·2	62·1	55·0	44·7	16·2	66·0
Means for North and South Islands	56·3	56·2	63·7	57·7	47·8	15·9	66·0

TABLE II.—Barometrical Observations.—Rainfall, etc., recorded for the Year 1876.

Place.	Mean Barometer reading for Year.	Range of Barometer for Year.	Mean Elastic Force of Vapour for Year.	Mean Degree of Moisture for Year.	Total Rainfall.	Mean Amount of Cloud.
North Island.	Inches.	Inches.	Inches.	(Sat. = 100.)	Inches.	(0 to 10.)
Mongonui ..	29·982	1·229	·450	79	58·640	5·7
Auckland.. ..	29·978	1·168	·418	80	44·025	6·1
Taranaki	29·946	1·352	·383	78	48·180	6·2
Napier	29·947	1·276	·365	71	33·390	3·0
Wanganui ..	29·964	1·320	·346	73	40·950	4·8
Wellington ..	29·942	1·581	·341	75	43·374	5·1
Means for North Island	29·959	1·321	·383	76	45·593	5·1
South Island.						
Nelson	29·857	1·541	·360	79	60·640	5·2
Cape Campbell ..	30·014	1·350	·376	75	12·940	6·3
Christchurch ..	29·922	1·724	·325	77	23·990	6·0
Hokitika	29·928	1·925	·358	84	116·325	5·0
Dunedin	29·717	1·642	·287	73	38·260	6·0
Queenstown ..	29·846	1·510	·239	61	30·930	6·0
Southland ..	29·808	1·420	—	—	40·590	6.6
Means for South Island	29·870	1·587	·324	75	46·239	5·8
Means for North and South Islands	29·914	1·454	·353	75	45·916	5·4

TABLE III.—Wind for 1876.—Force and Direction.

Place.	Average Daily Velocity in Miles.	Number of Days it blew from each point								
		N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	*Calm.
North Island.										
Mongonui	180	19	60	45	33	48	74	41	46	0
Auckland	294	38	67	34	18	45	89	49	26	0
Taranaki	223	46	54	34	90	11	68	42	21	0
Napier	234	37	98	15	38	46	56	37	16	23
Wanganui	296	3	26	2	32	0	57	17	143	86
Wellington	205	1	18	3	145	0	9	2	187	1
South Island.										
Nelson	148	75	78	16	58	9	71	11	48	0
Cape Campbell	421	8	1	4	102	70	2	55	106	18
Christchurch	116	7	101	41	16	9	149	10	32	13
Bealey	174	66	25	21	61	10	15	17	106	45
Hokitika	—	51	40	109	28	4	51	34	49	0
Dunedin	162	5	75	21	11	20	92	38	7	97
Queenstown..	114	11	24	2	12	14	70	55	89	89
Southland	†163	16	73	31	34	4	82	58	68	0

† For 11 months only.

* These returns refer to the particular time of observation, and not to the whole 24 hours, and only show that no direction was recorded for the wind on that number of days.

TABLE IV.—Bealey—Interior of Canterbury, at 2,104 feet above the sea.

Mean Annual Temp.	Mean daily range of Temp. for year.	Extreme range of Temp. for year.	Mean Barometer reading for year.	Range of Barometer for year.	Mean Elastic Force of Vapor for year.	Mean Degree of Moisture for year.	Total Rainfall.	Mean Amount of Cloud.
Degrees.	Degrees.	Degrees.	Inches.	Inches.	Inches.	Sat.=100	Inches.	0 to 10
47·7	16·2	78·2	*30·045	1·550	·235	69	91·271	5·6

* Reduced to sea level.

TABLE V.—Earthquakes reported in New Zealand during 1876.

Place.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Taranaki ..	..	..	27*	..	26	..	19*	..	23†	..	..	..	4
Wairoa ..	..	..	..	..	..	..	19*	..	..	..	..	..	1
Porangahau ..	..	..	..	..	..	..	19*	..	..	..	..	..	1
Tarawera ..	..	..	..	..	..	..	19,* 20	..	..	..	..	..	2
Napier.. ..	13†	..	..	..	..	..	19,* 20	..	28†	..	..	7	5
Patea	..	..	..	..	..	..	19*	..	..	..	..	..	1
Waipawa ..	..	..	..	..	..	..	19*	..	..	..	..	..	1
Wanganui ..	13	..	7*	13	5	..	19*	..	..	..	..	7	6
Foxton ..	..	..	..	..	3*	..	19*	..	..	..	..	..	2
Greytown ..	..	..	..	..	..	..	19*	..	..	..	..	..	1
Upper Hutt ..	..	..	..	..	..	..	19*	..	..	..	..	..	1
Wellington	..	29*	..	..	5, 31*	28	19*	7	3,* 13 25	..	..	..	9
Havelock ..	..	..	..	..	..	..	19*	..	28	..	..	..	2
Nelson ..	..	..	26	..	..	..	..	..	..	..	..	..	1
Blenheim ..	..	..	..	..	5	..	19*	..	..	..	..	..	2
Cape Campbell	..	29*	..	..	..	..	19*	..	..	..	..	..	2
Bealey.. ..	..	..	..	..	..	..	..	14*	..	..	..	..	1
Hokitika ..	10	..	..	..	..	..	19*	..	..	..	..	..	2
Christchurch	..	..	..	..	6	..	19*	..	..	..	..	..	2
Lyttelton ..	..	..	..	..	..	..	19*	..	..	..	..	..	1
Oamaru ..	..	26,† 28†	9,* 10*	11†	20,* 31	..	..	..	..	..	..	..	7
St. Bathans ..	..	..	..	11	..	..	..	..	..	..	..	..	1
Port Chalmers	..	26†	..	11	20*	..	..	..	..	..	..	..	3
Naseby ..	..	26	..	11	..	..	..	..	..	..	..	..	2
Waimate ..	..	26*	..	11	..	..	..	..	..	..	..	..	2
Queenstown ..	..	25, 26	..	11	14*	..	..	..	..	24	21	..	6
Waikouaiti ..	..	..	..	11	..	..	..	..	..	..	..	..	1
Dunedin ..	..	26	..	11	..	..	..	..	..	..	..	..	2
Palmerston ..	..	..	..	11	..	..	..	..	..	..	..	..	1
Invercargill ..	..	..	..	..	3	..	..	..	..	..	..	..	1
Inspich ..	..	..	..	..	..	..	19*	..	..	..	..	..	1
Bluff	..	..	..	..	3	..	..	..	..	..	..	..	1

The figures denote the days of the month on which one or more shocks were felt. Those with an asterisk affixed were described as *smart;* those with a dagger as *severe shocks*. The remainder were only slight tremors, and no doubt escaped record at most stations, there being no instrumental means employed for their detection. This table is, therefore, not reliable so far as indicating the geographical distribution of the shocks.

TABLE VI.—Comparative Abstract for 1876, and previous Years.

STATIONS.	Barometer.		Temperature from Self-registering Instruments read in Morning for Twenty-four Hours previously.					Computed from Observations.		Rain.		Wind.		Cloud.
	Mean Reading.	Extreme Range.	Mean Temp. in Shade.	Mean Daily Range of Temp.	Extreme Range of Temp.	Max. Temp. in Sun's Rays.	Min. Temp. on Grass.	Mean Elastic Force of Vapour	Mean Deg. of Moisture (Saturation=100.)	Total Fall in Inches.	No. of Days on which Rain fell.	Average Daily Force in Miles for Year.	Maximum Velocity in Miles in any 24 hours, and date.	Mean Am't. (0 to 10)
North Island.														
Mongonui	29·982	1·229	61·9	15·8	53·0	151·0	—	·450	79	58·640	192	180	685, on 10 April	5·7
Previous 10 years	29·989	—	60·4	—	—	—	—	‡·420	‡76	54·327	164	—	—	—
Auckland	29·978	1·168	60·0	14·4	48·5	—	29·0	·418	80	44·025	213	294	693, on 24 June	6·1
Previous 12 years	29·936	—	59·6	—	—	—	—	·411	79	44·704	185	—	—	—
Taranaki	29·946	1·352	58·2	17·1	53·5	154·0	26·0	·383	78	48·180	168	223	720, on 23 June	6·2
Previous 12 years	29·935	—	57·3	—	—	—	—	†·371	†73	57·525	160	—	—	—
Napier	29·947	1·276	59·4	14·1	54·0	140·0	30·0	·365	71	38·390	136	234	900, on 25 July	3·0
Previous 8 years	29·921	—	58·2	—	—	—	—	·391	76	36·264	106	—	—	—
Wanganui	29·964	1·320	56·8	19·8	56·0	160·0	23·0	·346	73	40·950	143	296	630, on {20 Mar. / 20 May	4·8
Previous 4 years	30·062	—	55·7	—	—	—	—	·329	72	40·427	127	—	—	—
Wellington	29·942	1·581	56·1	12·9	46·6	152·0	27·0	·341	75	43·374	147	205	630, on 23 Sept.	5·1
Previous 12 years	29·898	—	54·6	—	—	—	—	·331	72	52·337	159	—	—	—
South Island.														
Nelson	29·857	1·541	55·9	21·7	56·0	—	12·0	·360	79	60·640	82	148	496, on 23 June	5·2
Previous 12 years	29·899	—	55·5	—	—	—	—	·363	74	63·909	90	—	—	—
Cape Campbell	30·014	1·350	58·5	12·5	42·7	—	—	·376	75	12·940	80	421	1,098, on 22 Mar.	6·3
Previous 2 years	29·965	—	58·2	—	—	—	—	·360	74	24·830	107	—	—	—
Christchurch	29·922	1·724	53·2	17·0	59·2	152·0	12·6	·325	77	23·990	122	116	691, on 5 Aug.	6·0
Previous 12 years	29·878	—	53·4	—	—	—	—	·327	77	26·030	118	—	—	—
Bealey*	30·045	1·550	47·7	16·2	78·2	—	—6·0	·235	69	91·271	173	174	654, on 17 Mar.	5·6
Previous 8 years	29·826	—	46·4	—	—	—	—	·262	81	98·483	172	—	—	—
Hokitika	29·928	1·925	54·0	14·4	47·3	—	20·0	·358	84	116·325	189	—	—	5·0
Previous 10 years	29·930	—	52·6	—	—	—	—	·354	85	114·019	186	—	—	—
Dunedin	29·717	1·642	51·5	14·8	50·0	—	21·0	·287	73	38·260	151	162	860, on 4 Aug.	6·0
Previous 12 years	29·845	—	50·5	—	—	—	—	·281	74	33·465	164	—	—	—
Queenstown	29·846	1·510	51·0	16·8	66·0	—	—	·239	61	30·930	115	114	305, on 24 June	6·0
Previous 4 years	¶29·836	—	50·7	—	—	—	—	·248	67	30·782	119	—	—	—
Southland	29·808	1·420	—	—	—	—	—	—	—	40·590	200	§163	670, on 18 Mar.	6·6
Previous 11 years	29·805	—	‖49·9	—	—	—	—	‖·274	‖75	45·531	167	—	—	—

* 2,014 feet above sea level. † Eleven years. ‡ Nine years. ‖ Eight years. § For eleven months only. ¶ Three years.

NOTES ON THE WEATHER DURING 1876.

January.—Except at some of the Northern stations, the rainfall has been very much less than is usual for this month, very hot dry weather prevailing, with easterly winds, and generally moderate. The weather at Mongonui, Auckland, and Napier has, however, been very wet, squally, and unpleasant, the rainfall being greatly in excess of the average. Earthquakes were reported by the Observers at Napier on the 13th, at 4·13 p.m., sharp; at Wanganui, same date, at 4·25 p.m., slight; also by telegraph, same date, at Napier, 4·20 p.m., duration 12 seconds, direction E. and W., heaviest shock felt for some years. Also by Hokitika Observer, on the 10th, slight. Meteor observed at Queenstown on 22nd.

February.—Fine weather was experienced throughout during this period; rainfall below, and temperature above, the average; no gales of any note occurred. Earthquakes reported by Meteorological Observers are,—at Queenstown on 25th, at 3.20 a.m., and on 26th, at 8·40 a.m.; also at Dunedin, on 26th, shocks felt. At Cape Campbell, on 29th, a smart shock felt at 4·45 a.m. From the Telegraph Department we have the following reports:—On 26th at Oamaru, a severe shock was felt at 3·25 a.m., direction N.W. to S.E.; a slighter shock at 4·15 a.m.; another severe shake at 8·55 a.m., same direction; several chimneys down, others cracked, stone buildings damaged; on 28th, report that slight shocks still continued, no damage; on night of same date, however, a sharp shock was felt at 8·40 p.m., direction N.E. to S.W. At Port Chalmers, on 26th, at 3·24 a.m., a heavy shock, lasting twenty seconds, preceded by two very slight shocks, and at 8·50 a.m. another long shake, not so severe as the first; slight shakes have been reported since, but are rather uncertain. At Waimate, on 26th, two sharp shocks reported, one at 3 a.m., and one at 8·50 a.m., direction E. to W. At Naseby, on 26th, shocks felt slightly at 3 a.m. and 8·45 a.m., direction N. to. S. A smart shock reported to have been felt in Wellington on 29th, at about 4 a.m.

March.—Weather rather squally and unpleasant during this month; total rain about the average, but very showery, with thunder and hail in the South; temperature for time of year, high throughout. Earthquakes reported by Observers at Taranaki on 27th, at 10·10 p.m., smart; at Nelson, on 26th, at 4·20 a.m. From Telegraph Department—Shocks reported at Wanganui on 7th, at 1·20 a.m., sharp and abrupt; at Oamaru, on 9th, at 10·40 p.m., sharp, direction E. and W.; and on 10th, at 5·25 a.m., also sharp, and E. and W.

April.—Wet stormy weather during this month, with prevailing westerly winds, thunder and hail storms occurring at several of the stations, and in the South snow,—altogether an unpleasant month for time of year. Earthquakes are reported by Meterological Observers at Dunedin on 11th, direction N.E. to S.W.; at Queenstown, same date, at 11·40 a.m., direction E. to W.; at Wanganui, on 13th, at 6·10 p.m., loud rumble; a meteor seen at 6·5 p.m., just before the shake. A meteor also at Hokitika on 13th, at 6·20 p.m., and on 28th, at 8·40 p.m., large. From the Telegraph Department—Earthquakes reported on 11th, at St. Bathan's, Otago, 11·40 a.m., slight, but distinct, E. to W.; Naseby, 11·40 a.m., distinct and rumbling noise, W. to E.; Palmerston, 11·40 a.m., sharp; Waikouaiti, 11·40 a.m., slight and distinct, one second, N. to S.; Port Chalmers, 11·40 a·m., slight; Queenstown, 11·40 a.m., slight, S. to N.; Oamaru, 11·40 a.m., severe shock, heaviest yet felt, S. to N.; Dunedin, 11·40 a.m., slight; Waimate, 11·35 a.m., slight. Large meteor fell to W. at 6·15 p.m. on 3rd, at Patea, appearing to burst about 20° from horizon, leaving a brilliant streak of red light lasting several minutes. Also a meteor observed at Foxton, on 13th, at 6·14 p.m., very brilliant, apparently bursting about 20° from horizon, followed by a slight shock, as at Wanganui on same date.

May.—Strong westerly gales prevailed throughout this period; rain below the average. Earthquakes reported by Observers at Wanganui, on 5th, at 6·5 a.m., slight; at Wellington on 5th, at 6·10 a.m., slight, and on 31st, between 3 and 4 a.m., sharp; at Christchurch, on 6th, at 6·30 a.m., slight; at Queenstown, on 14th, at 5·40 p.m., two shocks; at Taranaki, on 26th. By Telegraph Department—At Invercargill, on 3rd, at 6·35 p.m., two slight shocks, direction W. to E.; at Bluff, on 3rd, at 6·30 p.m., slight, W. to E.; at Foxton, on 3rd, at 7·54 a.m., sharp, preceded by loud rumbling, N. to S., short duration; at Blenheim, on 5th, at 6 a.m., slight, E. and W.; at Queenstown, on 14th, at 5·50 p.m., two shocks, with noise, duration of first, 10 seconds, of second 20 seconds, W. to E.; at Port Chalmers, on 20th, at 4·17 a.m., smart; at Oamaru, on 20th, at 5·30 a.m., sharp; at Oamaru, on 31st, at 5·20 p.m., S.E. to N.W.

June.—Wet unpleasant weather generally throughout; rain greatly in excess at most of the Southern Stations. A severe westerly gale passed over the islands on 23rd and 24th, the barometer falling in some places to 28·548. Thunder and hail frequently occurred, and some hard frosts, also snow. Earthquake reported by Observer at Wellington on 28th, at 6·32 p.m., slight.

July.—Generally fine weather for the time of year. At some of the Northern Stations rain in excess, but otherwise below the average. Some severe frosts experienced in the South, and frequent snow. No gales of any note occurred. Earthquakes are reported by Observers at Napier, Taranaki, Wanganui, Wellington, Cape Campbell, Christchurch and Hokitika on 19th, about 4·15 a.m., generally smart, and in some cases preceded by noise. At Napier, on 20th, there was also a slight shock. By telegram, reports were received from the following stations of the shock felt on 19th, at 4·15a.m.:—Tarawera (also on 20th), Wairoa, Napier, Waipawa, Patea, Porangahau, Wanganui, Foxton, Greytown, Upper Hutt, Havelock, Blenheim, Inspich, and Lyttelton; considerable damage done at some places.

August.—Fine weather for time of year. On 4th and 5th a severe S.W. gale was experienced at most of the stations north and south. On the whole, the rain was below the average. Earthquakes are reported by Observer at Wellington, on 7th, at 3 a.m. slight tremble; and at Bealey, on 14th, at 8·4 p.m., smart, S.W. to N.E., 5 seconds.

September.—The weather generally for this period was wet and stormy, the rainfall being greatly in excess, especially in the South and on West Coast. Strong South and North-west winds prevailed, often amounting to gales, with heavy rain. Very low barometer during middle of month, when the maximum rain occurred. Earthquakes reported by Observers, at New Plymouth on 23rd, at 8·2 p.m., smart; at Wellington on 3rd, 12·16 a.m., smart, and at 5 a.m., slight; also on 13th, at 2 a.m., slight, and 25th, at 8 p.m., slight. By Telegraph Department, at New Plymouth, same time and date as above, described as heavy, E. to W., lasting 15 seconds, preceded by rumbling. At Hawke Bay, on 28th, at 6 p.m., heavy shake, travelling N. and S.; at Havelock, on 28th, at 6 a.m., slight.

October.—The weather throughout during this month extremely fine and pleasant for the time of year, approaching more to spring, the temperature of all the stations being higher than the average for the same period, at many places reaching over 4° higher. The winds were moderate, and chiefly from N.E. In some localities the want of rain was much felt. High barometer reading prevailed. Earthquake at Queenstown on 24th, at 2·3 a.m., N.W. to S.E.

November.—Generally showery during this period throughout, though the total fall of rain is about the average for same month in previous years. Frequent thunderstorms occurred. At Auckland, on the 12th, there was a violent S.W. gale, extending over a large area; also, on 4th, at the same place, a whirlwind passed near the Observatory, doing considerable damage: no disturbance in barometer observed in either case. The temperature throughout in excess, and at times very hot weather was experienced for the time of year. Earthquake reported at Queenstown on 21st, at 6·45 a.m., with rumbling noise.

December.—Unsettled and showery generally; at times fine and bright; the rain fell at most stations in excess of the average; low atmospheric pressure throughout, and the temperature rather low for the time of year; occasional thunder storms; wind generally strong. Earthquake reported by Observers at Napier, on 7th, slight, at 12·45 p.m.; and at Wanganui, on same day, at 11·30 p.m., slight.

The Climatic and Financial Aspect of Forest Conservancy as applicable to New Zealand. By Captain CAMPBELL WALKER, F.R.G.S.

[*A Lecture delivered in connection with the New Zealand Institute at the Colonial Museum, 19th March, 1877.*]

THE subject of this paper is entitled "The Climatic and Financial Aspect of Forest Conservancy as applicable to New Zealand." In the paper which I recently read at Dunedin on the subject of Forestry,* and more particularly State Forestry in general, I referred very briefly to the two points on which I have the honour to address you to-night. They represent, however, the most important aspect in which the whole forest question may be viewed or approached, and may be said to embrace, directly or indirectly, the whole subject. Were it not for climatic considerations, which we believe may be injuriously affected by the lack of a systematic and persistent system of Forest Conservancy, to the detriment of the health and welfare of the whole community, Forestry might well be left to private enterprise and the spasmodic efforts of private individuals or local bodies, liable as they must always be to the influences and considerations of the moment, and the popular feeling not of the nation or general public, but of a comparatively small section of it, representing local feeling and interests. Were it not for financial considerations, which must ever be more or less paramount in the conduct of our affairs, schemes for the conservation, creation, and improvement of forests would meet with much less opposition and be much more generally adopted than they are. My object in addressing you to-night is, therefore, two-fold; and I shall endeavour to show—first, that the climatic influence of forests is a very important matter, which cannot be approached too early or with too much care and deliberation in the life of a nation or colony; and second, that financial considerations may not only be made compatible with, but form a great inducement to, real Forest Conservancy, especially if it be commenced and sytematically adhered to on a broad but ever careful system before the forests have been seriously injured or encumbered with a mass of individual or communal rights and privileges; and further, that such financial considerations are not antagonistic to the development of the timber trade and industry, or to the general welfare and prosperity of the people.

The subject of the influence of forests on rainfall, climate, and water supply of a country, has of late years attracted much attention, and been

* *Ante.* p. 187.

freely discussed not only in scientific but general circles. So far as the actual rainfall of a particular locality is concerned, the evidence and arguments adduced have been very conflicting; and I am bound to record my opinion, as stated in Dunedin, that, so far, nothing has been proved to establish the theory, that extensive denudation will, of itself, cause a marked decrease in the rainfall. Forest-clad mountains will doubtless tend to induce rain-clouds to precipitate the moisture with which they are charged, but so will mountains without forests. No one would, I imagine, argue against the generally recognized fact, that the rainfall in mountainous forest regions is, as a rule, greater than it is in an open plain exposed to similar atmospheric conditions; but the question is, will the mere removal of the forests from the mountains, of itself, affect the rainfall on them and in their immediate vicinity, and may not the presence of the trees be the effect of a considerable rainfall, and not its cause? I confess that I feel no sort of certainty one way or the other; and in this respect I do not think I am singular, having with me, to my knowledge, Dr. Brundis, the Inspector-General of Forests in India, no mean authority, and doubtless many others whose minds are not made up on the subject. Recent observations in France, however, made with great care and complete sets of instruments, at different stations, do appear undoubtedly to establish the facts:—(1), that throughout the year 6 per cent. more rain falls in the forests than in the open; (2), that, of the total rainfall, 10 per cent. is caught by the leaves in a forest, and does not reach the earth; and (3), that the evaporation in the open country is five times as great as in a forest. So far as this colony is concerned, the evidence, if anything, tends to prove that the rainfall has increased at stations in the neighbourhood of which the forests have been extensively cleared. I have quite recently been going through the meteorological returns for the past ten years, and find that, whereas the mean annual rainfall of Wellington, as recorded for the first five years, is 48·709 inches, and the number of days on which rain fell 153; that for the last five years of the decade is 57.862 inches, and the number of days 177! At Taranaki, again, in the immediate neighbourhood of which I imagine the clearing has been extensive, the mean from 1866 to 1870 was 53·331 inches, and, from 1870 to 1875, 62·612 inches. Christchurch and Hokitika, with the lowest and highest rainfall in the colony, remain much the same during each of the periods of five years; the mean for the former being 113 days, with 27·033 inches during the first, and 125 days with 25·821 inches during the second five years; whilst at the latter place the means are 197 days with 112·622 inches, and 178 days with 115·418 inches respectively. We must, however, be careful how we accept these returns as conclusive evidence either way. The period over which they range is too short to afford reliable data; besides which, Dr. Hector will, I imagine, agree that the returns are likely to be more reliable and accurate during the last than the preceding five years. I would here point out that, so far as my observation goes, there is scarcely any point on which the popular or general opinion is more frequently erroneous and liable to mislead, than that of the rainfall of successive years or periods of years. I am pretty sure that most of the inhabitants of Wellington would give it as their opinion, in perfect good faith, that the rainfall had decreased of late years; whilst I was over and over again assured at Hokitika, that, although rain might fall more frequently, the annual average there was not in excess of that in other parts of the colony, the real facts being as stated above. From all I have said, you will gather that I think it better not to attempt to dogmatise on this point; and, with your permission, we will relegate it to a future occasion, when we may know more about it.

The question of the influence of forests on climate and permanent water supply, is, to my mind, in a widely different position; and nothing, I think, has been more clearly proved, both by scientific argument or theory, and actual observations or practice, than that the wholesale and indiscriminate clearing of forests exercises an injurious effect on both, whilst the formation of plantations in dry and arid regions ameliorates the climate and renders the water supply more copious and permanent.

If we consider first the question of climate, we shall find a host of evidence tending to prove that the general destruction of forests has rendered it more trying, less equable, and devoid of sufficient moisture; in short, has caused it to deteriorate both with respect to its effects upon the health of man and other animals, and upon the fertility and productiveness of the soil, whilst the regeneration of forests, or the formation of plantations, improves it.

Let us first endeavour to understand clearly what is meant by the word "climate." A recent writer says:—"The single word 'climate' expresses one of the most important relations of man to the natural world around him, a relation which concerns human existence in its every part. But this word 'climate,' taken in its largest sense, comprehends within itself all those elements of matter and force the mutual influences and actions of which produce the phenomena so familiar to us under the single expression." Dr. Daubeney, in his lecture on the influence of climate on vegetation, defines the "climate of a country to be its relations to temperature, light, moisture, winds, atmospheric pressure and electricity." We all know the popular and everyday meaning of the words "good" and "bad climate," and what an important matter it is considered. Equally important, therefore, is all that influences it, amongst which ranks the presence or absence of a certain proportion of forest area. Marsh, in his well-known work on "Man and Nature," published in London in 1864, says :—"One important conclusion at least upon the meteorological influence of forests is certain and undisputed, the proposition, viz., that within their own limits and near their own borders they maintain a more uniform degree of humidity in the atmosphere than is observed in cleared grounds." And, again, writing of the indiscriminate clearing in America ;—"With the disappearance of the forest all is changed. At one season the earth parts with its warmth by radiation to an open sky, and receives at another heat from the unobstructed rays of the sun ; hence the climate becomes excessive, and the soil is alternately parched by the fervour of summer and seared by the rigours of winter. Bleak winds sweep unresisted over its surface, drift away the snow that sheltered it from the frost, and dry up its scanty moisture." Innumerable quotations could be given and irrefutable evidence adduced from the works of Hooper, Schleiden, Becquerel, Humboldt, and Boussingault, all tending in the same direction. The Rev. W. B. Clarke, F.R.S., etc., recently read a paper before the Royal Society of New South Wales, on the subject of the "Effects of Forest Vegetation on Climate," with the general tone and direction of which I cordially concur, though unable to agree with him in all his deductions and conclusions. He quotes largely from Schleiden and Marsh, and gives an extract from an essay by the late Sir Henry Holland, in the "Edinburgh Review," viz.:—"It is the forest which actively ministers to the climatic condition of the earth, which, extirpated by the axe or restored by planting, changes both the face of nature and the distribution and destinies of human life." The case of some parts of Africa and Asia Minor, the Mauritius, St. Helena, Ascension, Madeira, etc., have all been given by various writers, and quite lately Dr. Croumbie Brown, formerly Government Botanist at the Cape, has done excellent service by publishing a series of works on the subject entitled "The Hydrology of South Africa," "Reboissement in France," "Forests and Moisture, or Effects of Forests on Humidity of Climate," the last of which I have not seen. Professor Laurent of the Forest School at Nancy, has also written on the subject, and "instances Fontenoy and Provence as places where the felling of forests has affected the climate." So much for the influence of forests on climate generally. We next come to that of their effect on the water supply and its regulation. Most of the authorities already quoted have written also on this point, but I prefer quoting from other sources of more recent dates. The paper by Monsieur Clané, from which I quoted in my Dunedin lecture, is a clear and exhaustive treatise on the subject. He refers to actual observation made by MM. Becquerel and Boussingault, and to those of M. Mathieu, of the Forest

School at Nancy, and M. Fantral, of a more recent date. He states that the results M. Mathieu has obtained are singularly uniform, and they have been reproduced so often that even so careful and conscientious an observer as M. Mathieu considers that they may be held to be dependent on a general law of nature. His observations lead to the conclusion that while on the one hand forests tend to lower the general temperature of a country, and so to promote the fall of rain at regular intervals, and in moderate quantities; on the other hand they ward off sudden meteorological changes, which are dangerous inasmuch as they cause sudden and heavy falls of rain, which result in floods and other like disasters. M. Fantral's results corroborate those of M. Mathieu; and M. Cantegiel, Inspector of Forests, near Toulouse, in the extreme South of France, has also carried out a similar series of observations, extending over a number of stations, with precisely similar results. Boussingault's example of the Lake of Valentia, in Venezuela, has been often questioned. This lake has no known outlet, and when Humboldt visited it the water was decreasing in a marked degree, the forests in the neighbourhood being at the same time largely cleared. Twenty-five years later, Boussingault found its dimensions increasing, which he ascribes to the War of Independence having occasioned a cessation of clearing, so that less timber was being cut down and a new growth springing up. He infers that this is the true explanation from the fact that other lakes in the neighbourhood, around which the forests had been left in their natural state, had shown no such fluctuations. The lakes of Neufchatel and Geneva have also been mentioned by Humboldt and Jaussure as instances of the same result. The case of the island of Ascension seems very conclusive, as it appears matter beyond doubt that the only spring in the island was dried up when the trees were removed, and commenced to run again when the forests were restored. St. Helena is also quoted as an instance in point, as are Mauritius and St. Vincent, the district of South America lying between the Orinoco and the Andes, and many other localities. I have myself observed the drying up of springs and decrease of the average amount of water in some of our mountain forests in India in which extensive clearing has taken place, and think there can be no reasonable doubt that such clearing does affect injuriously the supply of water for springs and permanent supply in the streams and rivers. Hof Rath Wex, in a paper contributed to the Vienna Geographical Society in 1875, actually states that the decrease of water in the Elbe and Oder has been 17 inches; Rhine, 24; Vistula, 26; and Danube at Orsova, 55 inches in 50 years. Not less conclusive in my opinion is the evidence at our disposal regarding what M. Clané calls the mechanical action of forests through the roots in retaining in its place the earth, especially on the sides of mountains and hills.

It is impossible to treat this part of our subject without reference to the preceding one, the argument being that forests by their presence act as storehouses of moisture, both from their leafy canopy which covers the earth and the bed of dead leaves on its surface, the loss of moisture by evaporation being by these means reduced to one-fifth, as stated above; and that, further, the bed of dead leaves acts like a sponge, soaking up and retaining the rain and regulating its distribution, whilst the roots not only "act as vertical drains, promoting the descent of the water into the lower strata of the earth, there to nourish the springs," but bind the soil on the mountain-sides together, and prevent its being carried away into the valley below. In short, it may be said that the forests exercise both a preventative and curative effect—first, preventing the rapid running off of heavy rain, and storing it up for gradual distribution; and, second, impeding the flow of water in its course, if already accumulated and coming down from bare or snow-covered heights above.

The disastrous effects caused by over-clearing of forests, in the shape of torrents and inundations, have been felt in many countries; but I think it will suffice if we instance France, where the subject has attracted more attention and at last been more thoroughly grappled with than anywhere else.

The case of France may also be considered as peculiarly applicable, and affords a valuable lesson to this country; for it was in the fancied best interests of the owners of sheep and cattle that the forests on the Alps and Pyrenees were gradually destroyed, to make way for more grass and more sheep: indeed, it is only quite recently that the representatives of these interests in the Communes affected have really awoke to the fact, that their interests and lives were at stake, and appear anxious to co-operate with the Forest Officers in re-clothing the hills. Dr. Croumbie Brown, in his book on "Reboissement in France," already mentioned, gives a detailed account of the causes which led to the clearance of the forests in the Higher and Lower Alps, the Loire, and the Pyrenees, the results in the shape of torrents, landslips, inundations, etc., and the remedial measures now in progress, which are calculated to extend over 140 years, and cost at least half a million sterling, besides the pay of the Forest Officers employed. Our time to-night does not admit of my following him even very cursorily; but I would strongly recommend a perusal of this and other works by the same author by all who take an interest in the subject.* The description which he gives, and which is unfortunately corroborated by far too many authorities to be doubted, of the devastations committed by the torrents, gradually augmenting year by year as each patch of forest and scrub was

* Published by King & Co., London.

removed, is trully appalling. The disappearance of the forests from the mountains gave up the soil to the action of the waters, which swept it away into the valleys, and then the torrents becoming more and more devastating buried extensive tracts under their deposits, tracts which will probably be for ever withdrawn from agriculture. The prediction of an Inspector of Forests, quoted by Surrell in his "Etudé sur les Torrents des Hautes Alps," has already been literally fulfilled :—"The crusts denuded of their vegetable soil, no longer permitting the infiltration of the waters, these will flow away rapidly on the surface of the ground. Then the springs will dry up, and the drought in summer being no longer moderated by their irrigation, all vegetation will be destroyed." These results, and far more serious ones in the shape of enormous loss both of human life, and of cattle, sheep, and property, have all come to pass. The loss of property by the inundations in the south of France, in 1875, was estimated by the Government at £3,000,000 sterling, and it is stated that 3,000 persons lost their lives. The indirect results in the shape of temporary or permanent damage to agricultural districts by the deposit of stones and shingle brought from the mountains by the flood waters cannot be estimated, still less the damage to pastoral lands on the mountains themselves. It may be stated generally, that the results of excessive clearing of forests and abuse of pasturage on the French Alps and Pyrenees, have reduced their capacity as a sheep and goat-carrying area to such an extent that they cannot carry the half of what they did 50 years ago; whilst the damage resulting to the agricultural districts below from the drying up of springs and streams, the torrents caused by heavy rains, and the melting of the snows and their effect on the river-banks and channels, followed by long droughts in summer, is simply incalculable, and such as cannot be repaired, even at a large expenditure, within two generations.

The French Government, after much delay and difficulty, the result of local prejudice and cupidity, have undertaken the task of "reboissement" in reclothing the mountains with forests, commencing with the most important points, viz., the sources, head waters, and courses of streams, and the gullies extending up to the higher ridges, where water, whether from the clouds or melting snows, is first precipitated and accumulates. The results appear, so far, to have been satisfactory; but it is admitted that it will probably take a longer time and much more money than originally estimated to mitigate or prevent the recurrence of the disasters, which have been steadily increasing in magnitude during the past century, whilst the improvement of the pasturage on the hills or undoing the damage already caused below is mere matter of conjecture. The measures proposed to be adopted at first, included, in the interests of the shepherds, a large proportion of "regazanement" or re-turfing, as distinct from "reboissement" or re-foresting; but the late floods, especially those in the valley of the Garonne, appear to point conclusively to the comparative uselessness of the former as a remedial measure, and I believe instructions have been issued to substitute "reboissement," or at least "reboissonement" (the planting of shrubs) wherever practicable. Such is a brief outline of the facts relating to forest denudation, its results, and the extensive measures of "reboissement" which have been forced upon the State in the interests of the community in France. To quote the words of Surell, writing some years ago:—"The country is becoming depopulated day by day. Ruined in their cultivation of the ground, the inhabitants emigrate to a great distance from their desolated land, and contrary to the usual practice of mountaineers, many never return. There may be seen on all hands cabins deserted or in ruins, and already in some localities there are more fields than labourers. The precarious state of those fields discourages the population left. They abandon the plough, and invest all their resources in flocks. But these flocks expedite the ruin of the country, which would be destroyed by them alone. Every year their number diminishes in consequence of want of pasture grounds. One commune, St. Etienne, which supported 25,000 sheep fifteen years ago, supports no more than 11,000 now. Thus the inhabitants, who sacrifice all their soil for the flocks, will not even leave this last inheritance to their descendants."

The work of "reboissement" must not be mistaken or mixed up with that of the planting of *Pinus maritima* on the low and sandy coasts at the mouth of the river Gironde, with the main object of fixing the shifting sands.

On this subject it may be useful to quote the process adopted* :—

"On the low and sandy coasts between the mouths of the Adour and the Gironde, every tide leaves behind it quantities of fine sand; the sand is continually drifted inland by the wind, and forms moving hills, which sometimes attain a height of 70 mètres (230 feet). These hills, as we should naturally expect, have a gentle inclination on the side of the sea, but descend abruptly towards the interior; sometimes they are long, continuous, and disposed in regular and parallel lines; at other times they run zigzag. This depends on the form of the coast-line. Thus, between the Adour and the Gironde, the first case presents itself; while, near the promontory of La Coubre, where the wind blows from several points, the elevations and depressions are entirely irregular.

"It is to these moving sand-hills that the name of *dunes* has been given. According to information furnished by M. Dutemps du Gric, Con-

* "Manual of Sylviculture," by G. Bagneris, Inspector of Forests, Professor at the Forest School of Nancy.

servator of Forests at Bordeaux, it has been ascertained that the average rate of their progression towards the interior is 4·30 mètres (14 feet) a year, and that the quantity of sand thus brought up is in the proportion of 75 cubic mètres for every mètre of coast-line (109 cubic yards for every yard). The hollow between two consecutive dunes (called *lette* by the natives), is very variable. It is flat at the bottom, and generally marshy when the dunes are devoid of all vegetation.

"One can easily conceive the great importance of fixing and utilizing these dunes, whose onward march has swallowed up everything before it, and has been a perpetual source of danger to human dwellings, which more than once have had to retire before them.

"The first attempt to fix these sand-hills was made with hurdles, and certain plants having well-developed roots, such as the *Psamma arenaria*, a *Euphorbia*, *Festuca*, etc. But these succeeded only temporarily. At length the *Pinus pinaster* was tried, with all the desired result. This pine is admirably adapted to the locality. It is indigenous in the parts of France possessing a mild climate; its tap-root penetrates deep into the soil and throws out strong lateral roots, which in their turn develope along their whole length numerous secondary roots in a vertical direction. In addition to these valuable properties, we may add the abundance and fine quality of its resin.

"The *Pinus pinaster* had long before been employed in the dunes, as is witnessed by the forest of La Teste, which dates back several centuries. But such attempts were successful only on the dunes in the interior, which were protected by those nearer the sea. It was not till the year 1787, when Brémontier began his labours, that they succeeded in planting up to the sea-shore. The method used at present for fixing the dunes is described in what follows :—

"Before any sowing operations can be attempted, it is absolutely necessary to establish a protecting-wall, in order to prevent the seeds and young plants from being buried over by the drifting sand. This wall is nothing more nor less than a dune, which is purposely allowed to form, called the *littoral dune*. A continuous line of paling is erected parallel to the coast-line, about 100 mètres from high-water mark. The paling is constructed of planks 1·60 mètres long, 3 centimètres thick, and from 12 to 15 centimètres broad, and pointed at the lower end. These planks are put into a trench 40 centimètres deep, and then driven 20 centimètres into the sand, so that, when the trench is filled in, one mètre remains above ground. An interval of two centimètres is left between two consecutive planks.

"The sand is arrested by the paling, and is thus deposited in the form of an inclined plane, sloping very gradually seawards. Some of it passes through the spaces left between the planks, and serves as a sort of backing, thus increasing their stability. When the sand reaches the top of the paling, and begins to cover it, the latter is raised by means of a lever with hooks. In this manner the littoral dune rises higher. This increase in height must be rendered as gradual as possible, otherwise the dune would be exposed to be washed away by the sea.

"To give the dune more stability, a tight-bound fence is erected behind the paling. Stakes 2·50 mètres in length are driven 50 centimètres into the sand, and the wattling is at first carried only up to a mètre above the ground. The wattling is continued upwards as the dune rises. When the dune reaches the top of the stakes, another fence of the same kind is put up, for the old fence obviously cannot be raised like the paling.

"The whole is at length fixed by planting over with the *Psamma arenaria* in tufts of five or six plants 50 centimètres (20 inches) apart. This grass possesses this important property, that, as the sand covers it, its stalk grows higher, and developes numerous adventitious roots, which form a veritable network. A hectare requires 300 bundles of this plant, weighing 10 kilogrammes (22 lbs.) each, besides 6 kilogrammes (13 lbs.) of seeds. The first thing done is to sow the seed broadcast, the operation of planting, and the going to and fro of the labourers, being enough to press them into the ground.

"A running mètre of paling costs from 2·50 to 3 francs (about 8d. per running foot). It lasts, on an average, five years, when the planks are made of the non-injected sapwood of the *Pinus pinaster*. The expense of keeping it in repair and raising it is about 50 centimes a-year (about one penny and a fifth per running foot). The price of a mètre of fencing is 30 centimes (about 0·88d. per foot), and a new fence must be put up nearly every year.

"If, notwithstanding these precautions, the wind is apt to make breaches in the littoral dune, other rows of paling, making a given angle with the first, are erected on the steep side. At the present day may be seen a littoral dune, well kept up along a coast-line of more than 200 kilomètres, reaching from the bar of the Adour to the mouth of the Gironde.

"A protecting wall against the wind being once obtained, the moment has arrived for beginning sowing operations on the inner dunes. This is done by scattering broadcast a mixture of the seeds of the *Pinus pinaster*, the common broom (*Sarothamnus scoparius*), the furze (*Ulex nanus*), and the *Psamma arenaria*. In the operations carried on by the State, the quantity of seed to be used per hectare is 10 kilogrammes of the pine, 9 kilogrammes of the broom, and 4 kilogrammes of the *Psamma arenaria*.

Over the whole is spread a covering of broom, furze, and other brushwood. One man unties the bundles, while two others spread them out, and a fourth throws on a spadeful of earth, at intervals of 20 inches, to keep the brushwood down. This covering is essential for preventing the seeds, and especially the sand, from being blown away by the wind. Furze is preferable to the broom, as it yields a richer manure by its decomposition.

"The sowing, and the spreading out of the brushwood, must be done simultaneously. At the close of each day's work, some spadefuls of sand are thrown over the last row of brushwood to enable it to resist the force of the wind. Care must be taken that the last row is spread out evenly and well against the ground, so as to prevent the wind from getting underneath. Without this precaution, a single night is sufficient to destroy the work of several days.

"The pines, the broom, and the furze come up together; and it has been remarked that the young pines are all the finer for growing along with a large quantity of broom and furze. When these latter are not sufficiently abundant, the covering of brushwood should be carefully maintained, as the protection it affords is necessary during nearly four years. Sometimes, indeed, it has to be renewed, and its maintenance constitutes one of the principal operations during that period.

"The *reboissement* of the littoral dune itself may often be undertaken at the end of a few years, by forming a new littoral dune nearer still to the sea. In any case, the maintenance of a littoral dune is a *sine quá non;* otherwise every result of previous operations must inevitably be lost by the continual drifting in of new sand.

"Such is a brief description of the operations employed in fixing the dunes. They often entail great labour, and the difficulty is sometimes so great, that the fixing and stocking of one hectare does not cost less than 500 francs (just over £8 per acre). This outlay ceases to appear considerable, if we balance against it the protection which it affords for all the country behind the dunes. Nearly the whole of it is absorbed by the erection and constant repair of the paling, and this principally by the transport of planks and brushwood over a long length of uneven country formed of deep and yielding sand."

In the "Australasian" of February 10th there is a letter from Mr. Hunter, M.B.F.C.S., on the subject of the influence of forests on the climate and water supply of Victoria, and in the same paper is an editorial headed "Forest and Lake." Both Mr. Hunter and the editor warmly advocate increased conservancy and improvement of the forests, which it is admitted on all hands have been allowed to deteriorate and be destroyed in a most shameful manner, with the worst effects on the climate and water supply.

Without going so far as Mr. Hunter, and estimating the annual increase in yield of wheat at eight bushels, which at five shillings per bushel would represent two million a year more of wealth without any extra expenditure—minute calculations which unsupported by facts I consider are likely to damage rather than improve an otherwise good case—I cordially agree with the editor, who sums up the argument by stating that "it is however possible for each colony to conserve local advantages which it owes to nature, and in this category we place not only forests, but water of every size and form. * * Let the Government not attempt to shirk its duty by handing over to local bodies the management of forests, but let it grapple with the whole question in a statesmanlike manner, and earn, even though it may not immediately win it, the gratitude and respect of the people whose interests have been entrusted to its care."

Our time to-night will have been spent to little advantage if you do not feel that this colony is eminently one possessing great "local advantages which it owes to nature," in the shape of forests and supply of water. These advantages it is our duty, as well as our interest, to preserve; and I think New Zealand is lucky in possessing statesmen like her late Premier, Sir Julius Vogel, who have looked ahead and seen the necessity of grappling with the difficulty in time, that is before the damage has actually been done, and when the necessary measures can be applied, as I hope to show you to night, by a very small temporary outlay, securing not only immunity from the damage and destruction which have taken place elsewhere, but a considerable and steadily increasing forest revenue to the State.

I do not think that any damage has as yet been done to the climate of New Zealand or its water supply by the clearing of forests; indeed, I have little doubt that the climate has in many instances been ameliorated by it. Some of my friends tell me that this City of Wellington is a case in point. But they also tell me that there is much less water in the streams which run down from the surrounding hills than formerly. I know naturally nothing as to the facts myself, and am inclined, as already stated, to take such expressions of opinion with a very large grain of salt. In the present case the opinions are exactly in unison with what I should have surmised from what I see; and I take the drying up of the streams as a warning to be wise in time, and not to kill the goose, *i.e.*, the forest, which lays the golden eggs, *i.e.*, moisture and water supply—a burning question, by the way, I believe, at the present time in Wellington. I may say the same of the West Coast of the South Island, from which I have just returned. No damage has as yet been done, rather the contrary; but ascending the narrow vallies of the Grey and Buller Rivers and their tributaries, walled in by steep forest-clad hills, a feeling almost of dread constantly presented itself to my mind as to what would be the result if these forests were ever to be cleared away without great discrimination and the retention of extensive reserves. Mr. Kirk was with me, and can tell you that the same thought presented itself to both of us almost simultaneously. These forests are of little commercial value, but I am certain we cannot be too careful of how they are felled and treated. Once gone, farewell to the smiling fields in the vallies below and abundant pasture on the lower slopes of the hills. There is but little soil or vegetable deposit on the top of the shingle—I do not know the exact geological term for it—of which those mountains are mainly composed. Remove the forest, and the coating of *humus*, or vegetable mould, will soon follow, perhaps after it has afforded pasturage for a few sheep for a few years, and the after-results will be those which I have attempted briefly to depict in the case of the French Alps and Pyrenees.

The same argument, of course, holds good more or less with regard to all the forest-clad mountain ranges in New Zealand. I say nothing of the actual rainfall, although the facts, as I have seen and compared them in this colony, almost convince me that forests have a direct influence even on the amount of that; for all along the East Coast, with bare plains and comparatively little timber on the hills, we have but a scanty rainfall even in the immediate neighbourhood of the hills themselves, whereas in the densely-wooded West Coast we have a rainfall greatly in excess of the average. The forests may, as has been asserted elsewhere, be the effect and not the cause; but I must say I, for one, see nothing to lead us to that belief, as, if it be so, why should not rain have fallen and forests been created on the eastern slopes of the mountains, on which the clouds, laden with moisture from the Pacific, first impinge? Be this as it may, I have no hesitation in advocating the careful conservancy of the forests on the Western slopes of the mountains, which may be called the backbone of New Zealand; and I have no doubt that the formation of plantations in Otago, Canterbury, and eventually probably in some of the Eastern districts of the North Island, will go a great way to ameliorating the climate, breaking the force of the wind—an advantage of planting which has almost escaped my notice, but which is matter of great importance, especially when the wind is a hot one, as it sometimes is in the Canterbury Plains, and decreasing excessive evaporation and consequent dryness of soil. In short, I am well assured that, by the initiation and systematic treatment of forest conservancy and planting, New Zealand may secure her proud pre-eminence as the best watered and probably most salubrious climate in the Southern Hemisphere, if not in the world.

Let us now consider the financial aspect of the question. The question of direct financial gain, or extracting a revenue from the forests by the

State, should ever be subordinate to their conservancy for climatic considerations and improvement, to meet the demands of the future. So long as this is borne in mind, and we are not tempted to overdraw and trench on the capital as well as the income of our forests in the shape of timber and minor produce, there is no reason why they should not be dealt with like any other property, nor why the State, as proprietor in trust for the public, should not derive from them the maximum amount of revenue compatible with the general welfare of the people.

The financial aspect forms always an important item for consideration in the conduct of our affairs, whether public or private, and at present the financial question is, I may say, paramount with the Government and people of New Zealand. I am not, therefore, surprised at the general satisfaction with which the public press has received my statement at Dunedin that the Forest Department should be entirely self-supporting, though I am surprised that it should never have struck people before that this could be done, as it has been done in other countries. I have no hesitation in reiterating the Dunedin statement, and proceed to explain how it is to be done. We cannot, of couse, maintain a department for the selection of reserves and their improvement, supervision of unreserved forests, forming plantations, etc., without money; but we may, I think, get that money from sources hitherto untapped, in, short by disposing of our surplus property, which we do not want, and which is much better in other hands, to the best advantage. No one in his senses would propose to reserve and keep permanently locked up, either for climatic considerations or prospective money value, one tithe of the forests of this colony as they now exist. Time and careful exploration, and selections on a definite system, can alone show what we should keep, and what may be parted with; but I may say broadly that probably nine-tenths of the existing area under forest in New Zealand may in time be cleared away, or at least not specially reserved, and devoted to the growth of timber. I propose that Government, *i.e.*, the public, should claim and take a fair share of the value of the timber remaining on the waste lands of the colony, and not allow it, as has been almost universal heretofore, to be monopolized solely for the benefit of individuals, or still worse, wasted and destroyed. I do not, let it be well understood, advocate for a moment, injurious restrictions on settlement, or withholding bush land not suitable for reserves from sale and occupation. To do so would be to put a stop in some districts almost entirely to the progress of the country; but I do say that whilst we are selecting the reserves (a matter which will take some time), and subsequently with regard to the margin left as unreserved, a system may, without inconvenience, be introduced and worked, under which Forest Officers shall be consulted by the Waste Lands Boards with regard to the proportion of the forests to be thrown open for settlement from time to time with a view to opening out gradually, and first as much as possible in places where the timber has a marketable value. And the waste land may therefore reasonably command a higher price on account of the timber standing on it, instead of as now, particularly in Wellington, being sacrificed along with thousands of pounds worth of timber at a mere nominal rate in order to attract a few settlers. I say boldly that this system of pushing settlement in localities not ripe for it, and in a Colony where there is still plenty of room for settlers, and sacrificing very valuable property in so doing, does not commend itself to me at all as being really for the best interests of the Colony, and I hope and believe, that if I am rightly understood, the Government and popular feeling will agree with me. If so, we should, by throwing open for settlement from time to time portions of the waste forest lands of the Crown, secure a price for the timber, or enhanced price for the land, which comes to the same thing, with the further indirect advantage that purchasers would probably set a higher value on the trees, and utilize, not destroy, those of economic value. So much for the actual disposal of forest lands not suited for reserves, and required for extension of settlement. I propose also to lease out to saw-millers blocks of the Government forest, not at present the reserves, to be worked on payment of a royalty or tithe of so much per 100 feet, and to require all parties indenting on the Government forests for building or fencing stuff, firewood, etc., to take out licenses on payment of seignorage or royalty, and fell, split, and remove what they require, in certain places to be prescribed from time to time, and not at will. I would make absolutely no exceptions to this rule. All should pay—squatter, miner, free-selector, etc. Everyone requiring timber from a Government forest should pay for it; but I would make such payment very light, and do everything in our power to save inconvenience and unnecessary interference, by the issue of annual licenses for firewood, upkeep of post and rail fences, etc., and especially in the case of squatters and farmers cutting on their own leasehold or neighbouring Crown forests. As regards the trade more particularly, our object would be to induce saw-millers to first enter on and work blocks of forest adjoining settlements. When they had taken all that they could profitably work up, give them new blocks further in, and allow the splitter and firewood-chopper to take what they can off the first block before its outright sale. This system has been tried in Southland to a certain extent, and as an experiment I consider successfully. The Waste Lands Board in that district have withdrawn from sale all the forests, which are extensive, and find no difficulty in getting saw-millers to work blocks on payment of royalty, or in collecting license fees, though the means at their disposal, consisting only of one Inspector, are very inadequate.

In Otago, they are leasing forests to saw-mills at so much per annum, averaging £1 per acre per annum for three years, and issuing licenses to hand-sawyers and splitters at 50s. per annum for a claim of 200 ft. square. In Westland, again, a fee of £5, for each man employed in working a Government forest, is charged; and I believe in Auckland a fee of £5 was charged for working a certain area of forest; but this has now been put a stop to. The Southland system recommends itself in every way, and appears to give satisfaction to saw-millers and those requiring timber generally. The present Government revenue, even at the very low royalty of 3d. per 100 from saw-mills, £2 settler's license for cutting firewood for domestic use, 1s. per cord firewood for sale, and 20s. per 500 pieces of fencing stuff, amounts to about £1,200 a-year. But the saw-mill industry is at present very stagnant, and there is doubtless great evasion, or non-enforcement of the license regulations, by settlers and splitters, owing to want of establishment or arrangement for their systematic working and supervision. There are regulations intended to prevent waste and restrict felling within certain limits; but these cannot be said to have been enforced, nor should I try to do so hurriedly. It is only by degrees, as we can help saw-millers to a better market for their small stuff, induce them to work out one block before going to another, and ensure economy in hand-sawing or splitting by levying royalty at so much a tree or number of trees, that we can hope to prevent waste and regulate felling. But it can be done only by degrees and taking the people along with us. Surely something in this direction, by which a forest revenue already amounting to upwards of £2,000 a-year in Otago and Southland—an amount which would probably be doubled the moment systematic supervision was introduced, whilst it gives us the means of gradually introducing improved management—is better than the *laissez aller* and general destruction of timber in other districts without any return direct or indirect to the State, or to disposing of forest lands, worth £30 per acre for the forest alone, at £2. It may be said that people will not buy forest land at enhanced rates, and will not pay to take timber from Government forest when they can get it from freehold. I maintain that they will gladly pay enhanced rates for forest land if we place it judiciously on the market, and not depreciate it by sacrificing the timber on it in order to push settlement, and that Government would have no objection to the supply being drawn from freehold lands, and can well afford to wait till they are exhausted. I know all the stock arguments as to the cost of clearing forest land, the advantages of opening out the country, which no one can deny; and the fact that timber is absolutely valueless and an encumbrance away from a market. I grant them all; but, if the forest land be not worth clearing, it had better remain uncleared till it is—at least till we have selected the reserves. If timber land is worth having, an extra £1 per acre will not prevent its being taken up. And, if the timber be absolutely valueless now from its situation and want of means of communication and transport, there is no reason that it should be so ten years hence. And I submit that the Colony can well afford to wait, and not force on the clearing of any more forest land, pending the selection of the reserves and development of the Public Works policy. I repeat, then, my expression of opinion, that, whatever may have been advisable in the past, it will be well to be circumspect in dealing with the area remaining as forest Crown Lands, which may be approximately stated at 12,000,000 of acres, out of a total area of 66,000,000 of acres; and that, whilst the permanent reserves are being selected, the tracts not required for that purpose be sold or leased with care and to the best advantage, and not indiscriminately or without any reference to the value of timber upon them. Outright sale commends itself in a Colony like this, where we do not wish to conserve or reproduce the crop; but I would not sell an acre except at a much higher price than is now generally obtained; failing which, I should lease to saw-millers, devote to felling for hand-sawyers and splitters, or include in pastoral leases under certain restrictions, as found most advantageous. I believe, by the adoption of such measures as I have thus sketched out, we shall secure a very considerable and increasing forest revenue, sufficient to balance all our expenditure and form plantations, whilst the reserved area is nursed, and, by degrees, treated on principles of scientific forestry, with a view to increasing its yield per acre, and improving the growth of timber on it where it is not simply retained for climatic considerations and is too remote or inaccessible to work. The increased forest will yield our revenue for the present, and the reserves and plantations which we constitute and improve from that revenue will well recoup us in the future.

It may be argued that this is but taxation in another form, and not at all what was expected when I said that the department would be self-supporting. If paying for what does not belong to me be a form of taxation, I admit that it is so; but I cannot see that anyone has any more right to take the forest products from the Crown—that is, public lands held in trust by the Government of the day—than he has from yours or mine, and think it will be admitted on all hands that Government have a right to charge him for them as you or I would. I believe there will be some difficulty with regard to miners, who consider that their £1 miners' right gives them a claim to use the wood they require free of any further payment; and of course if this right or privilege has been conceded to them, it must be respected, But I would rather advocate the withdrawal of the special tax upon him and let him pay for his wood like anyone else, as I cannot see that it is right or fair that the Westland or Nelson miner should get timber free for his £1, whilst the Otago miner gets none, and the Thames miner has to pay 25s. for each kauri tree, which I believe goes to the Natives. I have found that, if all have to pay, none complain or have a grievance, and there is nothing we should more carefully avoid or guard against than the creation of special rights or privileges—our special bugbear in India.

Before concluding, I should like to place before you very briefly some of the financial results of State Forestry in India and elsewhere.

Forest Conservancy in India by a State or Government department dates from about 20 years ago. The department, from very small beginnings, originating in many Provinces in the mere appointment of a few forest guards to protect certain trees, and the establishment of a few small nurseries and plantations, has gradually taken charge of a very large public estate, consisting of forests all more or less deteriorated to an extent of which you in New Zealand can have no idea, devastated yearly by fire, overrun by countless numbers of cattle and sheep, whose herds considered they had a right to cut down any tree from mere wantonness, or to allow their beasts to feed on the leaves, and encumbered with the rights and privileges of a Native population of over 200,000,000. Not a promising property to tackle and improve, still less to exact an annual surplus from. Still it has been done, and by the last returns for the whole of India, which I have with me, viz., those for 1873-74, the forest revenue was £700,000, and expenditure £414,000 odd, leaving a surplus of upwards of £285,000, or 41 per cent. on the total revenue. Both revenue and expenditure are about double what they were ten years previously, in 1864-65.

I do not say that there have not been faults in our Indian forest administration, that we may not have looked too much to revenue and too little to real conservancy and improvements; that some of the royalties—that on firewood for instance—may not have pressed hardly on the class of poor cultivators, who pay it when they have no village forest from which to obtain it free. But I do say, that whilst there is no doubt that the state of the forests has been and is being improved every day, reserves selected, demarcated, and surveyed, occupying a special branch of the department; plantations on a large scale established; the real rights and even privileges of the people, in the shape of timber for agricultural purposes, grazing, etc., have been scrupulously and liberally conceded to them; and that the manner in which revenue has always balanced and is now steadily yielding an increased surplus on expenditure, is most gratifying and encouraging to the forester in all parts of the world. I may add that in the Madras Presidency—the portion of India with which I have been more immediately connected—as regards the Forest Department, the policy of the Government has not been to produce a large surplus balance, but rather to increased liberality in the free grants of timber, and liberal concessions to the wants and circumstances of the poorer classes of the inhabitants. As they write so recently as last December to the Governor of India:—"It has been the policy of this Government (that of Fort St. George)—a policy which has been approved by the Secretary of State—that the production of a surplus is neither the present nor ultimate primary object of forest operations; and whilst seeking to increase the productive powers and revenues of the forests, this Government has had mainly in view the utilization of increasing revenues in extending plantations and in conserving indigenous forests, and by this means supplying the people and railways with cheap fuel, and preserving or restoring those climatic conditions which appear to be more or less dependent upon the existence of woodlands. The aim and object has indeed been to be self-supporting, and devote any surplus accruing to improvements, which is exactly what I would propose to do here for some years, though the circumstances here are widely different and much more favourable to expectations of a large surplus revenue even in the immediate future. For here we have a large area of almost virgin forest unencumbered by vested rights and privileges, whereas there we had to take over forests which have been more or less worked for centuries, and which were burdened by the claims, legal or otherwise, of a teeming native establishment, which in many cases more than represented the gross annual yield of the forests.

I have spoken in my Dunedin paper of the results of planting operations in India, and do not propose to recapitulate those results this evening. I may state, however, that, from reports received by the last mail, I learn that the yield of the *Eucalyptus* Plantations on the Nilgheri Hills is far exceeding the most sanguine expectations. The Conservator and a trained Forest Assistant having made a careful estimate and a series of actual experiments, the former officially reports the yield at 1,450 cubic feet, or 25 tons (58 cubic feet to the ton) of dry weight per acre per annum, whilst the indigenous forests on the Nilgheris, which have not been conserved, yield only half a ton per acre per annum. This speaks volumes for the financial benefit likely to be derived from planting the *Eucalypti* in some parts of this country, where the climate closely resembles that of the Nilgheris. I may mention that the average out-turn of indigenous New Zealand forests, as stated by saw-millers, does not exceed 15,000 superficial feet—1,250 cubic feet—per acre, and then it is presumed to be exhausted for ever. Mr. Kirk and I estimated the proper out-turn in timber, in a portion of the Seaward Bush, Invercargill, at close on 31,000 superficial feet—say 2,500 cubic feet; but it must be remembered that, under the present system, much timber which would be utilized elsewhere is discarded as worthless, and all small stuff is considered utterly valueless. I am in correspondence with the Chief Engineer on the subject of making use of it for the railway locomotives wherever practicable; and if we can thus find a market for it even at very little over price of actual haulage and sawing into billets, I consider that a great boon will be conferred on the saw-mill industry and the colony.

Leaving India, and turning to the Continent of Europe, I find that the annual revenue of the Forest Department in Prussia is £2,100,000, disbursements rather more than half, leaving a nett profit of £1,000,000, the disbursements including an item of £75,000 for commutation of forest rights and servitudes. The nett profit in Saxony is £249,000; Bavaria, £596,000; Austria, £90,000; Hanover, £162,000; whilst that of some of the smaller States, for which I have not returns in money, must be much greater in proportion, if we take their yield in timber as a guide. I may mention that, in Bavaria, the proportion of forest to total area is 34·4 per cent., or upwards of one acre per head of population. This is the largest area, in proportion to total extent or head of population, of any State in the German Empire.

In the debates on the Forest question, in the House of Representatives here, in 1874, I observe that several members took exception to Sir Julius Vogel's original Forest Bill, which was subsequently withdrawn on the ground that the conservation of the natural forests would not pay, judging from the results obtained in Germany, Austria, etc. I do not think that any such conclusion can be deduced from the published returns. Not only do they in most cases show a fair rental, amounting, in the case of Saxony, to 12s. 6d. per acre, but it must be borne in mind that much of the total area under conservancy on which the rental is calculated, is unproductive, only partially stocked, or subject to the free supply of the villagers and their right to pasture their cattle, and collect straw, litter, etc., therein, for which there is no money return. I have seen many instances in Germany and India in which the whole annual yield of a forest tract went to the inhabitants of neighbouring villages free of charge, thereby decreasing very considerably the annual revenue per acre calculated in the total area. We have no such rights and vested interests to lower the money return from the New Zealand forests; but it is true that we have at present a limited demand, owing to the sparse population; an evil, if it be an evil, which, if I may judge from the number of young New Zealanders one sees in every village, is fast remedying itself from natural causes, not to mention the results of immigration. The only point on which I consider we must be very careful is not to hamper the timber industry by vexatious regulations, or raise the price of timber to such an extent that it will be cheaper to import from neighboring Colonies, Europe, or America. I see no cause at present to fear such a result. The imports, it is true, are large, their value having been, roughly speaking, £180,000 in 1875; but the chief items are the *Eucalypti*, from Tasmania and Australia, imported for special purposes, and not in competition with New Zealand timbers. The value of New Zealand exports in timber and forest produce almost exactly balances the imports; but the main item of export is kauri gum (£130,000), on which valuable product the State has hitherto received little or nothing. I think we should leave out the kauri gum tracts or waste lands of the Crown, or levy a royalty on the quantity taken from them.

I see no reason why New Zealand should import so much timber as she does, when she has such indigenous timbers as kauri, totara, puriri, black pine, and black birch, at command. The main reason is, doubtless, dear labour; but I am sanguine that, as population increases, and the real value of the indigenous timber, when to cut and how to season them, becomes known, the imports will decrease not increase, whilst the demand for our surplus timber from the West Coast from Australia will be greatly augmented.

I think I have now said enough, and only trust that I may have presented the question of Forest Conservancy to you under a new and highly important aspect, so far as regards its influence on the climate, and that you will endorse the measures I have suggested for its gradual introduction—which are identical with those which I have recommended to your Government—with your approval.

His EXCELLENCY, after inviting discussion on the paper, which was not responded to, said: "As no gentleman seems inclined to make any remarks upon the very interesting lecture we have heard, I beg to propose a vote of thanks to Captain Campbell-Walker, and before doing so I should like to make a very few remarks upon it. The question of the climatic influence of forests upon a country, I think is one which in this present day few people will be inclined to deny. It is a subject which has attracted very general interest throughout Europe and in other parts of the world. It is self-evident that a mountain-side, divested of its natural forest covering, must be more susceptible to the influence of heavy rains—that the soil which attaches to its sides must be more liable to be washed into the valley beneath, than when the mountain-side is covered with forest, and that the fact of the forest shading the soil from the rays of the sun prevents the more rapid evaporation which occurs when the forest is taken away; and therefore it requires, I think, little argument to oblige one to admit that the existence of forests on the land must equalize the evaporation, and therefore to a great extent regulate the water supply of a country. Till I came into this room and heard the lecture, I was totally unaware of the line of thought which Captain Campbell-Walker intended to pursue, and therefore I am not in any way prepared to express any very decided opinion upon what has emanated from him, and I daresay many others are in the same position; but at the same time I think you will all agree with me that his lecture, from first to last, has taken a very practical turn. He has shown us that the existence of forests has a very decided and a very beneficial influence on climate, and while he has not presented to your view any magnificent scheme of forest regeneration—perhaps I am hardly correct in using that term, for I am happy to say there is no necessity for regenerating forests in New Zealand; but while he has not presented to your view any scheme for forest maintenance at a large cost to the country, he has told you whatever plan he advises will have the merit of being self-supporting. I entirely agree with him that it should be so, and I am equally confident that it might be made so, and that a scheme such as he suggests might be very easily and successfully carried out. I have been accustomed to live in forest countries, and nothing has struck me more than to see the gross way in which forests are abused and wasted. It has been my fortune on various occasions to visit the forest tracts of British North America, and I may say there is no doubt that while there is an enormous amount of very valuable timber annually extracted from those lands, yet there is a very much larger amount annually wasted. Still—I speak subject to correction, for it is some time since I left Canada—I believe the Government derives a considerable revenue from the forest country. In this colony I have constantly been told, 'Oh, in this district the soil is exceedingly good, but it is impossible to settle it, because the forest is so dense nobody can afford to clear it.' That was told me only the other day on the West Coast. Well, if this is the case, I think it becomes self-evident that if, before introducing the settler to such land, you can introduce the saw-miller, and so abstract the heavy timber, and further get rid of some of the smaller timber in the shape of firewood, not only will you be doing the intending settler no harm, but you will in fact be enhancing the value of the land by removing that which checks enterprise. For my own part I must own, from the experience I have had in new countries, I believe that the settler who can establish himself on forest land—I admit all the difficulties, the loss of time, and the expense of labour to be encountered—will reap a much better reward for his enterprise than will he who takes up land which requires no clearing. As I said before, I was totally unprepared for the line of argument Captain Walker has taken up, and therefore the few remarks I have made are very cursory and superficial. I am sure you will join with me in thanking him heartily for the interesting and practical lecture which he has delivered."

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