PROCEEDINGS

of the

FIRST PAN-PACIFIC SCIENTIFIC CONFERENCE

Under the Auspices of the

PAN-PACIFIC UNION

Honolulu, Hawaii

August 2 to 20, 1920

BERNICE P. BISHOP MUSEUM

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DELEGATES TO PAN-PACIFIC SCIENTIFIC CONFERENCE

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INTRODUCTION

HISTORICAL SKETCH AND ACKNOWLEDGMENTS

By Herbert E. Gregory, Chairman of the Conference

The study of the natural history of the Pacific has proceeded with few interruptions since the memorable observations of Captain Cook made the ocean generally known. The results of such surveys as are recorded in Voyage de La Pérouse; Voyage de *L'Astrolabe;* Voyage of the *Beagle;* the Wilkes Exploring Expedition; the *Challenger* Expedition; the Nederlandsche Nieuw Guinea Expédition, the Voyage of the *Discovery;* the Harriman Alaska Expedition; and the British Antarctic Expedition are the foundation stones for Pacific science on which rest the contributions of many individuals and institutions. The interest in systematic exploration during the past decade may be illustrated by the interchange of views that may be considered as the steps leading to the organization of the First Pan-Pacific Scientific Conference—a conference which is "first" only with respect to scope and personnel.

The desirability of a fuller knowledge of the Pacific was considered at the Australian meeting of the British Association for the Advancement of Science (1914), unhappily interrupted by the declaration of war. In 1916 Professor W. M. Davis, who had attended the sessions at Sydney, arranged a symposium on Pacific exploration for the annual meeting of the National Academy of Sciences, and my presence in New Zealand and Australia permitted an exchange of views with scientists of the southern Pacific. In 1918 a conference on international relations, in which Pacific scientific problems received attention, formed part of the program of the Semi-Centennial Anniversary of the University of California. At the close of the anniversary meetings in which Dr. Evermann, Dr. Merriam and Professor Ritter took important parts, the representatives from the countries of the Pacific expressed a desire to call another conference (possibly in Japan) soon after the close of the war. During 1919 continued interest was shown by a paper on Plans for the Exploration of the Pacific presented by invitation at the annual meeting of the National Academy, and by the program of the Pacific Division of the American Association for the Advancement of Science, which included a series of papers on the exploration of the North

Pacific Ocean. During 1920 the Committee on Pacific Exploration, originally appointed by the National Academy, was transferred to the National Research Council, and, with changes in membership and title, constitutes the present Committee on Pacific Investigations.

The meetings and informal conferences preceding 1920 brought out clearly the size and complexity of the scientific problems centering in the Pacific and the advisability of enlisting the interest of many institutions, individuals and governmental agencies in a combined attack. It became increasingly clear that a study of Pacific problems could be facilitated by a conference of interested scientists in Japan, Canada, China, Australia, New Zealand, Java, continental United States, Hawaii, and the Philippines and steps leading to such a conference were taken.

While plans were being considered a way was unexpectedly opened for holding such a conference in Honolulu under the auspices of the Pan-Pacific Union, an organization designed for promoting good-fellowship among peoples bordering the Pacific.

In April, 1919, the legislature of the Territory of Hawaii appropriated funds to be used by the Pan-Pacific Union in defraying the expenses of a "Pan-Pacific Commercial and Educational Congress" during 1920 or 1921, and the Governor of the Territory placed the organization of the proposed conference in charge of a committee composed of representative citizens of Honolulu with George P. Denison as chairman (see page 3). Meetings of this Committee on July 14th and subsequent dates resulted in a decision to give the 1920 session of the proposed congress the form of a conference dealing with the fundamental scientific problems of the Pacific. This action was so completely in harmony with the plans of the National Research Council and of similar bodies in other countries that the request of the Committee that the Director of the Bernice P. Bishop Museum accept the temporary chairmanship of the scientific congress, determine its scope and personnel, and perfect a preliminary organization, was granted by the Trustees of the Museum.

After consultation with scientists in Honolulu, the Temporary Chairman obtained the consent of the Committee on Pacific Exploration of the National Research Council to serve as a program committee for the coming congress, and at meetings in San Francisco, New York, Boston, and Washington, and through extensive correspondence with institutions and individuals interested in the Pacific work, the scope and purpose of the congress and the list of desired delegates were determined.

Early in April, 1920, invitations in the name of the Pan-Pacific Union were sent by the Temporary Chairman to scientists and scientific institutions, and complimentary invitations were sent by the Secretary of the Union to heads of governments, newspapers, and to distinguished citizens in Honolulu and elsewhere. Accompanying the invitation was the Bulletin of the Pan-Pacific Union for May, 1920, and a descriptive circular, from which is taken the following:

The purpose of the congress is to outline scientific problems of the Pacific Ocean region and to suggest methods for their solution; to make a critical inventory of existing knowledge, and to devise plans for future studies. It is anticipated that this congress will formulate for publication a program of research which will serve as a guide for coöperative work for individuals, institutions, and governmental agencies.

The program of the Conference is in the hands of the Committee on Pacific Exploration of the National Research Council.

The meetings will be arranged to place emphasis on the following topics:

1. The present status of knowledge of the various branches of anthropology, biology, geography, geology, and related sciences in so far as the Pacific Ocean region is concerned.

2. Research desirable to inaugurate; projects described in considerable detail with reference to their significance, and their bearing on other fields of study. Investigations designed to lay the foundation for a higher utilization of the economic resources of the Pacific may be included.

3. Methods of coöperation with a view to eliminating unnecessary duplication of money and energy.

4. The best use of the funds now available and the source of further endowments.

As shown by the list of delegates (pp. 22-26) the response to the invitations was unexpectedly gratifying but the Conference would have profited much by the presence of such men as W. M. Davis, R. Daly, S. Percy Smith, L. O. Howard, J. C. Merriam, W. E. Ritter, E. Edgeworth David, and T. F. Cheeseman, debarred by illness or important engagements; and of Father Rougier and G. H. Angenheister prevented from attending by lack of transportation—all of whom contributed from their store of knowledge and experience to the success of the gathering.

The three months immediately preceding the meeting of the Conference were devoted to enlisting the interest of governmental bureaus, institutions, and individuals and in perfecting local plans for organization. On June 17, 1920, the Trustees of the Pan-Pacific Union officially approved the formal and informal actions of the Committee of the Pan-Pacific Union, and in order to meet the restrictions of the appropriation by the Territory the forthcoming congress was given the official title: "The First Pan-Pacific Scientific Conference of the Commercial and Educational Congress." To complete the necessary organization a Committee on Arrangements and a Committee on Publications were appointed (see page 3), and funds were allotted for expenses of delegates, publication of proceedings, and for general purposes.

After the preliminary organization of the Conference had been effected the duties of the Temporary Chairman and of the preliminary Committee on Program came to an end. The Committee of the Pan-Pacific Union, the Committee on Arrangements, and the Committee on Publication continued to function but the Conference itself was completely autonomous, electing its chairman and other officers and its committees, arranging its program and making provision for future meetings. (See pages 3 and 10.)

The Conference was designed as a gathering of scientists directly interested in the solution of problems centering in the Pacific. The delegates from the various countries were invited as individuals, and not as official representatives of governments or institutions. As was to be expected in a body so chosen, racial, national and institutional interests were completely submerged in the desire for helpful coöperation.

The Pan-Pacific Union and the Conference are under great obligations to the individuals and the institutions that generously gave of their time and means to make the sessions profitable. The Committee on Arrangements (see page 3), under the leadership of Mr. J. R. Galt, were constantly on the alert to provide the delegates with congenial surroundings and with facilities for their work. Outstanding features of the program planned by this Committee are:

1. Informal conferences with educational, commercial and military leaders and the interesting public lectures: The Sugar Industry of Hawaii, by E. Faxon Bishop; The Pineapple Industry of Hawaii, by Dr. H. L. Lyon; The Wireless Communications of Hawaii, by J. A. Balch; The History of Volcanic Eruptions in Hawaii, by Lorrin A. Thurston, and Hawaiian Trails and Mountains, by Vaughan MacCaughey.

2. Military review by the 17th Cavalry, Colonel J. D. L. Hartmann, Commanding Officer, by courtesy of Brigadier-General H. C. Hodges, Jr., Post Commander, Schofield Barracks.

3. Complimentary excursions by automobile around the island of Oahu and by train over the lines of the Oahu Railway and the Hawaii Consolidated Railway.

4. Financial arrangements which made it possible for the Conference to hold a fully attended six-day session on the island of Hawaii.

5. Guest cards issued to delegates by the Commercial Club, the Country Club, the Pacific Club and the University Club.

6. The thoughtfully planned receptions given by the Bishop Museum and by the University of Hawaii, and the smokers arranged by the Country Club and by the University Club, which served to establish friendly relations between the people of Honolulu and the visiting delegates.

7. The dinner given by the Governor of Hawaii, the "chowder supper" of the Pacific Club at the home of Mr. John Guild, and the Conference dinner of the Pan-Pacific Union.

The cordiality of the hosts, the brilliant speeches, and the unique entertainments made those gatherings memorable events in the minds of the distinguished company present. Further appreciation by the Conference of the assistance rendered by the people of Hawaii is fittingly expressed in the widely distributed pamphlet prepared by the Committee on Resolutions of Thanks and Appreciation: Henry S. Washington, Chairman; E. C. Andrews; Charles Chilton; Elmer D. Merrill; and Fusakichi Omori.

In recognition of good will extended to them, nearly all of the visiting delegates responded to requests for addresses before the various clubs and societies in Honolulu and public lectures were delivered by Dr. William Bowie, Professor Charles Chilton, Dr. Alfred Mayor, and Dr. Elmer D. Merrill. Public lectures in the Japanese language were delivered by Professors K. Kishinouye, F. Omori, K. Shibata, and N. Yamasaki.

The Conference is indebted to several organizations and individuals for the loan of books and specimens and to the United States Geological Survey, the United States Navy, and to the Japanese Government for useful charts and diagrams.

STATEMENT OF COMMITTEE ON PUBLICATION

By ARTHUR L. DEAN, Chairman of the Committee

A Committee on Publication was appointed by the President of the Pan-Pacific Union in July preceding the opening of the Conference (see page 3). This Committee had the active cooperation of the secretaries of the sections in securing reports of the section meetings.

The manuscripts submitted by authors and the stenographic reports of discussions based on the stenographic record skillfully compiled by Olga Smith, Marie Neal, Anne Satterthwaite, and Marie Gregory have been selected and arranged as follows: papers on anthropology, by Clark Wissler; papers on botany by W. E. Safford; papers on biology, by Paul Bartsch, C. H. Edmondson, H. F. Moore, and F. Muir; on geography, by William Bowie and George F. McEwen; papers on general geology, by Herbert E. Gregory and T. Wayland Vaughan; papers on volcanology and seismology, by T. A. Jaggar, H. S. Washington, and H. O. Wood; and other material by the members of the Committee on Publication resident in Honolulu. To fill undesirable gaps in the presentation of certain topics, the Committee has received the generous assistance of scientists who were unable to attend the meetings of the Conference.

Because of limitations of space, the Committee has abstracted or curtailed certain articles and has reluctantly returned several important manuscripts to their authors. As indicated in the following pages, some of these manuscripts have already been published elsewhere. The others are expected to appear in appropriate journals or transactions.

As announced by the Committee on April 4th, it has been found impracticable to submit proof to all the widely separated authors. Residents of Hawaii and members of the staff of Scripps Institution have had opportunity to see their contributions in the galley form. Proofs of the preliminary pamphlets (pp. 1-46 of Part I) were read by Miss Olga Smith and Arthur L. Dean. Proofs of the remaining pages were read by Miss Bertha Metzger and by Herbert E. Gregory, and also, for their respective branches of science, by Ralph Linton, ethnologist; H. F. Bergman, botanist; C. H. Edmondson, zoologist; T. A. Jaggar, Jr., volcanologist; Arnold Romberg, seismologist; Lawrence Daingerfield, meteorologist; H. S. Palmer, geologist. Proof of the sections on Methods of Cooperation and Training of Scientists and Addresses of Welcome were read by Arthur L. Dean. It is hoped that this procedure has resulted in no serious errors in statement or context.

The titles of the delegates have been published in the list on pages 22 to 26 and are not repeated elsewhere; the titles of non-delegates are printed where their names occur.

It has been found desirable to issue the Proceedings in three volumes bound as Part I, containing the Introduction and pages 1 to 308; and Part II, containing pages 309 to 636; and Part III, containing pages 637 to 949. With the title "First Pan-Pacific Scientific Conference; Organization, Proceedings, Resolutions," pages 1 to 46 of Part I were separately issued as a pamphlet in November, 1920.

The Committee regrets its inability to publish these Proceedings at an earlier date. The fact that the members have been widely separated and have been obliged to rely upon correspondence to a considerable degree has delayed their work, a delay which was increased because of the necessity for correspondence and interchange of manuscripts with delegates residing in different countries. It has been the belief of the Committee that the importance of the work of the Conference justified a comprehensive treatment of many important topics and the inclusion of papers from sources outside the Conference itself. It is believed that these Proceedings are fundamental and define the problems of the Pacific, both in respect to what is already known and to the program for the future. The thanks of the Committee and of all who are interested in scientific work in the Pacific are due to those contributors who were not able to be present at the Conference, as well as to all who have assisted in the work of publication.

ORGANIZATION

Chairman... Herbert E. Gregory
Vice-Chairman and Secretary............ Arthur L. Dean

Executive and Program Committee

The Chairman, the Vice-Chairman and the Leaders of the Sections.

Committee on Publications.

Arthur L. Dean, Chairman. T. Wayland Vaughan, Henry S. Washington, Herbert E. Gregory.

Committee of the Pan-Pacific Union.

George P. Denison, Chairman. F. C. Atherton, C. K. Ai, W. R. Castle, W. F. Frear, A. Lewis, Jr., Prince Kuhio Kalanianaole, Vaughan MacCaughey, I. Mori, R. H. Trent; Ex-officio: the President, Secretary and Treasurer of the Pan-Pacific Union.

Committee on Arrangements.

John R. Galt, Chairman. Robbins B. Anderson, Lyman H. Bigelow, C. H. Edmondson, Alonzo Gartley, T. A. Jaggar, Jr., Lorrin A. Thurston, Gerrit P. Wilder. Secretary, Miss A. Y. Satterthwaite.

Organization of Sections.

Anthropology

Leader, Clark Wissler, Curator of Anthropology, American Museum of Natural History, New York City.

Secretary, John F. G. Stokes, Anthropologist, Bernice P. Bishop Museum, Honolulu.

Biology

Leader, Charles Chilton, Professor of Biology, Canterbury College, Christchurch, New Zealand.

Secretary, C. H. Edmondson, Professor of Zoology, University of Hawaii.

Botany

Leader, W. E. Safford, Economic Botanist, United States Department of Agriculture.

Secretary, Charles N. Forbes, Curator of Botany, Bishop Museum; Mrs. Forest B. H. Brown, Research Associate in Botany, Bernice P. Bishop Museum, Honolulu.

ENTOMOLOGY

Leader, F. Muir, Entomologist, Hawaiian Sugar Planters' Association.

Secretary, D. T. Fullaway, Entomologist, Board of Agriculture and Forestry, Territory of Hawaii.

GEOGRAPHY

Leader, William Bowie, Chief Division of Geodesy, United States Coast and Geodetic Survey.

Secretary, G. W. Littlehales, Geographer, U. S. Bureau of Navigation.

Sub-Sections: Geodesy and Topography, N. Yamasaki, Chairman; Terrestrial Magnetism, J. T. Watkins, Chairman; Meteorology, L. H. Daingerfield, Chairman; Physical Oceanography, G. F. McEwen, Chairman.

GEOLOGY

Leader, T. Wayland Vaughan, United States Geological Survey.

Secretary, Harold S. Palmer, Assistant Professor of Geology, University of Hawaii.

SEISMOLOGY AND VOLCANOLOGY

Leader, Fusakichi Omori, Director, Seismological Institute, Tokyo, Japan.

Secretary, T. A. Jaggar, Jr., Director, Hawaiian Volcano Research Observatory.

PROCEEDINGS OF THE GENERAL SESSIONS

MONDAY, AUGUST 2, 9:00 a. m.

Chairman: Herbert E. Gregory.

Addresses of Welcome.

Hon. C. J. McCarthy, Governor of Hawaii.
Hon. George R. Carter, ex-Governor of Hawaii.
A. L. Dean, President, University of Hawaii.
H. P. Agee, Director, Experiment Station of the Hawaiian Sugar Planters' Association.
A. F. Judd, President, Board of Trustees, Bernice Pauahi Bishop Museum.

Addresses on Salient Features of Science in Hawaii.

William T. Brigham: Anthropology.
Charles N. Forbes: Botany.
Otto H. Swezey: Entomology.
H. A. Pilsbry: Conchology.

Read by Title.

Charles H. Edmondson: Marine Biology.
Lawrence H. Daingerfield: Meteorology.
T. A. Jaggar: Volcanology.

MONDAY, AUGUST 2, 2:00 p. m.

Chairman: Herbert E. Gregory.

Organization of the Conference.

Following preliminary statements regarding the plans for entertainment and the trip to Hawaii, the Chairman opened the subject of the organization of the Conference. It was

Voted: That the Chairman, Vice-Chairman, and the Leaders of the Sections constitute an executive and program committee.

TUESDAY, AUGUST 3, 9:00 a. m.

Chairman: C. M. Fraser.

Subject: Ocean Currents and Their Significance.

George F. McEwen: The Pacific Ocean and Its Importance to Pacific Countries.

G. W. Littlehales: The Hydrographic Aspects of Ocean Currents.

N. Yamasaki: Oceanographic Research in Japan.

Lawrence H. Daingerfield: Meteorological Aspects of Ocean Currents.

R. A. Daly, of Harvard University: Some Suggestions for Geological Research in the Pacific Islands. (Read by the Secretary.)

R. C. Wells: Chemistry of Natural Waters.

H. S. Washington: Relations of Geological Change to Ocean Currents.

Wm. Bowie: Influence of Isostasy on Ocean Currents.

J. T. Watkins: Inshore Currents.

WEDNESDAY, AUGUST 4.

No general sessions. The delegates made the trip around the island of Oahu with informal addresses at points of interest.

THURSDAY, AUGUST 5, 9:00 a. m.

Chairman: Joseph A. Cushman.

Subject: Hawaiian Flora and Fauna.

Forest B. H. Brown: The Origin of Hawaiian Flora.

F. Muir: The Origin of the Hawaiian Flora and Fauna.

H. A. Pilsbry: The Dispersal and Affinities of Polynesian Land Snail Faunas.

W. A. Bryan: Origin of Hawaiian Flora and Fauna.

Discussion by: Alfred G. Mayor, William E. Safford, Paul Bartsch, H. A. Pilsbry.

FRIDAY, AUGUST 6, 9:00 a. m.

Chairman: F. Wood-Jones.

Subject: Race Relations in the Pacific.

H. E. Gregory: The Dominick Expedition.

A. G. Mayor: Similarity Between Japanese and Polynesians.

A. F. Judd: Scarcity of Proper Wall Maps and Teachers Familiar With Geography of Pacific Lands.

Clark Wissler: Man in the Pacific.

A. L. Kroeber: Anthropology of the Philippines.

L. R. Sullivan: Physical Anthropology in Polynesia.

Alfred Tozzer: Anthropological Study of the Hawaiian Race.

J. F. G. Stokes: Religious Significance of Polynesian Feather Work.

T. G. Thrum: Hawaiian Archaeology—Temple Structure.

Discussion by: W. E. Safford, Chas. Hedley, A. G. Mayor, Forest Brown.

SATURDAY, AUGUST 7, 9:00 a. m.

Chairman: Leo A. Cotton.

Subject: Relation of Ocean Currents to Marine Organisms.

Paul Bartsch: Ocean Currents, the Prime Factor in the Distribution of Marine Mollusks on the West Coast of America.

H. F. Moore: Relation of Ocean Currents to Fish.

T. C. Frye: Ocean Currents and the Problem of More Food for Man.

Wm. E. Safford: Dispersal of Plants by Ocean Currents.

Discussion by: H. A. Pilsbry, G. F. McEwen, T. Wayland Vaughan, Charles Hedley, G. W. Littlehales, A. G. Mayor, Charles Chilton, C. M. Fraser.

AUGUST 8 to AUGUST 13

The delegates visited the Islalnd of Hawaii, devoting special attention to the crater of Kilauea.

SATURDAY, AUGUST 14, 9:00 a. m.

Chairman: T. Wayland Vaughan.

Subject: The Framework of the Pacific.

E. C. Andrews: The Structural Unity of the Suboceanic Mass of the Pacific Ocean.

R. T. Chamberlin: Framework of the Pacific and Its Relation to the Americas.

F. Omori: Geographic Distribution of Volcanoes in the Pacific.

Wm. Bowie: The Bearing of Geodetic Investigation on the Knowledge of the Geologic Structure of the Pacific.

Discussion by: H. S. Washington, C. A. Sussmilch, T. A. Jaggar, W. D. Smith, L. A. Cotton, Wm. Bowie, R. C. Wells,

MONDAY, AUGUST 16, 9:00 a. m.

Chairman: J. Allan Thomson.

Subject: Mapping of the Pacific.

William Bowie: Shore Lines of the Pacific.

G. R. Davis: Coast and Island Topography.

T. Wayland Vaughan: Sedimentation and Bottom Configuration.

George F. McEwen: Recommendations Concerning Investigations of the Pacific Ocean Waters.

G. W. Littlehales: The Deeps of the Pacific Ocean.

N. Yamasaki: Islands of the South Pacific.

J. T. Watkins: The Survey of the Shoreline and Coastal Waters of the Pacific Ocean.

E. A. Beals: The Importance for Weather Forecasting of a Thorough Knowledge of the Pacific.

Discussion by: H. F. Moore, Paul Bartsch, H. C. Richards, L. A. Cotton, C. M. Fraser, J. Allan Thomson, A. G. Mayor, T. Wayland Vaughan, R. C. Wells.

TUESDAY, AUGUST 17, 9:00 a. m.

Chairman: Elmer D. Merrill.

Subject: Presentation by Sections of Programs of Research.

The Leaders reported the resolutions recommended by their Sections.

Clark Wissler: For the Section of Anthropology.

C. M. Fraser: For the Section of Biology.

Wm. E. Safford: For the Section of Botany.

Wm. Bowie: For the Section of Geography.

T. Wayland Vaughan: For the Section of Geology.

T. A. Jaggar, Jr.: For the Section of Seismology and Volcanology.

Following the discussion of the resolutions it was

Voted: To print the proposed resolutions and distribute copies among the delegates for their study.

Voted: To refer the proposed resolutions to the Publication Committee for revision with instructions to report back to the general session of the Conference to be held August 20.

WEDNESDAY, AUGUST 18, 9:00 a. m.

Chairman: N. Yamasaki.

Subject: Training of Scientists for Pacific Work.

Addresses by: A. L. Dean, Wm. Bowie, H. C. Richards, W. E. Safford, A. F. Judd, E. C. Andrews, B. W. Evermann, Paul Bartsch, Chas. Chilton, H. E. Gregory, Josephine Tilden, L. A. Cotton, C. M. Fraser, T. W. Vaughan.

THURSDAY, AUGUST 19, 9:00 a. m.

Chairman: C. A. Sussmilch.

Subject: Means and Methods of Cooperation.

The following delegates addressed the conference in behalf of the several institutions represented by them.

H. C. Richards: The University of Queensland.

Barton W. Evermann: The California Academy of Sciences.

J. Allan Thomson: The Government of New Zealand, Institutions of New Zealand and Individual Scientists.

C. M. Fraser: The Biological Station, Nanaimo, B. C.

Charles Hedley: The Australian Museum, Sydney.

John B. Henderson: The United States National Museum.

K. Kishinouye: Japan.

George F. McEwen: The Scripps Institution for Biological Research, of the University of California.

William E. Ritter: (Read by G. F. McEwen)—The Role of the Scripps Institution in a Program of Pacific Exploration.

A. F. Judd: The Bernice P. Bishop Museum.

H. A. Pilsbry: The Philadelphia Academy of Sciences.

Elmer D. Merrill: The Philippine Bureau of Science.

E. O. Hovey: The American Museum of Natural History.

William E. Safford: The United States Department of Agriculture.

Charles Chilton: Canterbury College, Christchurch, N. Z.

H. F. Moore: The United States Bureau of Fisheries.

T. C. Frye: The Puget Sound Biological Station of the University of Washington.

Josephine Tilden: Inland Universities.

FRIDAY, AUGUST 20, 9:00 a. m.

Chairman: A. L. Dean.
Subject: Adoption of Resolutions.
Resolutions were presented by:
F. Wood-Jones on Anthropology,
Charles Chilton on Biology,
W. E. Safford on Botany,
William Bowie on Geography,
T. Wayland Vaughan on Geology,
T. A. Jaggar, Jr., on Seismology and Volcanology.
General Resolutions were presented by:
H. E. Gregory on Ships for Exploration,
William Bowie on the International Research Council,
H. E. Gregory on Future Conferences.
H. E. Gregory on Permanent Organization,
A. L. Dean on Promotion of Education.
The resolutions as adopted are printed elsewhere.

H. S. Washington presented a resolution thanking the institutions and individuals in Hawaii whose cooperation and hospitality had contributed to the success of the Conference and the pleasure of the Delegates.

It was voted to request the Bishop Museum to preserve the records of the Conference, to publish and distribute the reports, papers and proceedings, and to act as representative of the members of the Conference after its adjournment.

It was voted that the Delegates from each country represented at the Conference elect one of their number to serve on a committee to arrange for future Conferences. The following were selected to serve with Herbert E. Gregory: E. C. Andrews, Australia; C. M. Fraser, Canada; F. Omori, Japan; Charles Chilton, New Zealand; T. Wayland Vaughan, United States.

PROCEEDINGS OF THE SECTIONS.

SECTION OF ANTHROPOLOGY.

Monday, August 2.

The Section was organized with Clark Wissler, Leader, and J. F. G. Stokes Secretary. The work of the Section was outlined.

Tuesday, August 3.

On plans for an extended exploration of the Pacific, and on the characteristics of the Hawaiians in 1864-5. William T. Brigham.

Thursday, August 5.

Report of the Archaeological Committee, presented by J. F. G. Stokes.

Report of the Committee on Linguistics, presented by A. L. Kroeber.

Friday, August 6.

Hawaiian Temples. Thomas G. Thrum. Read by Gerard Fowke.

Anthropology of Formosa. N. Yamasaki.

Kitchen Middens of Japan. K. Kishinouye.

Anthropology in Australia. F. Wood-Jones.

Influence of Insects on Race Distribution. F. Muir

Monday, August 16.

Notes on the Migrations and Dispersals of the Polynesians. J. F. G. Stokes.

Alleged Similarity of Fortified Villages in New Zealand and Fiji. J. Allan Thomson.

Committee appointed to formulate a statement regarding the value of records of early Spanish and Whaling Voyages.

Tuesday, August 17.

Report of Committee on Spanish and Whaling Voyages, presented by F. Wood-Jones.

Letter from Charles B. Davenport on the "Type Unit" Method of investigation.

Letter from David Fairchild of the American Genetic Association on the subject of heredity.

Consideration of resolutions to be presented to the general sessions of the Conference.

Suggestions on botanical methods calculated to be of ethno-botanical value. Miss Josephine Tilden. Read by the Chairman.

SECTION OF BIOLOGY.

Monday, August 2.

Section organized with Charles Chilton, Leader, and C. H. Edmondson, Secretary. The program of work for the Section was outlined.

Tuesday, August 3.

Discussion of the distribution of animals in the Pacific.

Joseph A. Cushman: Distribution of Foraminifera.

Paul Bartsch, John B. Henderson, and Henry A. Pilsbry: Distribution of Mollusca.

Charles Chilton: Distribution of Amphipods and Isopods.

F. Muir and O. H. Swezey: Distribution of Insects.

Charles H. Edmondson: Shallow Water Crustacea.

K. Kishinouye: Relationships of the Fauna of Japanese Waters.

C. M. Fraser: Distribution of Hydroids.

T. Wayland Vaughan: Distribution of Corals.

The general conclusion was that the weight of evidence supports a closer relationship with Indo-Pacific forms than with those of American shores.

Thursday, August 5.

Illustrated lecture, New Zealand's Call to the Botanist, by Charles Chilton.

Friday, August 6.

Joint meeting with Section of Geology. For program see report of Geology Section.

Saturday, August 14.

The Fisheries of Japan. K. Kishinouye.

Ocean Pastorage and Ocean Fisheries, a paper sent to the Conference by W. E. Allen of the Scripps Institution for Biological Research of the University of California.

The Necessity for Conservation of Fish Resources. Barton W. Evermann.

Further Data Showing the Necessity for Conservation of the Fish Supply. C. M. Fraser.

The Present Inadequacy of Statistics of Fisheries. H. F. Moore.

Monday, August 16.

Joint Meeting of the Sections of Botany and Zoology devoted to discussion of Biological Stations and other Scientific Institutions bordering the Pacific.

The Biological Station, Nanaimo, British Columbia. C. M. Fraser.

The Biological Station, Friday Harbor. T. C. Frye.

The Biological Station of Minnesota. Miss Josephine E. Tilden.

The Biological Station of California, and the Work of the Fish and Game Commission. Barton W. Evermann.

Biological Station in Australia. Chas. Hedley.

The Work of the National Museum. Paul Bartsch.

The Work of the Boston Society of Natural History. Joseph E. Cushman.

The work of the Natural History Society of Philadelphia. H. A. Pilsbry.

Biological Work in Japan. K. Kishinouye.

The Work of the Philippnie Bureau of Science. Elmer D. Merrill.

The Work in Entomology in Honolulu. O. H. Swezey.

The Biological Station of the University of Hawaii. C. H. Edmondson.

The Bureau of Fisheries. H. F. Moore.

The Biological Station of New Zealand. Charles Chilton.

Consideration of resolutions to be presented to the general Conference.

Tuesday, August 18.

Experimens on the Growth of Reef Organisms. Frank Potts.

Discussion of the effect of temperature on the size of marine organisms, participated in by C. M. Fraser, H. F. Moore, C. H. Edmondson, B. W. Evermann, Paul Bartsch.

Breeding Experiments. Paul Bartsch.

Presentation of proposed program of research in Pacific Ocean Algae by Miss Josephine E. Tilden.

Wednesday, August 19.

Discussion of resolutions to be presented to the general Conference.

SECTION OF BOTANY.

Monday, August 2.

Section organized with William E. Safford, Leader, and C. N. Forbes, Secretary. The work of the Section was outlined.

Ethno-Botany of the Polynesians. William E. Safford.

Tuesday, August 3.

The American Element in Hawaiian Vegetation. Forest B. H. Brown.

Cultivated Plants of the Pacific Islands as an Index to the Migrations of the Polynesians. W. E. Safford.

Thursday, August 5.

Joint meeting of the Sections of Botany and Zoology.

New Zealand's Call to the Botanist, an illustrated lecture by Charles Chilton.

Friday, August 6.

The Tapestry Forests of the Island of Oahu. Vaughan MacCaughey.

Saturday, August 14.

Owing to the death of Charles N. Forbes, Mrs. Forest Brown was appointed secretary.

Some Problems in Plant Physiology and Ecology in Hawaii. H. F. Bergman.

The Field Label in Botany. Elmer D. Merrill.

Monday, August 16.

Joint meeting of the Section of Botany with the Section of Biology. For program see "Section of Biology."

Wednesday, August 18.

The Flora and Phytogeography of Japan and Adjoining Regions. K. Shibata.

Notes on the Algae of the Northwest Coast. T. C. Frye.

The Medicinal Plants of the Philippines. Leon M. Guerrero.

SECTION OF ENTOMOLOGY.

Wednesday, August 4.

Section organized with F. Muir, Leader, and D. T. Fullaway, Secretary.

Assignment of topics to members of the Section.

Tuesday, August 17.

Some Problems in Hawaiian Entomology. F. Muir.

Need of Further Exploration and Study of the Hawaiian Insect Fauna and Value of Such Study in the Exploration of the Pacific. O. H. Swezey.

Some Aspects of Economic Entomology in Hawaii. D. T. Fullaway.

What Horticultural Inspection Has Done and Can Do for Hawaii. E. M. Ehrhorn.

Ideas on How an Entomological Expedition Should be Conducted. F. X. Williams.

Medical Entomology. D. L. Crawford.

Discussion on the necessity for further entomological exploration in the Pacific area.

SECTION OF GEOGRAPHY.

Monday, August 2.

Section organized with William Bowie, Leader, and G. W. Littlehales, Secretary. The work of the Section was outlined.

Tuesday, August 3.

Observations of Temperature and Salinity at Selected Coastal Stations in Japan; accompanied by an index-chart showing the location and extent of regularly observed hydrographical sections on the coast of Japan. K. Kishinouye.

The Desirability of Supplying Information in Greater Detail Upon Sea Charts. N. Yamasaki.

The Extent to which the Contours of Configuration of the Basin of the Pacific Ocean have been Made Known by Deep-sea Soundings; including an account of methods of deep-sea soundings, and of the mathematical investigations which have been made to define the theoretical form of isolated submarine peaks, and the intervals which should obtain between deep-sea soundings to disclose the topography of the bottom of the ocean. G. W. Littlehales.

The Investigations in Physical Oceanography of the Scripps Institution of the University of California. George F. McEwen.

Thursday, August 5.

The Growth and Present Extent of Ocean Magnetic Surveys, with an account of the investigations in Terrestrial Magnetism by American Institutions. J. T. Watkins.

The Purposes, Instruments and Methods of the Hawaiian Magnetic Observatory, with Its Records and Publications. Harold McComb.

On the Atmospheric Electricity of the Hawaiian Islands. Lawrence H. Daingerfield.

Friday, August 6.

Meteorological Centers of Action in the North Pacific Ocean. E. A. Beals.

Researches in the Geodetic Work of the Pacific. William Bowie.

Saturday, August 14.

Extent of Geographical Surveys in the Hawaiian Islands. George R. Davis.

Monday, August 16.

Low-Sun Phenomena in Luzon. Willard J. Fisher.

Tropical Geology and Engineering. Warren D. Smith.

Tuesday, August 17.

Consideration of resolutions to be presented to the general sessions of the Conference.

Wednesday, August 18.

Consideration of resolutions to be presented to the general sessions of the Conference.

SECTION OF GEOLOGY.

Monday, August 2.

T. Wayland Vaughan was selected Leader of the Section. The Chariman outlined the work before the Section and a tentative program was arranged.

Tuesday, August 3.

Harold S. Palmer was appointed Secretary of the Section. Presentation of formal papers was postponed until the arrival of the delegates from the south and west.

Thursday, August 5.

The Structural Framework of the Pacific. E. C. Andrews.

The Melanesian Plateau, with Especial Reference to the Land Shell Fauna. Charles Hedley.

Salient Features of the Geologic Structure of the Philippine and Neighboring Islands. Warren D. Smith.

The Essential Structural Features of Japan. N. Yamasaki.

The Relation of Gravimetric Surveys to the Framework of the Pacific Region. William Bowie.

The Structure of the Cordilleras of North and South America. Rollin T. Chamberlin.

The Structure of the Caribbean Region. T. Wayland Vaughan.

Letters from Professor Bailey Willis of Stanford University and Dr. Alfred H. Brooks of the U. S. Geological Survey were read.

Friday, August 6.

The Basis of the Correlation of the Tertiary and Quaternary Geologic Formations of the Pacific Islands. T. Wayland Vaughan.

Correlation of the Tertiary of Australia and Adjoining Regions. C. A. Sussmilch.

Correlation of the Geologic Formations of Australia. E. C. Andrews.

The Stratigraphy of the Philippine Islands. Warren D. Smith.

The Fossil and Existing Foraminifera of the Atlantic and Pacific Regions. Joseph A. Cushman.

The distribution of the molluscan fauna was discussed by H. A. Pilsbry, and that of the Foraminifera by T. W. Vaughan.

Saturday, August 14.

Geodetic Research in the Pacific Region. William Bowie: listened to jointly by the Sections of Geology and Geography.

The Status of Areal Geologic Mapping in the Pacific Region was discussed by T. Wayland Vaughan for the Americas; by J. Allan Thomson for New Zealand; by E. C. Andrews for New South Wales and the outer islands; by H. C. Richards for the rest of Australia; and by N. Yamasaki for Japan, Korea and China.

It was proposed to summarize the progress in the Pacific region by a series of key maps. The work was divided as follows:

New Zealand	J. Allan Thomson
Australia	E. C. Andrews
The Philippines	W. D. Smith
Japan, Korea and China	N. Yamasaki
North and South America and Dutch East Indies	T. Wayland Vaughan
Antartica	L. A. Cotton

Monday, August 16.

Indurated Glacial Clays from Australia. C. A. Sussmilch.

The Status of Areal Geologic Mapping in the Philippines. Warren D. Smith.

A letter from Dr. Alfred H. Brooks pointing out the need of work on the correlation of Alaskan areal stratigraphy with that of eastern Siberia and northwestern Canada was read.

Consideration of resolutions to be presented to the general sessions of the Conference.

Tuesday, August 17.

The Glaciation of the Mountains in Japan. N. Yamasaki.

Discussion of Glaciation by T. Wayland Vaughan, Rollin T. Chamberlin, C. A. Sussmilch, E. C. Andrews, T. A. Jaggar, Jr., Alfred G. Mayor, Paul Bartsch and W. Alanson Bryan.

The Great Barrier Reef and the Reefs of Fiji. E. C. Andrews.

Coral Reefs on Tutuila. Rollin T. Chamberlin.

The Ecology of the Reef Corals of Tutuila. Alfred G. Mayor.

Chemical Investigations Relating to Corals. Roger C. Wells.

Theories of the Formation of Coral Reefs. T. Wayland Vaughan.

Wednesday, August 18.

Possible Deformation Resulting from Slight Wanderings of the Pole. L. A. Cotton.

Consideration of resolutions for presentation to the general sessions of the Conference.

Thursday, August 19.

Joint meeting with the Section of Volcanology and Seismology.

Earthquake Frequency with Special Reference to Tidal Stresses in the Lithosphere. L. A. Cotton.

Pit Craters and the Persistence of Vents, Henry S. Washington.

The Chairman of the Section of Geology made the following assignments:

Country	Geologic Mapping	Stratigraphic Correlation
New Zealand	J. Allan Thomson	J. Allan Thomson
Australia	E. C. Andrews	H. C. Richards
China, Korea, Japan	N. Yamasaki	N. Yamasaki
North and South America	T. W. Vaughan	T. W. Vaughan
Dutch East Indies	T. W. Vaughan	T. W. Vaughan
Philippine Islands	Warren D. Smith	Warren D. Smith

The work of the Committee on Sedimentation of the Division of Geology and Geography of the United States National Research Council. T. Wayland Vaughan.

SECTION OF SEISMOLOGY AND VOLCANOLOGY

Monday, August 2.

Section organized with F. Omori, Leader, and T. A. Jaggar, Jr., Secretary. The work of the section was outlined.

The Growth of the Work of the Hawaiian Volcano Research Association. L. A. Thurston.

The Organization of the International Research Council. H. S. Washington.

Tuesday, August 3.

Pulsatory Oscillations. F. Omori.

The Present Status of the Seismological Work in the Pacific, a paper sent to the Conference by Otto Klotz, of the Dominion Observatory, Ottawa, Canada, and read by the Secretary.

Extract from a letter by Harry Fielding Reid of Johns Hopkins University, dealing with seismology in the Pacific.

Thursday, August 5.

Volcano Types and the Chemistry of Magma. H. S. Washington.

Friday, August 6.

Hawaiian Earthquakes. T. A. Jaggar, Jr.

Tectonic Controls in the Case of Volcanic Earthquakes. H. O. Wood.

Volcanic Tremors and Volcanic Earthquakes. F. Omori.

Monday, August 9.

Volcano House, Hawaii.

The Volcanoes of the Pacific. H. S. Washington.

Tuesday, August 10.

Volcano House, Hawaii.

A Program of Experimental Volcanology. T. A. Jaggar, Jr.

Earthquake Zones in and Around the Pacific. F. Omori.

Regional Seismology vs. World Seismology. H. O. Wood.

Saturday, August 14.

Joint meeting with the Section of Geography. For program see report of the Section of Geography.

Sunday, August 15.

Discussion of the resolutions to be presented to the general Conference.

Monday, August 16.

Report of the Section of Volcanology of the American Geophysical Union. H. S. Washington.

Tuesday, August 17.

Discussion and Drafting of Resolutions.

Wednesday, August 18.

Joint meeting with the section of Geology; for program see report of that Section.

Thursday, August 19.

Joint meeting with the Section of Geology; for program see report of that Section.

The joint meeting was followed by a session of the Section of Seismology and Volcanology in which the following papers were presented.

Seismical Phenomena at Samoa. G. Angenheister; read by Arnold Romberg.

Historical Statement of the Growth of Seismology in the Philippines. M. S. Maso.

Friday, August 20.

Exhibition of records made with a special duplex pendulum, and maps of soundings in Kagoshima Bay before and after eruption of Sakurajima. F. Omori.

Notes on Seismic Triangulation with Instruments of more than one Magnification for Regional Seismometry. H. O. Wood.

DELEGATES PAN-PACIFIC SCIENTIFIC CONGRESS

AGEE, H. P.,
Agriculturist, Director Experiment Station Staff, Hawaiian Sugar Planters' Association, Honolulu.

AITKEN, R. T., B. S.,
Anthropologist, Public Museum, Milwaukee.

ANDREWS, E. C., B. A.,
Geologist, Chief Geological Survey, New South Wales.

BAKER, ALBERT S., M. A., B. D., M. D.,

BARBER, EDWARD,
Naturalist.

BARTSCH, PAUL, B. S., M. S., Ph.D.,
Zoolologist, Curator Division Marine Invertebrates, United States National Museum.

BEALS, E. A.
Meteorologist, U. S. Weather Bureau, San Francisco.

BERGMAN, H. F., Ph.D.,
Professor of Botany, University of Hawaii.

BOWIE, WILLIAM, B. S., C. E., M. A., Sc.D.
Hydrographic and Geodetic Engineer, Chief Division of Geodesy, U. S. Coast and Geodetic Survey.

BRIGHAM, W. T., A. M., Sc.D.,
Ethnogolist, Director Emeritus, Bernice Pauahi Bishop Museum, Honolulu.

BROWN, ELIZABETH, Ph. D.,
Research Associate in Botany, Bernice Pauahi Bishop Museum, Honolulu.

BROWN, FOREST B. H., M. S., Ph. D.,
Botanist, Bernice Pauahi Bishop Museum. Honolulu.

BRYAN, WILLIAM ALANSON, B. S.
Zoologist.

BRYAN, EDWIN H., Jr., B. S.
Assistant in Entomology, Bernice Pauahi Bishop Museum, Honolulu.

CAUM, E. L., B. A.,
Assistant Pathologist, Experiment Station Staff, Hawaiian Sugar Planters' Association, Honolulu.

CHAMBERLIN, ROLLIN T., B. S., Ph.D.,
Professor of Geology, University of Chicago.

CHILTON, CHARLES, F. L. S., M. A., Sc.D., M. B., C. M.,
Professor of Biology, Canterbury College, Christchurch, New Zealand.

COTTON, LEO A., M. A., D. Sc.
Professor of Geology, University of Sydney, Australia.

CRAWFORD, DAVID L., M. A.,
Professor of Entomology, University of Hawaii, Honolulu.

CUSHMAN, JOSEPH A., B. S., Ph.D.,
Zoologist, Museum Director Boston Society of Natural History.

DAINGERFIELD, LAWRENCE H., Ph.D.,
Meteorologist, U. S. Weather Bureau, Honolulu.

DAVIS, GEORGE R.,
Geographer, in Charge Pacific Division, U. S. Geological Survey.

DEAN, ARTHUR L., Ph.D.
President, University of Hawaii, Honolulu.

DILL, H. R.,
Assistant Professor of Biology, University of Iowa.

DILLINGHAM, FRANK T., A. M.,
Professor of Chemistry, University of Hawaii.

DONAGHHO, JOHN S., A. M.,
Professor of Astronomy and Mathematics, University of Hawaii.

EDMONDSON, C. H., Ph.D.,
Professor of Zoology, University of Hawaii.

EHRHORN, E. M.,
Entomologist, Board of Agriculture and Forestry, Honolulu.

EMERSON, JOSEPH S., B. S.,
Ethnologist, President Hawaiian Historical Society, Honolulu.

EMORY, KENNETH, B. S.,
Assistant Ethnologist, Bernice Pauahi Bishop Museum, Honolulu.

EVERMANN, BARTON W., B. S., Ph.D.,
Zoologist, Director California Academy of Sciences, San Francisco.

FISHER, W. J., Ph. D.,
Assistant Professor of Physics, University of Philippines.

FORBES, CHARLES N., B. S.,
Curator of Botany, Bernice Pauahi Bishop Museum, Honolulu.

FOWKE, GERARD,
Archaeologist, Bureau of Ethnology, Smithsonian Institution, Washington, D. C.

FRASER, C. M., M. A., Ph. D.,
Zoologist, Director Biological Station, Nanaimo, British Columbia.

FRYE, T. C., B. S., Ph.D.,
Professor of Botany, University of Washington.

FULLAWAY, D. T., A. M.,
Entomologist, Board of Agriculture and Forestry, Honolulu.

GIFFARD, WALTER M.,
Entomologist, Board of Agriculture and Forestry, Honolulu.

GILDER, W. A.,
Representative of Society for Protection of Native Races, Melbourne, Australia.

GREGORY, HERBERT E., Ph.D.,
Director Bernice Pauahi Bishop Museum, Honolulu; Professor of Geology, Yale University.

GROSVENOR, GILBERT, A. M.,
President National Geographic Society, Editor-in-Chief National Geographic Magazine.

GUERRERO, LEON M., Phar. D.,
Economic Botanist, Philippine Bureau of Science.

HEDLEY, CHARLES,
Zoologist, Curator Australian Museum, Sydney.

HENDERSON, JOHN B., A. B., LL. D.,
Zoologist, Regent U. S. National Museum.

HENKE, LOUIS A., B. S.,
Agriculturist, Professor of Agriculture, University of Hawaii.

HOLM, ADOLF,
Superintendent of Forest Nurseries, Hawaiian Sugar Planters' Association, Honolulu.

HOVEY, EDMUND OTIS, Ph.D.,
Geologist, Curator American Museum of Natural History, New York.

JAGGAR, T. A., Jr., A. M., Ph.D.
Volcanologist, Director Hawaiian Volcano Observatory, Hawaii.

WOOD-JONES, FREDERICK, M. B., B. S., D. Sc.
Anthropologist, Professor of Anatomy, University of Adelaide.

JUDD, ALBERT F., A. B.,
President, Board of Trustees, Bernice Pauahi Bishop Museum, Honolulu.

JUDD, C. S., M. S.,
Botanist, Superintendent of Forestry, Territory of Hawaii.

KISHINOUYE. K., Sc.D.,
Professor of Fisheries, Tokyo Imperial University, Japan.

KRAEBEL, CHARLES, A. B..
Assistant Superintendent of Forestry. Territory of Hawaii.

KROEBER, A. L., A. M., Ph.D.,
Professor of Anthropology, University of California.

LITTLEHALES, G. W., C. E.,
Hydrographic Engineer, U. S. Hydrographic Office.

LYON, H. L.. Ph.D.,
Botanist in charge Experiment Station Staff, Hawaiian Sugar Planters' Association, Honolulu.

MACCAUGHEY, VAUGHAN, B. S.,
Botanist, Superintendent of Public Instruction, Honolulu.

MASO, REV. FATHER MIGUEL S., D. D., Ph. D.,
Seismologist, Chief Seismic and Magnetic Division, Philippine Weather Bureau.

MAYOR, ALFRED G., M. E., Sc.D.,
Biologist, Director Department Marine Biology, Carnegie Institution.

M'COMB, HAROLD,
Observer, Coast and Geodetic Survey, in charge Honolulu Magnetic Observatory, Ewa, Oahu.

McEWEN, GEORGE F., Ph.D.,
Oceanographer, Scripps Institution for Biological Research of the University of California, La Jolla, California.

MERRILL, ELMER D., B. S., M. S.,
Botanist, Director Philippine Bureau of Science.

MILLER, GERRIT S., Jr., A. B.,
Curator Division of Mammals, U. S. National Museum.

MOORE, H. F., Ph.D.,
Deputy Commissioner, U. S. Bureau of Fisheries.

MORITZSON, A.,
Dunedin, New Zealand.

MUIR, F.,
Entomologist, Experiment Station Staff, Hawaiian Sugar Planters' Association.

OMORI, FUSAKICHI, Sc.D.,
Professor of Seismology, Tokyo Imperial University, Japan.

OSBORN, H. T.
Assistant Entomologist, Experiment Station Staff, Hawaiian Sugar Planters' Association.

O'TOOLE, GEORGE BARRY, Ph.D.,
Professor of Biology, Seton Hill College, Greensburg, Pa.

PALMER, H. S., A. B.,
Assistant Professor of Geology, University of Hawaii.

PEMBERTON, C. E.,
Assistant Entomologist, Experiment Station Staff, Hawaiian Sugar Planters' Association.

PHILLIPS, STEPHEN, W., A. B.,
Historian, Salem, Mass.

PILSBRY, H. A., B. S., Sc.D.,
Conchologist, Curator Department of Mollusks, Philadelphia Academy of Sciences.

POTTS, CAPT. FRANK,
Zoologist, Fellow Trinity Hall, Balfour Student, Cambridge University, England.

RICHARDS, HENRY CASELLI, Sc.D.,
Professor of Geology, University of Queensland, Australia.

ROMBERG, ARNOLD, Ph.D.,
Seismologist, Professor of Physics, University of Hawaii.

SAFFORD, WILLIAM E., Ph.D.,
Economic Botanist, U. S. Department of Agriculture.

SHIA HSU TAN,
Chinese Consul, Honolulu.

SHIBATA, K., Sc.D.,
Professor of Botany, Tokyo Imperial University, Japan.

SMITH, WARREN D., B. S., M. A., Ph.D.,
Professor of Geology, University of Oregon.

STOKES, J. F. G.,
Ethnologist, Bernice Pauahi Bishop Museum, Honolulu.

SULLIVAN, L. R.. M. A.,
Anthropologist, American Museum of Natural History.

SUSSMILCH, C. A.,
Geographer, Director School of Technology, Newcastle, New South Wales.

SWEZEY, OTTO H., M. S.,
Entomologist, Curator of Entomology, Bernice Pauahi Bishop Museum, Honolulu.

THOMSON, J. ALLAN, M. A., D. Sc.
Geologist, Director Dominion Museum, Wellington, New Zealand.

THRUM, THOMAS G.,
Ethnologist, Editor "Hawaiian Annual" and "Fornander Papers," Honolulu; Associate in Hawaiian Folk Lore, Bernice Pauahi Bishop Museum, Honolulu.

THURSTON, LORRIN A.,
President Hawaiian Volcano Research Association, Honolulu.

TILDEN, JOSEPHINE E., B. S., M. S.,
Professor of Botany, University of Minnesota.

TIMBERLAKE, P. H., A. M.,
Assistant Entomologist, Experiment Station Staff, Hawaiian Sugar Planters' Association, Honolulu.

TOZZER, ALFRED, M. A., Ph.D.,
Ethnologist, Associate Professor of Anthropology, Harvard University, Cambridge, Mass.

VAUGHAN, T. WAYLAND, B. S., M. A., Ph. D.
Geologist, U. S. Geological Survey, in Charge of Coastal Plain Investigation and Geological Survey of Dominican and Haitian Republics.

WALKER, COMMANDER R. L.,
Oceanographer, U. S. Naval Station, Pearl Harbor, Honolulu.

WASHINGTON, HENRY S., A. M., Ph.D.,
Volcanologist, Carnegie Geophysical Laboratory, Washington, D. C.

WATKINS, COMMANDER J. T.,
Hydrographic and Geodetic Engineer. Chief Division Terrestrial Magnetism, U. S. Coast and Geodetic Survey.

WEINRICH, WILLIAM,
Agriculturist, Hawaiian Pineapple Company.

WELLS, R. C., Ph.D.,
Physical Chemist. U. S. Geological Survey.

WESTGATE, J .M., M. S.,
Botanist, Director U. S. Experiment Station, Honolulu.

WILDER, GERRIT P.,
Associate in Botany, Bernice Pauahi Bishop Museum, Honolulu.

WILLARD, H. F., B. S.,
Assistant Entomologist, in charge Mediterranean Fruit Fly Investigation, U. S. Bureau of Entomology, Honolulu.

WILLIAMS, F. X., Sc.D.,
Assistant Entomologist, Experiment Station Staff, Hawaiian Sugar Planters' Association.

WISSLER, CLARK, A. M., Ph.D.,
Anthrolopologist, Curator of Anthrolopology, American Museum of Natural History, New York.

WOOD, H. O., A. M.,
Seismologist, National Research Council, Washington, D. C.

YAMASAKI, N., Sc.D.,
Professor of Geography, Tokyo Imperial University, Japan.

I. GENERAL RESOLUTIONS.

1. FUTURE CONFERENCES.

Since the present Conference has been found highly inspiring and illuminating and an invaluable aid in defining the essential problems of the Pacific Region, be it

RESOLVED, That future similar conferences should be held at intervals of not over three years.

2. PERMANENT ORGANIZATION.

The results of the First Pan-Pacific Conference have demonstrated the high value of meetings for the discussion of problems common to all countries whose interests lie wholly or in part within the Pacific area; and have shown that the problems relating to the welfare of Pacific peoples are too large and too complex to be solved satisfactorily except by sympathetic cooperation of individual institutions and governmental agencies. To develop a unity of interest and to make harmonious coordination practicable, it seems desirable that some permanent organization be established which may serve as the point of contact for representatives of various interests in the countries of the Pacific. Be it therefore

RESOLVED, That the attention of the Governor of Hawaii be called to the great opportunity afforded by an organization designed for the advancement of the common interests of the Pacific, including scientific research, and to the desirability of taking action which may lead to the development of such an organization vouched for and supported by the various Pacific countries.

3. INTERNATIONAL RESEARCH COUNCIL.

Since this Conference commends the organization of the International Research Council as a means toward coordinating research in science, be it

RESOLVED, That it is the desire of this Conference that any agency created for the guidance of scientific research and exploration in the Pacific region may be affiliated with the Council and with the various National Research Councils of the nations of the Pacific.

4. SHIPS FOR EXPLORATION.

The cost of scientific researches in the Pacific which involve the continuous use of a ship is prohibitive for most scientific institutions and individuals. The results of the Challenger and the Wilkes expeditions have demonstrated the great advantage gained by the use of government-owned ships for scientific exploration. Be it therefore

RESOLVED, That the members of this Conference unite in inviting the attention of governments to the desirability of providing vessels for suitably planned expeditions.

5. PROMOTION OF EDUCATION.

The results of scientific research have led to extensions of human knowledge and to increased control of the forces and resources of nature the values of which cannot be measured. All scientific work which is well done is of value, and no man can predict to what useful purposes the results of any investigation, no matter how recondite, may be put. It is of fundamental importance that sufficient numbers of young men and women of first class ability shall be adequately trained, and that teachers and investigators shall be properly compensated. This Conference therefore

RECOMMENDS:

(a) That in order that young men may enter upon scientific careers without sacrificing all hope of reasonable financial returns, the compensation for instruction and for research in science be increased so that all can at least be assured of a comfortable living for themselves and their families, and that men of exceptional attainments may receive financial rewards which shall approximate those which their powers could command if directed to commercial ends.

(b) That persistent efforts be made to inform the public of the progress of science and of its bearings upon the practical affairs of life.

(c) That to enlarge the experience and vision of the instructors in the colleges and universities of the Pacific countries, making them thereby more competent and inspiring teachers, the exchange of teachers between institutions in different countries be encouraged and made possible.

(d) That a clearing house of information relative to opportunities for scientific study and research in the Pacific area be established.

(e) That arrangements be perfected between the universities and other research institutions whereby properly qualified students may move from institution to institution carrying on their work at the place or places where the best facilities are available for the special kind of work upon which each may be engaged.

(f) That a considerable number of fellowships, with adequate stipends, be provided, which shall be looked upon as compensation for the faithful performance of scientific work, and that especially able work by young investigators be rewarded by substantial prizes.

(g) That to stimulate interest in the Pacific and inculcate a knowledge of its importance and unity, text books be prepared in which proper emphasis will be placed upon the Pacific area, its physical features, peoples, fauna, flora, resources, and trade, and that the schools in Pacific countries be encouraged to give instruction which will stimulate the interest and enthusiasm of young students in the objects and phenomena of their environment.

II. ANTHROPOLOGY.

1. NEED FOR POLYNESIAN RESEARCH.

Recognizing the necessity for the immediate prosecution of anthropological research in Polynesia, this Conference calls the attention of governments, patrons of research, and research foundations to this important scientific need, and

RECOMMENDS, That the most prompt and efficient steps be taken to record the data necessary to the understanding of man's development in the Pacific area.

2. FACILITIES FOR INSTRUCTION AND RESEARCH IN ANTHROPOLOGY.

Since there is urgent need both for anthropological research and the training of men and women therefor, and since experience has shown the advantage of close association between the graduate departments of universities and persons and institutions carrying on anthropological investigations, this Conference

RECOMMENDS, That centers be created for the study of anthropology and original research therein, such centers to be developed by the expansion of university departments or the alliance of universities with other research institutions with the result that these schools of anthropology shall combine all the essential features of a museum, a research staff, and a graduate school. And, further, because of the peculiar conditions under which anthropological data must be gathered, necessitating both intensive field work in circumscribed areas extending over several years, and intensive synthetic work by men who are masters in many fields, thus requiring a number of men through a period of years, we therefore recommend the establishment of research fellowships in Polynesian anthropology, such endowments being provided that these fellowships will attract the best men available and provide for uninterrupted work during an adequate number of years.

3. THE BAYARD DOMINICK EXPEDITION.

It is evident that fuller knowledge of the history and culture of the Polynesian race is essential to the solution of the ethnologic problems of the Pacific; and also that the opportunities for obtaining information are rapidly disappearing. It is therefore gratifying to learn that Mr. Bayard Dominick has conceived a plan for ethnological studies in the Pacific on a scale not hitherto attempted and has provided funds for the initiation of this research under the guidance of Yale University and the Bishop Museum.

RESOLVED, That the commendation of this Conference be extended to Mr. Dominick for his far-sighted interest and generosity and that assurance of good will and cooperation be given him.

SHIPS FOR BAYARD DOMINICK EXPEDITION.

The Bayard Dominick expedition of the Bishop Museum is now in the field and the successful continuation of its work depends upon obtaining a ship suitable for the navigation of waters outside of established trade routes.

The Conference invites attention of the United States Government to the benefits likely to result from providing this expedition with a suitable vessel.

III. BIOLOGICAL SCIENCE.

1. MARINE BIOLOGICAL SURVEY.

The necessity for conservation of natural resources has become imperative, since, in the case of the Pacific Ocean, certain economic marine species have been exterminated and others are in peril of extinction or grave depletion. Measures for such conservation must be based on an exact knowledge of the life histories of marine organisms. Knowledge of the biological, physical, and chemical phenomena of the Pacific Ocean is meager and wholly inadequate to serve as the basis for rational conservation measures; therefore be it

RESOLVED:

(a) That the First Pan-Pacific Scientific Conference recommends that the governments of the several nations bordering on the Pacific Ocean cooperate, through their several agencies concerned in surveying and charting the sea, toward the collection, compilation and publication of data relating to the topography of the bottom, and the temperature, salinity, acidity, currents, and other physical and chemical properties of the waters of this ocean, fundamental to biological research and the improvement and conservation of the fisheries.

(b) That the Conference recommends that a comprehensive systematic biological survey of the Pacific ocean and its contained islands be undertaken, with special reference to the economic fisheries problems and that the investigation be carried on in so far as possible through existing agencies, such agencies to be provided with the additional apparatus and facilities necessary, the investigation to be carried on under such cooperation as will prevent duplication of effort.

(c) That the Conference recommends that the several museums, biological stations, and other institutions engaged in biological investigations relating to the Pacific ocean, associate themselves for the purpose of exchanging information concerning past, current, and proposed investigations, the exchange of facilities and personnel, the coordination of work, and the prevention of duplication in their respective activities. It is further recommended that a survey be made of the facilities afforded by the several institutions, said survey to cover material, equipment, environment, and the personal qualifications of the respective staffs for supplying special information and working up material. It is further recommended that the National Research Council of Washington, D. C., be invited to undertake or arrange for such survey and that a committee of this Conference be appointed to represent the interests of the botanical and zoological sections in this regard, the committee to be appointed by the Chairman of this Conference.

(d) That the Conference recommends that systematic statistics of the fisheries be collected and published annually and that such statistics be, as far as possible, uniform in character and in such detail as to methods of fishing and geographical distribution as to make them useful in fisheries administration and conservation. It is further recommended that the several governments provide for a joint commission for the arrangement of the details of such statistical compilations.

2. RECOMMENDED INVESTIGATIONS IN MARINE BIOLOGY.

Because of the urgency or importance of certain investigations, this Conference

RECOMMENDS:

(a) The collection of bottom samples from depths under 20 fathoms, since these are not usually obtained by deep sea expeditions and can be readily obtained at anchorage by simple apparatus.

(b) The study of the brachiopod faunas above the 1000 fathom line inasmuch as a knowledge of these Brachiopods supplies important evidence on the question of former land connections.

(c) A systematic and thorough study of Pacific Ocean algae and of the conditions under which they occur and of the part they play in their environment; this could be obtained by means already employed for certain parts of the Pacific Ocean and would be of great scientific value.

(d) Because the Hawaiian Islands lie on the margin of the tropical seas, and therefore occupy a critical position for the study of the ecology of marine organisms, among which corals are important; and because data obtained from ecologic investigations in this locality would be of value to geologists in interpreting the conditions under which fossil faunas lived, the Conference recommends a careful study of the ecology of the marine organisms of the Hawaiian Islands, and particularly a study of the corals and of the organisms associated with the corals on the reefs.

3. LAND FAUNA.

The part played by living animals in the solution of many scientific problems in the Pacific is well recognized. The relationship of their present to their former areas of distribution and to that of extinct allied forms is the key to some of the geological problems; they have direct bearing upon many ethnological problems and they are the chief source of evidence upon which our ideas of evolution must be built. From a knowledge of the land fauna follow great economic advantages, such as the protection of the human race against many diseases and crops against pests.

Although in certain continental Pacific areas and some of the larger islands the land fauna is fairly well known, yet in none is knowledge yet complete, and in some, such as Polynesia, it is very deficient. The urgency for this work is great, as large areas are rapidly being swept of their native land fauna. Therefore this Conference

RECOMMENDS:

(a) That surveys, as complete as possible, be made of the land fauna, especially of those smaller islands in which the native fauna is fast disappearing, or is likely to become extinct in the near future.

(b) That the attention of zoologists be called to recently made land areas due to volcanic or other activity and the importance of the study of ecological development with special reference to the appearance of animal life upon such areas.

(c) That since land mollusks supply information of value in zoogeographical researches, material for a comparative study of the anatomy of the soft parts of land snails be obtained from all the high islands of Polynesia, Micronesia, and Melanesia, and that adequate faunistic collections be made on islands the faunas of which are not at all or only partially known.

4. ORNITHOLOGICAL SURVEY OF THE PACIFIC

This Conference expresses its gratification at the fact that arrangements have been made by the American Museum of Natural History for the purpose of undertaking and carrying on a comprehensive and intensive ornithological survey of the islands of the Pacific Ocean, particularly those of the South Seas, and extends its thanks to those who have made provision for the expedition.

5. COLLECTING POLYNESIAN LAND FLORA.

Since a definite knowledge of the flora of Polynesia is essential to a proper understanding and correlation of numerous problems bearing on the life and origin of Polynesian peoples, problems of forestry, agriculture, ethnobotany, plant diseases, physiology, and ecology; since the original vegetation of some island groups is rapidly being destroyed; and since botanical exploration of Polynesia has been sporadic and in many regions incomplete, therefore the First Pan-Pacific Scientific Conference

RECOMMENDS:

(a) That botanical exploration of Polynesia be extended as rapidly as possible in order to assemble comprehensive collections with as complete notes as possible covering the scientific and economic aspects of Polynesian botany.

(b) That this work of exploration be carried on by existing agencies, by special botanical expeditions, and by heads of non-botanical expeditions employing and supervising native collectors, whenever feasible, for the collection and preservation of botanical material.

(c) That material be collected in bulk, from ten to fifteen specimens of each species, with the object of distributing duplicate specimens to Pacific institutions and to the larger botanical centers of the world.

6. PLANT ECOLOGY ON LAVA FLOWS.

Since new lava flows and other volcanic ejecta offer fresh terrane for the abode of life, therefore this Conference

RECOMMENDS, That studies be made of the stages of ecological development with special reference to the appearance of forms of plant life on new volcanic deposits following an eruption; and also of plants best suited to the speedy rehabilitation for agricultural uses of regions covered by such volcanic ejecta; and of the resistance of plants to volcanic fumes.

7. PRESERVATION OF THE HILLEBRAND GARDEN (HONOLULU)

Since the botanical garden of the late Dr. William Hillebrand, author of the "Flora of the Hawaiian Islands," situated in the city of Honolulu, is one of the most remarkable gardens in the world, possessing as it does many unique and rare plants introduced into the Hawaiian Islands by Dr. Hillebrand, and since this Conference believes that the preservation and perpetuation of this garden, which is threatened with destruction, would be a great benefit to botanical science, it recommends that the steps be taken to insure the preservation of this garden.

IV. GEOGRAPHY.

1. TOPOGRAPHIC MAPS.

The exploration of Pacific regions in many branches of science is handicapped by the almost total lack of topographic maps. There is scarcely any human activity which does not depend to a greater or less degree upon a knowledge of the configuration of the land. This is especially true in such work as mining, railroad and highway extension, and maintenance, and the utilization of water in power development, irrigation, and transportation. The natural resources of the world cannot be discovered and utilized efficiently without such maps.

Topographic maps of any given area should be adapted in scales, accuracy and details, to the scientific and economic needs peculiar to the area.

The benefits derived from adequate topographic maps are far greater than their cost and this Conference urges that a plan be made for carrying on a topographic survey of the lands of the Pacific regions, and that this plan be designed to give uniformity of results. This Conference commends the countries of the Pacific region for the work already done by them.

2. SURVEY OF THE SHORELINE AND COASTAL WATERS.

A general hydrographic survey of the continental shelves extending off-shore to the one-thousand fathom curve and of the island platforms should be executed, in order to supply basic data essential to all research work involved in the general scientific exploration of the Pacific ocean.

This survey should establish a system of horizontal and vertical control, determine the shore line and adjacent topographic features in true geographic position, develop submarine relief, collect and describe the materials of the bottom, observe temperature and salinity, and define vertical and horizontal movements of the water. The hydrographic bureaus of the nations of the Pacific, as now organized and operating, need only to expand their equipment and extend their field to meet the requirements of this project. Closer cooperation is desirable in the interest of uniformity and to avoid duplication.

These results, in addition to their bearing upon research work, have so great economic value to the shipping, fisheries, and other marine interests that the cost of the survey for the collection of the necessary data is relatively insignificant. It is stated in a recent publication of the United States Coast and Geodetic Survey that the vessels wrecked in the coastal waters of California, Oregon, and Washington in the year 1917 on account of the incompleteness of the charts, involved a loss which amounted to more than double the estimated cost of a complete hydrographic survey of those waters.

This unfinished state of the hydrographic survey along the west coast of the United States is not exceptional; few regions of the Pacific of any considerable extent have been thoroughly surveyed. This Conference makes appreciative acknowledgment of the notable contributions made to the survey of the coastal waters of the Pacific by the several nations bordering thereon; but in view of the magnitude of the work and the length of time involved in its execution it commends this general project and urges its early execution.

3. USE OF WIRELESS TELEGRAPHY IN LONGITUDE DETERMINATION.

This Conference commends the use of wireless telegraphy for the improvement of determination of the longitude of the islands in the Pacific.

4. MAGNETIC SURVEY.

The general magnetic survey of the Pacific ocean should be continued to an early conclusion and provision made for such additional work as may be needed to determine annual and secular changes in the magnetic elements. The field of work should be extended to include the coastal waters, where the magnetic phenomena are complex, and their determination essential to many important interests.

Systematic operations under this project are a comparatively recent undertaking; but already excellent results have been obtained in the Pacific from the work of the Carnegie Institution of Washington.

The work is of immediate and vital importance to navigation and surveying, in addition to its bearing upon the general subject of geophysics, and this Conference hopes that plans may be made for a complete magnetic survey of the Pacific region and that the work may be expedited.

5. PHYSICAL OCEANOGRAPHY.

Oceanographic investigations yield results which constitute a basis essential for scientific exploration and research in the Pacific region, notably in meteorology, geology, botany, and biology. Moreover, such investigations are of importance to navigators in disclosing dangers to vessels sailing the ocean and are of economic value in enabling vessels to save time and fuel in their navigation.

The present knowledge of the oceanography of the Pacific is deficient in every branch and constitutes but a meager array of data scattered widely.

In the oceanographic investigation of the Pacific waters the configuration of the bottom should be determined, specimens of the bottom deposits collected and their thickness and stratification revealed, the physical and chemical characteristics of the water at different depths and times determined, and the horizontal and vertical circulation of the waters observed.

The field work involved in such investigations must be carried on almost entirely by the governmental hydrographic organizations of the countries bordering on and contained within the Pacific ocean, owing to the great expense involved in creating new and special agencies, and because the governmental agencies have the personnel trained in this work. Those carrying on oceanographic surveys in the Pacific should avail themselves of the services and advice of individuals and organizations dealing with those branches of science depending upon the results of such surveys.

This Conference feels that a systematic oceanographic investigation of the Pacific should be undertaken as soon as possible. The plan adopted should be designed to complete the survey of the most critical areas at an early date, and eventually of the whole Pacific region.

6. METEOROLOGY.

Investigations in meteorology or the physics of the atmosphere designed to lead to an accurate scientific knowledge of atmospheric phenomena are of recognized importance. Very little is known of the behavior of the upper air over the land, and still less over the ocean. The fundamental aspects of these phenomena are exhibited in their simplest manner over the greatest of oceans, the Pacific. Hence it is necessary to make meteorological observations over the Pacific for use in studying the more complex problems over the land.

Moreover, the collection and prompt dissemination of marine meteorological data are of great benefit to humanity in carrying on its commerce and in weather forecasting which is now limited by a lack of synchronized, uniform meteorological data over great areas not within the customary track of vessels.

Observations at the place of origin of typhoons, hurricanes, larger cyclonic and anticyclonic areas, as well as the development, dissipation, oscillation, and translation of the same, are essential to successful forecasting and the study of ocean meteorology. Moreover, the meteorological survey of these ocean areas has practical value. Therefore, the governments of the countries bordering on the Pacific ocean are invited to consider carefully these matters with a view to increasing the number of meteorological vessel and land stations within the confines of this ocean and on its borders, especially the establishment of vessel reporting stations in somewhat fixed positions. In considering these matters, it is believed that special attention should be given to increasing the number of stations in the well known "centers of action."

The First Pan-Pacific Scientific Conference commends the ocean navigation companies and their masters of vessels for the valuable assistance they have rendered the meteorological services of several stations and urges them further to cooperate especially in the matter of transmitting their weather reports by radiograph as well as by mail.

7. METEOROLOGICAL STATION ON MACQUARIE ISLAND.

Since the observations made at the meteorological station on Macquarie Island resulted in improvements in the accuracy of weather forecasting, this Conference expresses the hope that observations at that station, interrupted by the war, may be resumed at an early date.

8. METEOROLOGICAL STATION ON MAUNA LOA.

In view of the fact that Mauna Loa, Island of Hawaii, the highest accessible point in the central Pacific, offers exceptional opportunities for the exploration of the upper air, this Conference recommends that a station of the first order be established on its summit for continuous meteorological observations.

9. EARTH TIDES.

The successful operation of the Michelson earth-tide apparatus at a station in the United States of America has furnished data from which the knowledge of the physical characteristics of the interior earth has been increased, and it is desirable that earth tide stations be established in the Pacific region at widely separated points in order to discover whether the physical characteristics vary from place to place.

This Conference hopes this work will be extended.

10. ISOSTATIC INVESTIGATIONS.

Investigations in the theory of isostasy have thrown much light on the subject of deviation from the normal densities in the outer portions of the earth, which is of importance in the study of geology and in other branches of science.

Much can be added to our knowledge of isostasy by a mathematical reduction of existing field data, following well known methods, which would involve only slight expense.

This Conference urges, in the interest of geophysical and other sciences, the early reduction of existing geodetic data and the extension of geodetic field work to those regions of the Pacific where such data are now lacking.

This Conference commends the Coast and Geodetic Survey of the United States, the Trigonometric Survey of India, and the Dominion Observatory of Canada for work they have done in isostatic investigations.

V. GEOLOGY.

1. GEOLOGICAL MAPS.

Since it is in the interest of science and of value in the development of the natural resources of the different countries concerned, be it

RESOLVED, That the following maps of the Pacific region on the international scale of 1:1,000,000 be completed as expeditiously as possible:

(a) A base map showing by contours or hachures as many topographic features as practicable.

(b) A map showing geological formations or groups of geological formations.

(c) A map showing mineral resources.

2. GEOLOGICAL SURVEYS OF CRITICAL INSULAR AREAS IN THE PACIFIC OCEAN.

GEOLOGICAL SURVEY OF EASTER ISLAND.

Since a knowledge of the geology of Easter Island might throw light on the question of whether there was in past geological time a westward extension of the land area of the South American continent, be it

RESOLVED, That it is desirable to have a careful study of Easter Island to determine the character and geologic age of the rocks composing that island.

GEOLOGICAL SURVEY OF THE HAWAIIAN ISLANDS.

Since the results of a detailed geological survey of the Hawaiian Islands would aid in the solution of many problems of the Pacific region, be it

RESOLVED, That this Conference strongly recommends that a geological survey of the Hawaiian Islands be made and that appropriate geological maps and descriptive texts be published.

GEOLOGICAL SURVEY OF SEVERAL SMALL ISLANDS IN EASTERN FIJI.

Since raised coral atolls with exposed basements of bedded limestone or of volcanic material are found in eastern Fiji, and since a geological survey of these islands supplemented by reconnaissance work in the neighborhood of Suva would be invaluable in the study of the origin of coral reefs, and in the elucidation of the geology of the southwest Pacific, be it

RESOLVED, That a topographic and geological survey of the several small islands, such as Mango, Thithia, Lakemba, Vanua Mbalavu, and Tuvutha be made at the earliest opportunity, and the results published.

3. FORM OF OCEAN BOTTOM.

Because of their importance as supplements to geological work on land in determining the structural framework of the Pacific region and in interpreting the geological history of the region, be it

RESOLVED:

(a) That the configuration of the bottom of the Pacific ocean be determined with adequate accuracy.

(b) That charts of the littoral and sub-littoral zones be made in all practicable detail; for example, wherever possible these charts should be on scales ranging between 1:10,000 and 1:40,000.

4. POST-CRETACEOUS CORRELATION.

Since such knowledge is essential to the establishment of an adequate basis for the stratigraphic correlation of the post-Cretaceous formations of the Pacific region, be it

RESOLVED:

(a) That in addition to the study of the post-Cretaceous stratigraphy and paleontology of the Pacific islands and of the land areas on the margins of the Pacific ocean, such work also be expedited in the Caribbean region and in the region from Burma through the Himalayas to the Mediterranean sea.

(b) That inventories of the living fauna and flora of the Pacific region be prepared at the earliest practicable date.

5. STUDIES OF SUBAERIAL AND SUBMARINE EROSION.

Since it is coming to be recognized generally that a knowledge of subaerial and submarine erosion is indispensable to a correct interpretation of the history of the continents, the continental margins, and the oceanic islands during post-Cretaceous time, be it

RESOLVED:

(a) That geologists, geographers, seismologists, biologists, and others who are interested in the facts of form within the Pacific ocean and along its margins devote attention to the study of physiographic processes and the forms resultant from such processes.

(b) That geologists and physiographers make special study of the physical, chemical, and other properties of igneous and sedimentary rocks so as to ascertain the difference in their resistance to erosive agents.

(c) That efforts be made to obtain assistance in furthering the study of wave and current erosion, the factors limiting wave base, the action of weathering and corrosive agents at the headwaters of streams, the forms of stream channels, the form of sea cliffs at different stages of development, the action of plants in retarding land erosion, and the sequential stages of erosion of fault scarps.

6. STUDIES OF SEDIMENTARY PROCESSES AND SEDIMENTARY ROCKS.

Since it is generally recognized that the interpretation of a large part of the geological record demands a knowledge of the processes of sedimentation and the results of these processes in the formation of deposits of past geological time, therefore be it

RESOLVED:

(a) That geologists, oceanographers, geographers, biologists, and others who may be interested devote as much attention as possible to the study of modern sediments and the processes by which they are formed.

(b) That geologists make special studies of the physical, chemical, and other properties of sedimentary rocks to ascertain the conditions under which the deposits were formed and the changes that may have taken place in such sedimentary rocks after deposition.

(c) That all existing agencies be urged to study the phenomena referred to in paragraphs (a) and (b) above, and that efforts be made to increase the number of agencies for the prosecution of such investigations.

6. GEOLOGICAL COOPERATION.

Since it is desirable that the projects undertaken by the different workers in the Pacific region be so selected and so designed that each may be supplementary to the rest and so contribute to the uniform accumulation of geological information concerning the Pacific region, be it

RESOLVED, That steps be taken to advise in the planning of research, to correlate the efforts of the different workers, and to promote in such ways as may be proper a uniform mode of publication of results.

VI. SEISMOLOGY AND VOLCANOLOGY.

The dominant motive which has appeared in the convention of seismologists and volcanologists of the Pacific here gathered together for the first time, has been to promote more localized and more continuous observation of regional phenomena than has hitherto been accomplished in most seismic and volcanic districts. On the other hand, there is agreement that precise teleseismic triangulation is not a field for amateurs or for stations equipped with a multiplicity of inferior and diverse instruments.

There is urgent need for mutual information, regularly supplied by each observer to his distant colleagues, concerning volcanic and seismic happenings in each land. The employment of mariners and scientific expeditions to collect specimens and notes for the volcanologists in remote places may be organized.

Education of the people in matters of earthquake-proof construction and safeguards against disaster has been proved to be a practicable and effective method of meeting volcanic and seismic crises.

Interest has recently developed in the earth tide, changes of level about volcanoes, and measurable horizontal and vertical displacements directly related to earthquakes. These are matters for the national geodetic surveys and for geophysical investigation of high mathematical precision.

The consideration of the needs indicated above, namely, localized work, distribution of information among workers in this field, education of the people at large, and the applications of precise geophysics has led to the following resolutions:

1. ESTABLISHMENT OF VOLCANO OBSERVATORIES.

Useful volcano experiment stations have already been established in some lands, and more volcanologic experience is needed for protection against disaster of the increasing populations of Pacific countries and for the advance of science; therefore this Conference

RECOMMENDS the continuance of the present volcano observatories and the establishment of new permanent volcano observatories in lands about the Pacific; and recommends that such a station for maintenance and publication of continuous observations should be placed on one or more active volcanoes in each important volcanic district.

2. PROMOTION OF LOCALIZED SEISMOMETRY.

In addition to the work of existing establishments, the intensive study of both large and small earthquakes in seismic provinces by all appropriate physical, geological and other scientific methods may lead to important and rapid advancement in geophysical knowledge. This knowledge is of importance for economic and humanitarian as well as scientific ends. This Conference therefore

COMMENDS the existing institutions, recommends their continuance and expansion, and urges early establishment of further specific programs of investigation and continuous observation in regional seismology in special seismic districts about the Pacific. Timely publication of results is recommended. Moreover this conference recommends to the National Research Council of the United States the establishment of a program of research in regional seismology in the southwestern part of the United States.

3. PUBLICATION OF VOLCANO AND EARTHQUAKE INFORMATION.

The workers in regional seismology and volcanology need accurate information about geophysical events in other localities than their own; therefore this Conference

RECOMMENDS, That prompt and authoritative publication of current facts and measurements concerning volcanoes, earthquakes, submarine eruptions, and tidal waves be an essential part of the routine of all Pacific observatories.

4. PRECISE LEVELING AND TRIANGULATION IN RELATION TO VOLCANOLOGY AND SEISMOLOGY.

Great earthquakes and volcanic eruptions are often preceded and followed by elevations, depressions, and horizontal displacements in the regions concerned; therefore this Conference

RECOMMENDS, That precise leveling and triangulation be carried on at definite time intervals, in selected seismic and volcanic districts, in order to ascertain precursory and other changes in underground stress accompanying great seismic and volcanic disturbances.

5. COLLECTION AND PUBLICATION OF STATISTICS OF EARTHQUAKES AND ERUPTIONS.

There is needed for certain Pacific countries more complete statistics concerning earthquakes and eruptions; and a complete list for the world should eventually be maintained; therefore this Conference

RECOMMENDS, That each Pacific country publish statistical lists of local eruptions, earthquakes, tidal waves, and other related phenomena; and issue catalogues of active, dormant and extinct volcanoes, and of local seismic features.

6. CENTRAL SCIENTIFIC BUREAU.

Dissemination of volcanologic and seismologic knowledge will be furthered by working through a body cooperating with all Pacific countries; therefore this Conference

RECOMMENDS the establishment of a central bureau for dissemination of scientific knowledge among the volcano and earthquake stations of the Pacific.

7. SAMOAN GEOPHYSICAL STATION.

This Conference COMMENDS highly the work done at the Geophysical Observatory at Apia, Samoa, and expresses the hope that the service of that station will be continued.

8. EDUCATION OF DWELLERS IN DISTRICTS LIABLE TO DISASTER.

Great injury and loss of life to persons and damage to human constructions may be caused by earthquakes and volcanic eruptions and may be decreased by general education; therefore this Conference

RECOMMENDS, That countries liable to seismic disaster educate the people in proper methods of construction, in behavior during emergencies, and in the history of such catastrophes elsewhere.

PAPERS PRESENTED

DISCUSSIONS

ADDRESSES OF WELCOME

RACE RELATIONS IN THE PACIFIC

INTRODUCTORY REMARKS

By F. Wood-Jones, Herbert E. Gregory, Alfred G. Mayor and A. F. Judd

Mr. F. Wood-Jones, Chairman of the Session: There are some subjects which are on the same footing as those industries which we have learned in recent years to term "key industries." We must all acknowledge, of course, that whatever our opinions with regard to the Pacific, we must all in the end bow to the geologists. They have the key subject in the solution of problems in the Pacific. Looked at from that point of view, anthropology is apparently unimportant. There is very little, one thinks at first sight, which anthropology can solve or hope to solve. I am sure some of you yesterday must have been struck by the findings of Dr. Pilsbry when he demonstrated how apparently the land shells had come into this great Pacific world from the west toward the east. Very soon after we were told that vegetation had come in from the east toward the west, thus dealing with two utterly different groups, and two utterly different methods of dispersal. In Dr. Mayor's opinion it is quite possible that man has been responsible for the spread of economic plants and animals from west to east. For anthropologists this Conference will close, I am quite certain, with the feeling that we know extraordinarily little of the problems with which we are supposed to deal. Our knowledge of the distribution of man and his wanderings in spite of the enormous amount of work done is extremely vague. Our knowledge is extremely scattered at best. We do not occupy the position of a key science. If we knew more of the comings and goings of man in the Pacific we could trace much better that very earliest type of sailor who has been navigating the Pacific for a thousand years; and we should be much more in a position to dictate to the zoölogist and botanist if we knew what sort of cargo he carried, which way he came and which way he went. We could tell you a good deal you are telling us. It is because our knowledge is so scattered that we need to get right to work. All of you geologists and botanists are dealing with permanent features which you can go back to at any time and study. The days are numbered in which anthropological studies can be made. From the point of view of this Conference anthropology is one of the very first subjects which should be taken care of. Ever since I have been in Australia I have been trying to urge on scientific bodies that if they are going to study these problems they must study them now because there are so few days left in which to study.

It is exactly the same with the culture and physical anthropology of Polynesia. If we are going to do this as an outcome of this Conference I would ask all interested in anthropology that your first plan should be a proper study of races from the physical and cultural points of view.

This point of view is held I believe by the Bishop Museum and I would ask the Director of the Museum, Professor Gregory, to supplement my remarks.

MR. GREGORY: The statement of your chairman that anthropological and ethnological research is an urgent problem as compared with certain others is at the base of the plans of the Bishop Museum. Fortunately the Museum is unrestricted in its plans for the study of Polynesian ethnology and natural history, and problems may be chosen with reference to their urgency or with reference to their bearing on other problems. The activity which calls loudest for immediate attention is the study of vanishing races, and primarily some groups of the Polynesians.

The much desired researches in geology and botany can scarcely be classed as urgent and the marine fauna will probably be here for centuries, but if the history of the Polynesian race is to be more than a collection of expanded notes, it must be written during this generation. The natural net decrease in the population is speeded up by epidemics. During the past two years influenza has wiped out about one-fourth of the population of British Samoa and of Tahiti and the Marquesans seem to be marked for extinction. The late William Churchill mentioned three Pacific Islands in which the last inhabitant disappeared in 1919—no word of their dialect will ever again be heard. The death of old men and women familiar with tribal customs and traditions is removing the source of information. Professor Crampton recently told me of three old men in Tahiti, talented men whom he had intimately known for a number of years. In his opinion if these three men have been swept away by the influenza epidemic the possibilities of effective ethnological study in Tahiti will have declined 50 per cent.

Under these circumstances it is fortunate that the Museum is able during the present year to emphasize anthropological research. A gift to Yale University of $40,000 for studies of the Polynesian people opened the way for intensive work. With the approval of the donor, Mr. Bayard Dominick of New York, this fund was transferred by Yale University to Bishop Museum in the belief that the Museum was in an exceptionally favorable position to utilize this generous contribution. Plans have been formulated with great care in consultation with Dr. Wissler, Professor Dixon, Professor Kroeber and William Churchill. Parties consisting of an ethnologist and an archeologist are now in the Marquesas Islands and in Tonga; a third party is to leave soon for the Austral Island group, and in Hawaii a comprehensive study of physical anthropology is in progress. With each expedition a botanist is being sent, for the simple reason that the story of the migration of the Polynesian race may have to be read in terms of the origin and distribution of food, medicinal and ceremonial plants.

The Museum hopes to be in a position to carry on these investigations for a series of years, but with no idea of preëmpting the field. The Museum is doing this work because it needs to be done and because it is equipped to make a contribution at this time. Other institutions will find Polynesia a fertile field for study. I have no doubt that effective coöperation can be established and I am not much worried about funds; the chief obstructions in the path are the lack of a comprehensive and workable plan and the dearth of trained investigators. I believe this Conference can supply the plan but I don't know where the workers are to be obtained. Mr. Chairman, you may rely on the Bishop Museum to lead or follow, ride tandem or abreast, with other institutions interested in making an immediate attack on the large and complex problem of race relations in the Pacific.

MR. MAYOR: I think we should all congratulate ourselves and the Bishop Museum in having such a broad-minded man as Dr. Gregory. Research in these days is largely a matter of efficient coöperation. The spirit which the Bishop Museum has displayed in this matter in acting as an agent or clearing house for the whole world is most admirable. There is no question that it is only by such methods and by giving a fair chance to agencies properly equipped to do specific things that the work can be carried on. For the first time in my life I feel that matters of fundamental import in the anthropology of the Pacific are about to be solved. It is very late to start. Nevertheless, although many pages of the story have long since been torn out or lost, enough remains to provide material for a very interesting volume.

MR. A. F. JUDD: May I emphasize a point made by Dr. Gregory that there is a tremendous need for men? I would like also to venture the hope that the committee on resolutions will pass on in suitable strong wording a memorandum on this subject which should be called to the attention of the Bureau of Education in Washington. Interested as I am in education in Hawaii, being connected with two schools, I find the great difficulty in teaching geography is in getting teachers who know anything about the country. There are plenty of teachers who can teach admirably the boundaries of the State of Wyoming, but they are not familiar with the Pacific Ocean. Neither are we able to purchase proper wall maps of the Pacific; they seem not to exist. I believe every school room in this territory should have such maps, and they should be in every normal school on the mainland and in every school of the countries bordering the Pacific both north and south of the equator.

MAN IN THE PACIFIC

By Clark Wissler

The topic before us today is "Man in the Pacific." It is not exactly a racial problem as that problem is conceived in popular thought, where it is restricted to certain specific economic and social problems. Our interest is a broader one, but centers in the man of prehistoric time. Yet since historic time in the Pacific scarcely begins before 1750, we may almost ignore this modern fragment which the historian claims as his special province. However, we cannot ignore one of the problems the events of this single historic century have created and one which the historian cannot, or does not, solve; viz., the problem of race mixture.

Anthropologists are well aware that race mixture is not a modern phenomenon. One of the distinguishing characteristics of man, in contrast to other mammals, is his tendency to cross: the only close parallel we have is among certain species of canines—particularly among the dogs. Curiously enough, the history of the dog is intimately associated with man from earliest paleolithic time and is just as difficult to untangle as man's own zoölogical history. I have frequently urged zoölogists to take up the dog, but they always tell me that the problem is too complex. But there is no reason to believe that it is more complex than the human problem, where crossing has gone on for ages. Yet in some parts of the Pacific we have race mixture on an extensive scale and for once the phenomenon can be accurately observed. Hence, regardless of any social or political interest, race mixture should be one of the problems to come before this congress.

We turn now to the prehistoric, or main part of our problem. Primarily this rests in the Polynesians. A great deal of random information has been recorded, bearing upon the numbers, behavior (culture) and appearance of the many insular groups. The mere mass of this data is at first a bit disconcerting, but nevertheless, it is totally inadequate to the problem as we see it today. It is not my intention to burden you with a summary of the available data; but rather to remind you of certain fundamental points of view growing out of the research experience of contemporary anthropologists and to suggest that leads these viewpoints indicate for those who take up specific projects in Polynesia.

In the first place anthropological research in Polynesia seeks an answer to each of three questions: (1) Whence came the Polynesian? (2) What are the hereditary strains in his blood? (3) What are the essentials of his history in the Pacific? In other words tell us the origin, blood and chronology of Polynesia—*whence, what* and *when!* There is no difficulty in the formulation of this problem and there is nothing vague in its statement. The plain every-day man can grasp its import without effort. Yet in this beautiful simplicity lies a real danger; for such simple and direct statements often lead one to expect ready and positive solutions. If anyone sets out with the expectation of a ready and clear-cut solution to these questions as the result of a single explorative drive, then it needs no prophet to predict something in the way of disappointment. The ultimate solution of the Polynesian problem will tax to the utmost the research ingenuity of science and will demand the long and persistent labor of two or three of the best scientific minds, capable of synthetizing the results of many sciences.

One of the misfortunes of anthropology is that it looks so easy that anyone backed by a little enthusiasm is tempted to roll up his sleeves and go to it. No doubt this is partly because it is a human problem, but also because the technique and methods of the anthropological investigator are not formulated under a new and high-sounding terminology. For example if a gardener, who dearly loves plants, takes it into his head to be a botanist, the first man he meets knocks all the conceit out of him by reciting a few phrases from the descriptive terminology of the subject. Even my fellow scientists, zoölogists, geologists, etc., often fail to see that anthropology has well developed methods and technique for dealing with all the usual phenomena one meets in exploration. In this discussion, therefore, we can ignore all questions of technical details, taking them for granted just as we do in the case of botany, geology, etc. On the other hand the tendency to underestimate the complexity of anthropological phenomena is so universal, that we can well afford to give some attention to the fundamental viewpoints of the anthropology of today and consider their bearing upon the projected Polynesian research, the consideration of which is before this congress.

One of the primary objectives in an anthropological undertaking of this kind is, the establishment of a chronology. Those of you who are familiar with the great achievements in Egypt and western Europe, need not be reminded that the chronologies for the two areas are the very foundation stones of the anthropology of today. In the case of western Europe, we have now one great sequence of cultures, or civilizations, beginning with the earliest known stone age and passing on up through the bronze and early iron ages, finally connecting with historic time in which we have recorded dates. One can now say with confidence that the answer to the *when* for western Europe can be given with fair precision and a reliable outline of the chief events in man's career in that part of the world can be given in sequence, showing the time relations between such events as the use of fire, the working of iron and the invention of a steam engine. In short for one small corner of the world we know the outline of the whole story from the first to this very hour. That is no mean achievement and furnishes us the ideal for anthropological research in other parts of the world, to which the Polynesian area is no exception.

There are two main methods of attaining a chronology for man. By man we mean a creature with some kind of a culture; before man began to use tools the chronological methods of zoölogy and palaeontology will suffice; but when we come to deal with a creature who uses tools and who has ideas and communicates them, some specialization in method is necessary.

One of these special methods is that of super-position, or stratification, which literally takes a leaf from the note-book of the geologist. The archaeological method, it is sometimes called, though that term has a much wider application. The point of view in this method of super-position is that undisturbed strata are of necessity formed in the order of their position—the older at the bottom, etc. The stratification of culture remains is, however, man made, in contrast to geological stratification, the different strata representing sequential periods in man's history. From these sequences we get relative time relations, but for the dating of these, anthropology must ultimately appeal to geology, either directly or indirectly, through the fauna and flora involved.

Turning now to Polynesia, we see the necessity for the application of stratification methods in order that a chronology may be realized. Parts of each island must be dissected, as it were, to determine the strata of human occupation and culture. We can be reasonably certain for example that the shell heaps of New Zealand contain the story of man in that island and perhaps the general outline of Polynesian chronology as a whole. Likewise these islands, though so far no definite refuse deposits have been located here, contain ruins, caves and town sites, from the proper study of which a chronology may be constructed. These problems of chronology are complex and difficult, but not insuperable. So far this fundamental method has not been applied to any part of the Polynesian area. The secret of success, however, is the man behind the spade; put a keen scientific mind behind the project and results will come. A real intellect and a single section of a large shell heap will open up a new vista in Polynesian research.

We should not forget, however, that the assistance of other sciences will be needed to solve this problem of chronology. First, we need a geological survey of the several island groups; for as we have stated, the backbone of man's chronology is geological chronology. Further, we need data upon the fauna and flora of the respective islands. It is the realization of this inter-relation of problems that underlies the conception of this congress and is its only excuse for being. You tell us the history (a relative chronology) of such plants as taro, bread-fruit, the paper mulberry, etc., and the story of such mammals as the pig, chicken and dog in the islands of the Pacific and we will soon fill in the gaps in the chronological scheme for the Polynesians.

So far we have considered only the man of the past as he survives in skeletal remains and the refuse of culture; but anthropology is not entirely a matter of the paleontology of civilization, it is also called upon to deal with living men and cultures whose antecedents lie far back in the past. How can the chronology of these be attained? For example which is older in Polynesia, the *Kapu* system or the *aawa drinking* complex? In such cases we generally fall back upon distribution. Zoölogists and botanists also use this method; they have by its use discovered the centers of dispersal for many forms and their chronological relations. Anyway anthropologists find that culture complexes are distributed in geographical areas and that the more primitive forms frequently survive in the margins of the areas. The same is true of the anatomical types of man.

The most primitive men survive, when they survive at all, on places like Tasmania, the southern tip of South America, South Africa, etc. Their positions in the whole distribution of mankind mark them as among the older forms.

By way of illustration, we may cite a more specific and unusual example of the interpretation of distribution in terms of chronology. You are aware that the Spanish explorers found in Mexico and Peru and at intermediate points, very complex cultures like those of the Aztec and the Inca. The area of distribution for these higher cultures is in general terms from the southern boundary of the United States to the northern bounds of Chile.

Now, in the United States a peculiar type of pottery is found north of Mexico, and again south of Peru we have pottery strikingly similar. In western United States we find a curious frame for holding a baby and for carrying it upon the back of the mother; among some of the tribes of Chile and Argentine we find the same form of baby carrier. Then a curious kind of wooden hitch was used in belt looms, both in Argentine and south-western United States. Again, on both the north and the south margins, the natives had the custom of chopping off one or more fingers as a sacrifice to the sun in compliance with conventional vows made in times of great personal danger. Other correspondences could be added to this list, but these will serve as an illustration.

Now, what is the significance of this? Are we not justified in concluding that we have here on the two margins of this great culture area of the New World, the remnants of an older form of culture that once covered the whole intervening area? And are we not justified in concluding that this belongs near the bottom of our chronological scale? In other words by the study of distribution in great detail we can at least infer chronology.

Now, when we turn to Polynesia, we meet with an insular distribution, but in the main the same methods will apply. Never to my knowledge has this method been applied to Polynesia except in the most general way, chiefly because the data are not yet adequate. Yet one or two tentative illustrations may suffice.

The domestication of the south Asiatic fowl, or chicken, was known to the Polynesians. The center of origin for the domestication of the chicken is placed in south Asia, the home of the wild species. It spreads westward to Persia, thence to Egypt, down into Africa and over into Europe. East of Asia the chicken spread to the Malay islands and into Polynesia, even to Easter Island, but failed to reach America.

From Egyptian researches we know that the chicken reached Egypt about 700 B. C. From Egypt it spread to the negro tribes of the Congo in Africa where the date of its appearance is placed at 400 B. C. For the introduction of the chicken into the Malay area we have not satisfactory data and likewise for Polynesia; but Egypt and Polynesia are both marginal to the center of dispersion. We may expect, therefore, that the appearance of the chicken in Polynesia can not be much earlier than 1000 B. C. and in all probability much later.

Another interesting culture complex is the making of paper cloth, or tapa as it is called. The materials used are from the paper mulberry, introduced from Asia. In the tapa complex, are printing from wood blocks, the making of lint for the dressing of wounds and the use of a paper kite. In old China paper was made from the same plant by a similar process, and printing from wood blocks was known, also lint for wounds and the paper kite. How completely the paper complex of old China and Polynesia will correspond we cannot yet say for lack of data, but here is a good problem. Most of these processes can be dated in China and to these the parallel processes for Polynesia can be related. One of the first steps, however, is a study of the plants furnishing the materials—the botanists must come to our aid here. When all the returns are in, the relative time of the appearance of the tapa complex in Polynesia can be stated.

While it is true that a great deal of work remains to be done before the origin of the Polynesian can be stated, nevertheless we can forecast his chronology with sufficient precision to project the problem. In the main we find the Polynesian race marginal to the Malay-Asiatic area. There is little in the geological setting to prevent him being also marginal to America, but the parallels to America are so vague that their existence is still in the controversal stage. On the other hand we can be certain that anthropologically Polynesia is primarily marginal to the Malay-Asiatic center. Hence, the problem of the Polynesian is a part of the Micronesian problem, the Melanesian problem, the Malay-Philippine problem, and finally a part of the Asiatic problem. It is clear then that the ultimate solution of the Polynesian problem demands intensive work in each of these areas and must in consequence be approached as an international project in the coordination of research.

Another important point is, that as compared with Western Europe, the arrival of the Polynesian is a recent event. Polynesian chronologies have been proposed by Churchhill, Percy Smith, et al. As previously stated these must be taken as very tentative, owing to lack of check data. Yet strange to say all of these estimates place the Polynesian arrival at near 2000 years ago.

Churchill's chronology may be taken as the type.

A. First Proto-Polynesian migration....A. D. 0
B. Tonga-Fiji migration 600
C. Great Polynesian expansion 1,000

This chronology is based upon linguistic and culture data, but has not been handled by the most advanced methods. It has, however, so great a consistency with the data at hand that we may accept it as a working basis.

As to whether the Polynesian was preceded by a different race, is still too uncertain to be discussed here. It can be formulated only as a problem. Shell deposits, if they exist in sufficient number, may answer this question, but it is useless to speculate as to what the result will be.

In this discussion I have touched lightly upon the racial affinities of the Polynesian and upon the modern question of race mixture, as these topics will be presented by other members of the congress. I have tried to give you a glimpse of the point of view of the anthropologist and to show you that our problem deals both with the living and the extinct, and that because of man's peculiarities, we must consider his functional history as well as his morphology; the data of one will in the end supplement the other; that what we seek in Polynesia is to interpret man's distribution in terms of time and space, as the outline for the investigation of his evolution.

Finally I beg to remind you that the fauna of our subject is on the verge of extinction. The rocks at the bottom of the sea will remain, but the old Polynesian is passing the last mile post of his career. Hence, if anything is to be done with the Polynesian problem, it must be done now.

DISCUSSION

MR. MAYOR: When we consider the manner of life of Polynesians we see that in fundamental things the Japanese and Polynesians are remarkably alike. Their mental attitude, religious concepts, manners, habits, etc., are so similar that they cannot be due to outside influence but must be due to blood relationship far distant. It is too complex to be a mere matter of accidental resemblance. The whole mental attitude of the Polynesians is so different from the mild code of the Puritans which now dominates the world that they will not tell us their myths and traditions. These stories they know will shock us. Consequently they can only be secured as a reward of the greatest possible patience and tact; perhaps women may achieve greater success than men in such a quest.

MR. SAFFORD: The theory which has sometimes been advanced that the Polynesians came from the East is absurd. Their principal economic plants are of Asiatic origin, and have been carried to Polynesia with their Asiatic, or more strictly speaking their Malayan names. In addition to the coconut, sugar cane, pandanus, hau, milo (*Thespesia populnea*) and noni (*Morinda citrifolia*), may be cited. Sugar cane, called *to* in southern Polynesia and *ko* by the modern Hawaiians, is called *topo* or *tupu* in Guam and *tubu* in the Malay Archipelago. The well known hau tree of these islands (*Hibiscus tiliaceus*) from the inner bark of which the Polynesians made cordage and strainers for their 'ava, and whose light wood was used not only for the outriggers of canoes but also for making fire, is called *fau* in Samoa; and this name can be traced through *pau* to *pagu, pago,* and *bago,* to its Philippine name *balibago.* Some of the plant names of Hawaii reappear in New Zealand where they are applied to species of the same genus or to plants having a similar appearance or habit of growth. As an example the bastard sandalwoods belonging to the genus Myoporum may be cited. In both the Hawaiian Islands and New Zealand their vernacular name is *naio.* On the other hand species of Metrosideros, belonging to the same genus as the beloved *ohia lehua* of the Hawaiians have a very distinct vernacular name in New Zealand. It would thus appear that before their separation the common ancestors of the Hawaiians and the New Zealanders dwelt in a locality where species of Myoporum grew but from which Metrosideros was absent.

From plant names and also from the names of fishes, birds, and other animals a fauna and flora of the ancestral home of the Polynesians could be compiled. Numerous examples can be cited as striking as that of *hala* and *fala,* applied in Hawaii and Samoa to species of Pandanus or screw pines. The same principle applies to the names of nearly all natural objects, such as sky, sun, moon, star, sea, ocean, water, stone, bird, fish, seaweed, also to the word for fire, *ahi* in Hawaii and *afi* in Samoa, and *aki* in modern Malayan. The numeral system and many grammatical forms of the Hawaiians and Samoans have been brought from Malaysia.

MR. WOOD-JONES, Chairman of the Session: Dr. Hedley, I believe, has evidence which leads to a different conclusion.

MR. HEDLEY: When a historian wishes to trace the progress of some vanished race, he will ask for documentary evidence, some carving or writing or pottery. I have no evidence to offer except soft herbs, and grasses which may have been where they now are before the human race appeared and may be there when all our race has vanished. The Swedish botanist, De Candolle, wrote many years ago, an account of the history of the coconut palm which he declared was essential to the human race in this part of the world. In summing up he presented two alternatives: one was that the coconut palm originated in South America, and the other that it came from Asia and Ceylon. The chief argument in favor of American origin is that there are two hundred species and twenty genera, all of which are related to the coconut palm which comes from this part of the world. There are no coconut relatives on the other side, and if you believe in Candolle's hypothesis of descent with modification, that evidence alone would incline you to believe that the coconut came from South America. On the other hand there is documentary evidence to the effect that the king of Ceylon cultivated and grew the coconut palm three thousand years ago. De Candolle, who was not an ethnologist, was confronted with the difficulty that there were no means of transporting the coconut from America to Asia three thousand years ago. He did not know that the finest race of navigators which the world had then seen were the Polynesians. Here were a people who were capable of transporting the coconut from one side of the Pacific to the other a thousand years before Magellan. If you were to find a very desolate island on which man had never lived, you would find no coconuts. No wild coconut has ever been found by botanical explorers. The coconuts have been tended by human hands and like all cultivated plants would wither and disappear without attention. They are as dependent upon human care as a canary.

Australia from Torres Straits down the coast for a thousand miles is as well suited to support dense coconut groves as is Polynesia, Melanesia and New Guinea, yet along this stretch not one is to be found, while on the opposite shores of New Guinea, Solomon Islands and the New Hebrides, there are dense forests of coconuts. According to the poetic explanation, that coconuts drift over sea and establish themselves on the beach without the aid of man, these beautiful groves should have drifted from island to island. The coconut is not the only evidence. The sweet potato is a native of South America and Captain Cook found it cultivated all over the South Sea Islands.

MR. SAFFORD: I have assisted in opening two hundred prehistoric graves on the coast of Peru and Chili. In these graves were receptacles of all kinds including gourds and imitations of gourds in pottery. There were also many other kinds of fruits and vegetables imitated, but neither I nor any other explorer has found a fragment of a coconut shell nor the representation of a coconut in the prehistoric graves of Peru or of any other part of America. It is very strange that the coconut, if it really grew in prehistoric America, should await the arrival of Columbus before it began to disseminate itself. It is also remarkable that there is not one native American name for coconut; while in many parts of Polynesia and the East Indies there are not only general names for the coconut itself but for innumerable varieties of it, some of them prized for the excellence of the kernel, others for the enclosed water which is used as a beverage, others for the fiber of the husk, etc. On the Pacific coast of Mexico, in the vicinity of Acapulco and farther north, the sap derived from the immature inflorescence is made into a fermented drink, called by the Philippine name *tuba*. Those who write of the history of the coconut usually begin with the first appearance in literature of the name *coco*. As a matter of fact its early name was *nux indica*, and it was under this name that Marco Polo described it before the discovery of America, telling of the important part it played in the economy of certain tribes in the East Indies. Another significant fact is the presence on oceanic islands where the coconut grows of the coconut crab, *Birgus latro,* which does not occur in America. Undoubtedly the coconut has been widely spread through human agency. In Polynesia it has taken with it its Malayan name *niu.* That it can establish itself without man's aid has recently been demonstrated in the exploration of Palmyra Island. As Beccari and others have stated it is especially adapted for floating and thus for being disseminated by ocean currents.

An example of the way a coconut can find its way to a new island through human agency is offered in the narrative of one of the early exploring expeditions. A native of the Caroline Islands who had been shipped as one of the crew went ashore on one of the Aleutian Islands. After a short time he got into a boat and returned to the ship. On being questioned he replied: "I come for coconut to plant ashore: these poor people no got coconuts; how can they live?"

The chief argument advanced for the American origin of the coconut is that its nearest relatives are American. It now appears that the so-called cocos palms of South America do not really belong to the genus Cocos, and that its nearest relative is an African palm.

MR. MUIR: Insects have exerted a large influence on race migration. The Arab migration in Africa may be cited as an example. It has been observed that the Arabs spread southward to the border of the belt occupied by the Toltse fly, but not beyond. It is probable that Arabian culture would have spread entirely over the continent of Africa, but for the bar established by the fly.

THE STATUS OF PHYSICAL ANTHROPOLOGY IN POLYNESIA

By Louis R. Sullivan

It is an easy task to define the status of somatological research in Polynesia. In all fairness to those who have worked in this part of the world, it may still be said that this is a virgin field. Disregarding the scanty data contributed by enthusiastic but in many cases untrained observers, the serious contributions to physical problems in Polynesia may be enumerated in a very limited space. Davis (1867),[1] Flower (1897) and Turner (1884, 1885) in their catalogues have described a few crania from Polynesia. Allen (1898) has described a fairly large collection from Hawaii, and Poll (1904) a series of skeletal remains from the Chatham Islands. Ten Kate (1915, 1916) has measured a few Polynesian natives. We have the unpublished work on the living Hawaiians by Von Luschan and Tozzer. Considering the area of Polynesia and the number of people inhabiting it, the data is entirely inadequate for conclusions as to the racial or inter-insular affinities of the Polynesians from a physical standpoint. As a matter of fact, the various observers enumerated above have appreciated the meagerness of their data and have carefully refrained from drawing any such conclusions or elaborating any theories of origin or migrations. They have been content to stop with descriptions more or less detailed as their interests dictated.

But does that mean that there is a poverty of theories and speculations as to the relationships and migrations of the Polynesians? No, indeed. Probably the history of no other similar group of mankind has been so much speculated upon and so maltreated as has that of the Polynesians. Voyagers, missionaries, legislators and students of all subjects who have traveled in Polynesia or have talked with some one who has traveled in Polynesia, or who have seen photographs of the natives, have been generous in their contributions to the theories and speculations in vogue; nor have they been backward in adding new theories of their own manufacture. In the literature it is easy to find authority for including or excluding the Polynesians in or from all the races of mankind. They have been grown here, or brought here from America, Northern Asia, India, Africa and even northwestern Europe by various authorities.

[1] A bibliography is published at the end of this paper.

In order that I may not seem to exaggerate, let me be more specific in my statements. Lesson regards the Polynesians as autocthones, originating in South Island of New Zealand, which he thinks is the Hawaiki of tradition. Fornander (1870) says they came from Saba, Arabia by way of India and are a branch of the great Indo-European family. Fenton (1885), Gill (1876), Tregear (1904) and Gudgeon (1885) follow Fornander with trifling qualifications and reservations. Ellis (1829) says they came from the West. He later suggests that they first crossed the Pacific to America and then returned to Polynesia. Brown (1920) suggests two migrations, one by way of Europe, northern Asia and the Philippines and a sceond by way of India.

So much for speculations as to the origin and migrations of the Polynesians. The solution of these two problems will always remain more or less speculative. It is certain that physical anthropology can not offer the solution. Nor, I believe, can any of the other branches of anthropology alone. It is only after extensive study of the physical anthropology, archaeology, linguistics, ethnology, ethnobotany and ethnozoölogy of the Polynesians that we can have any hope of an approach to a solution.

To what problem or problems then can physical anthropology offer solutions? It can accurately define and describe the Polynesian groups. It can prove beyond reasonable doubt the racial origin and affinities of the Polynesians. It can designate fairly accurately to what branch of a given race they belong. It can determine the degrees of relationships between the various Polynesian groups. It can point out the probable types with which the Polynesians have come in contact and have intermixed during their migrations and in recent times. This data, when interpreted with the results of other phases of Polynesian research, may throw some light on the more general problems.

If physical anthropology is capable of solving the problems enumerated above, how has it succeeded thus far? The answer is, "Not at all." The racial affinities of the Polynesians are as confused and obscured in literature as are their origin and migrations. Saint-Hilaire (1861), Huxley (1870), Flower (1882), Topinard (1885), and Peschel (1874) describe them as mongoloid. Ellis (1829) and Lang (1877) assign them more specifically to the American Indian type. Pritchard (1866) groups them with the Malays. Deniker (1900) classes them as a special race of which he says "the relations are somewhat vague." Giuffrida-Ruggeri (1912) assigns them to a separate species including the Polynesians, the Indonesians and the Ainu. Quatrefages (1889) classes them as Caucasian. Giddings (1909) groups the Polynesians with the Europeans. Smith (1910) says they are generally acknowledged now to be a branch of the Caucasian race who originated in north Africa. Brown (1920) says: "Thus the hair and complexion, rather than the head-form, added to the tall stature and fine features, point back to the north-west of Europe." Keane (1908) describes them as follows: "Such are the Maori of New Zealand, the Tongans, Tahitians, Samoans, Marquesas and Ellis Islanders and Hawaiians, all of whom present a most remarkable uniformity in their physical appearance, mental qualities, customs, traditions, mythologies, folk lore and religious notions. That they are one people is obvious, and that they are an Oceanic branch of the Caucasian division is now admitted by all competent observers such as Dr. Guillemard who writes that the Polynesians are in no respect inferior to the average European either in complexion, physical beauty or nobility of expression." Lord George Campbell also declares that "there are no people in the world who strike one at first sight so much as these Friendly Islanders (Tongans). Their clear, light copper, brown colored skins, yellow and curly hair, good humored and handsome faces formed a novel and splendid picture of the genus homo; and as far as physique and appearance go they certainly gave one an impression of being a superior race to ours."

It is of interest to note that if we group the men quoted into two groups we get more uniformity of opinion. The biologists are almost unanimous in regarding the Polynesians as of mongoloid origin, while the ethnologists and others have a tendency to regard them as Caucasian.

If physical anthropology can answer these questions why all this confusion of ideas and opinions? The reason is obvious. It is simply necessary to remind you that physical anthropology is a biological subject. In the early days anthropology was chiefly physical anthropology. It is now far from that. Physical anthropology is only one of the many divisions of anthropology. But the transition has been so gradual and the traditions of the science so strong that even up to the present time it is customary for the various specialists in archaeology, linguistics, ethnology, anthropology and even history and sociology to carry on work in physical anthropology as a side line. It is taken for granted that no particular biological training or background is necessary to discuss its problems or prosecute its research. Even among ethnologists, our closest colleagues, it has come to be largely a course in surveying. One has only to know how to take a limited number of measurements of the body or skeleton to be an authority. To go a little further, I think it may be justly said the cephalic index has become synonymous with physical anthropology in the minds of a majority of ethnologists and scientists in closely allied subjects. This is shown clearly by the periodical revolts that are made by certain scientists when they call upon the cephalic index in time of trouble and find it wanting. One of the most recent secessioners is Brown (1920), who confesses as follows: "When I started out on my travels over and around the Pacific I had unquestioning faith in headform as the ultimate test of race. But as I proceeded there arose in my mind doubts and questions. . . . . . . I have now lost faith in the measurements of heads or skulls, at least in Polynesia." We can only say to Mr. Brown that his faith was too great. Even now it is shaken only by the chances of a head or a skull being artificially deformed. Yet disregarding the possibilities of deformation, few physical anthropologists would defend headform, at least as expressed by the cephalic or cranial index as the ultimate test of race. I have yet to meet the physical anthropologist who, given an individual or skull to identify racially, pays any attention to the cephalic or other indices.

In order to clear up certain misunderstandings that exist as to the scope and methods of physical anthropology, I would like to indicate briefly the principles underlying its technique and procedure.

We have two methods of attack. The first and most fundamental is the biological method. Here we rely upon anatomical characteristics for our racial relationships. Under this head come the form, color and texture of the hair, the amount and distribution of the hair on the face, limbs and body, the color of the eye, the color of the sclera, the form of the upper eyelid, the color of the skin, the form of the nose, lips and ears, the development of the glabella, the contour of the face and profile, peculiarities of the incisor and molar teeth, the development of the chin and hundreds of other similar observations. These are the characteristics upon which we depend in the main for determining racial relationships. They yield the best results only in the hands of a person who has given the subject serious thought and attention since they are expressed in terms of relative degrees, and one's description is restricted by his experience.

The second method is biometric and is not peculiar to physical anthropology. It is used in various other biological sciences. It is adapted to eliminate as far as possible the personal equation in description. It is based on the law of averages. Given any two sufficiently large samples of the same race, the average size of their shoes or collars should be the same. While these two characteristics are not used in practice, they illustrate the principle involved. Certain diameters which vary considerably in mankind and split rather definitely along the lines of racial or local groups, have been selected to add to and strengthen the descriptive data enumerated above. Among these are the diameters of the nose or nasal skeleton, the diameters of the fleshy ear, the diameters of the face, the maximum diameters of the brain case, and stature. The ratios of these diameters are called indices and certain of these indices notably the nasal, cephalic, craniofacial and facial have come to have a special biological significance. The nasal index comes the nearest to splitting along the racial lines, the cephalic the farthest. Yet one rarely hears of the nasal index, while the cephalic index figures prominently in every anthropological or semi-anthropological paper or discussion. The nasal index has its shortcomings and does not distinguish between types of noses having similar proportions. All of these indices are rough expressions of something that exists in nature. They are better than verbal descriptions but must be interpreted by one who has seen the material involved at first hand. Attempts to classify mankind by consistent adherance to the cephalic, nasal or other indices have yielded weird results, as they must, for mankind in its differentiation into groups has not been conveniently consistent. Only when both of these methods of attack are used in the proper proportions to meet the demands of the case in hand can we hope for good results. The application of a universal formula of attack results in a waste of time, money and energy, and the results are most often obscured by details. Each area of the world presents its own peculiar problems which must be attacked by methods adapted to its peculiarities.

Another important consideration is that the investigator should be capable of distinguishing impressions from facts, that he be capable of determining what is typical and what is atypical or extreme. Extremes strike the untrained observer more forcibly than the mean or average. A good example of this may be seen in the section quoted above where Keane quotes Lord George Campbell's description of the Tongans as having yellow hair. Surely this is not the average form and color of hair for any Polynesian or Melanesian group. Another interesting episode is Brown's attempt to explain the "negroid" characteristics of the Polynesian nose. He says, "But there is another feature that is manipulated in babyhood; the nose; the nostrils are carefully flattened out as in negroid faces . . . ; we may, in fact, conclude that his negroid form was not the nose that nature endowed most of them with." Mr. Brown does not seem to appreciate the difficulties involved in deforming the nose permanently. It could not be accomplished in babyhood, since the nose is one of the last things to reach its adult form and size. That the Polynesian nose could be produced with such uniformity by such methods is beyond belief. There are hundreds of such ways in which one who has not made physical problems his primary interest may, and usually does, go astray.

The old method of sending a man who is a specialist in one field out with a basket to collect data in all fields, has not, and will not yield the most desirable results. If you wish an example look to America. Over 180 tribes or groups of American Indians have been studied and described from the standpoint of physical characteristics by men more or less interested and more or less trained in the subject. In many cases the data has been the by-product of an expedition for other purposes. The observer has had no particular problem in mind, but collected the data simply becaues it was considered a good thing to do. As a result what do we know of the interrelationships of the American Indian? Very little. There is probably not more than one or at most two men who have any idea of their relationships, whether there is one type, or two, or a dozen. And whatever ideas this man or these men may have are based not on the data collected by others, but on their own research.

The only way to obtain satisfactory results is to have a problem, map out the procedure and attack it logically and consistently. The physical problem in Polynesia is a separate problem, at least insofar as its prosecution is concerned. Its satisfactory solution can be accomplished only by sending out trained men to a fair sample of the islands to devote their entire time to this problem. You would not send out an archaeologist, a linguist or an ethnologist to study the interrelationships of the fauna or flora of an area. Why send them out to study one of the most complicated of any of the animals groups—man?

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THE ANTHROPOLOGY OF THE HAWAIIAN RACE

By Alfred Tozzer

From an anthropological point of view there are three angles of approach to the study of the Hawaiians. The first of these is a comparative study of the Hawaiians in relation to other Polynesian people—the origin of the Polynesians—in other words that most popular, most difficult, and most nebulous of subjects. The second means of approach is a physical study of the Hawaiians as a racial unit. This investigation is now being carried out by the Bishop Museum under the immediate direction of Mr. Louis R. Sullivan. The third angle is an investigation of the Hawaiians in their relations to other peoples, the racial mixtures now present in the Territory. This is the subject which I wish to discuss very briefly at this time.

Let us consider, first of all, the history of foreign immigration to these islands, and influx of peoples which has brought about one of the most complex problems of miscegenation now available for study.

TRADITION OF WRECK

Tradition states that about 1528 at Keai in South Kona, Hawaii, a foreign vessel was wrecked. The captain and his sister alone were saved. Practically all authorities agree that this vessel must have been Spanish. It is known that Cortes at about this time fitted out several exploring expeditions from the Pacific coast of Mexico. The first of these, in 1527, consisted of three vessels, two of which never returned. It has been assumed by many that the vessel wrecked on the Kona coast was one of these ships. Tradition goes on to tell us that this captain and his sister were kindly received by the natives. They intermarried with the Hawaiians and it is said that they became the ancestors of certain well known families of chiefs. It is generally believed that the present reddish haired Hawaiian called "Ehu" is the result of this Spanish influence. I think this supposition is decidedly doubtful.

Returning to the historical aspects of the question, there is little doubt that these islands were discovered in 1555 by the Spanish navigator, Juan Gaetano. The islands seem to have been incorrectly placed on early Spanish charts from about this time.

It was not, however, until almost 225 years later, in 1778, that the voyages of Captain Cook made the islands generally known. From Cook's time onward, there was a constant succession of voyages to the Islands among these being Portlock and Dixon, Young, and Vancouver. The latter in 1791 found 14 Chinese merchants already located there.

The arrival of the first American missionaries, just 100 years ago, marks the first distinct immigration of a foreign people. The wholesale arrival of alien peoples did not begin, however, until the latter part of the 19th century. The influx of foreigners was almost solely due to the necessity of obtaining cheap agricultural labor for the sugar plantations, which were rapidly being developed.

EARLY COLONIZATION

Before enumerating some of the successful attempts at colonization let me review some of the less successful efforts to bring other peoples into these islands. Kamehameha III wished to have the few inhabitants of Pitcairn Island brought to Hawaii. In 1868 an attempt was made to introduce Polynesian peoples. Ten years later 2000 inhabitants from the Gilbert Islands were actually brought here. Nearly all of these were later returned to their homes. An East Indian immigration was planned in 1867 but it was never carried out. In 1870 a white colony was placed on Lanai. This met with disaster. Seven years later a Hindu immigration was contemplated.

Of the peoples other than white who have played a great part as a racial ingredient in Hawaii, first place goes to the Chinese. The first colony, consisting of 180 coolies, arrived as early as 1851. With the establishment of the Bureau of Immigration in 1864, a definite policy of oriental immigration became effective and in the following year 500 Chinese arrived. In 1866 the Chinese in the Island numbered 1200; in 1878, 6000; and in 1886, 21,000. This number has remained practically constant ever since.

Far less important as a racial factor from the point of view of miscegenation are the Japanese. The first came in 1869, a colony of 48. In 1890, there were over 12,000 and in 1910 almost 80,000.

THE PORTUGUESE ELEMENT

The Portuguese were practically unknown here until the last quarter of the last century. There were, of course, sailors who came here in early times on the whalers, mostly from the Cape Verde Islands. They furnish a negro strain in some of the present day natives. The first large body of Portuguese, 180 of them, came in 1878 from Funchal. In the seven following years almost 10,000 arrived, mostly from the Azores and from Maderia. The Portuguese represent the largest element in the European population of the Islands at the present time.

The Koreans and Filipinos were the last of the oriental peoples to arrive. The Koreans began to arrive in 1900 along with the Porto Ricans. The Filipinos were brought in 1909 for the first time.

Let us now consider the main components of the present population. The last figures published are from the census of 1910. The estimates of the population in 1919, published in Thrum's Annual for 1920 differ considerably in the proportions of the different elements of the population from the enumeration of ten years ago. Taking the 1910 figures the Japanese stand at the head, forming 41 per cent of the total population. This should be borne in mind when we come to consider the small part of the Japanese play in racial mixture. The percentages of the other nationalities are as follows:

	1910	1919 (estimate)
Hawaiian,	13.5	8.5
Portuguese,	11.5	9.4
Chinese,	11.2	8.6
White [1]	7.7	11.7
Hawaiian-White,	4.5	6.2
Porto Rican,	2.5	2.
Korean	2.3	1.9
Hawaiian-Asiatic,	1.9	
Spanish	1.	
Black	.3	
Filipino,		8.3
All others,	1.4	.2

[1] American and European other than Portuguese and Spanish.

RECENT DATA

I next propose to present a sample of mixtures found in 200 individuals whom I have measured within the last three weeks. I regret I have not the figures for 300 other persons measured by me in 1916. It is not claimed that this sampling is a fair test of the relative frequency of pure and mixed bloods but it will indicate the variety of crossing available for study here in the islands. These measurements were made for the most part at a pineapple cannery, on the docks, and at the Summer Normal School. 34 per cent of those measured called themselves pure Hawaiians.

The Hawaiian-White mixture formed 35 per cent of the individuals investigated, running all the way from ½ Hawaiian and ½ White, to ⅞ Hawaiian and ⅛ White, and ⅛ Hawaiian and ⅞ White. There is little doubt that the census figures giving the Hawaiian-White mixture as 4.5 per cent of the population is far too low an estimate. An improvement in collecting these data could be made.

The frequency of this mixture is probably due far more to racial and social causes than in the case of the Hawaiian-Chinese mixture, where it was due to the relatively few Chinese women in the country.

JAPANESE DID NOT MIX

The Japanese who were in a similar position regarding the small available choice of their fellow country-women as mates did not intermarry with Hawaiians to any appreciable extent. The advent of the "picture bride" is too recent to have played a part in this almost total lack of Japanese-Hawaiian mixture. I found only 2 per cent of those measured of Japanese-Hawaiian descent and this in spite of the fact that the Japanese furnish over 40 per cent of the population.

Of the 200 people studied, 5 per cent were Hawaiian-Chinese-White in varying mixtures, the greater number being ½ White with ¼ Chinese and ¼ Hawaiian. Four per cent had negro blood. This negro element came, for the most part, from the Cape Verde islanders. Finally 2 per cent of those measured came into a miscellaneous class which includes traces of Malay, Tahitian, Samoan, East Indian, different tribes of American Indian and a Mexican.

Let me give only 2 cases in detail. The first mixture was ⅜ Hawaiian, ¼ Chinese, ¼ White, ⅛ Negro. The second was 1/4 Hawaiian, 1/4 Porto Rican, 1/4 Spanish, 1/8 Portuguese, 1/8 Northern European.

Nothing can be said at this time regarding the racial characters of these mixtures, the special racial traits inherited in varying degrees as shown by the head, face and body measurements. This is a subject for a more extended treatment than can be given at this time.

FIELD FOR STUDY

I have said enough, however, to indicate that this paradise at the crossroads of the Pacific has been in very truth a centre of miscegenation perhaps not equalled in the same number of people anywhere else in the world. This study of the racial complexity here opens up a fertile field for the eugenist, the student of heredity, the sociologist, the psychologist, and the economist as well as for the anthropologist. I cannot urge too strongly upon the local scientists this unexampled opportunity for profitable research which they have in their midst. This situation shows in very truth that the hands across the Pacific are in many cases the hands of marriage.

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NOTES ON POLYNESIAN FEATHER WORK

By John F. G. Stokes

No doubt the wearing of feathers originated in the motive of displaying trophies of the chase or hunt, in a manner analogous to the custom of wearing human hair and other substances as trophies of battle. As trophies or "first fruits" of the hunt, they were also offerings to the gods. The Polynesian veneration for feathers may have resulted from the latter association, or, may have been remnant of a great bird-cult.

In using the terms "religion" and "sacred" in this context the Polynesians' concepts must be understood. These people as exemplified in Hawaii attributed a divine origin to their kings and venerated them as gods. This did not imply that humans were raised to the heights conveyed by our ideas of divinity, but that gods, to Polynesians, were little more than human.

Gods were present in many shapes. In human form they differed from people only in substance and in unlimited supernatural power. They intermarried among themselves and with humans, and begat children. The distinction between kings and gods was the matter of mortality, but the transition from immortal gods to mortal kings in the line of divine descent, has not been satisfactorily explained.

We do know, however, that the Polynesians believed in the ability of humans to implant supernatural power in inanimate objects, and thereby create a god which would do the bidding of its human creator. It was much practiced in the black art, and had its parallel in the investiture of Polynesian kings, a ceremony by which the divine power was infused into the king's person, and which I will presently describe.

In Polynesia the use of feathers was confined, in general to the chiefly or kingly caste, and to worship.

The sacred color was primarily red, as was the sacred feather. The Polynesian red-feather cult had reached the height of its development in the Society Islands at the time they were first explored by foreigners. Red feathers had then become the necessary medium for invoking the great gods, particularly the god of war. All prayers in and out of the temple were said over a small bunch of red feathers held in the fingers. The god himself could be implanted in red feathers by contact and prayer, and his presence might thus be simultaneously transferred to hundreds of homes, while his image remained in its place in the temple. The war god was worshippd in bird form in Samoa and in bird form or effigy in the Society group, and similar conditions might have been noted in other islands. Effigies of birds were found about the tombs of the Society and Marquesas islands, but this may have been the effect of a form of bird-totemism which was prevalent in Polynesia. A tern cult was observed in Easter Island and, as is reasonably shown by Balfour, seems to have been evolved from a frigate-bird cult analogous to that in Melanesia.

Rarity of feathers played a minor part, as the Hawaiian feathered representation of the war god remained principally red, even though red feathers were so common on Hawaii as to have been entirely replaced in the royal cloak by yellow. At the same time other colors were to be found creeping in as complementary to the red.

The girdles were emblems of royal investiture, equivalent to the crowns of monarchy, but as fetishes were far more potent because they imbued the wearer with power direct from the god. By inference, their use was limited to certain pure lines of purported divine ancestry.

Records of four girdles have been preserved, one each from Raiatea[1] and Tahiti[2] or the Society group, and two from Hawaii. The Hawaiian specimens I will call a sash and cordon, respectively, after the manner of wearing. The sash[3] is nearly in fragments, but the cordon[4] is almost perfect. The condition of the specimens, and a difference in the technique, indicate that the sash was the older and it was probably the predecessor of the cordon.

All the girdles were of feathers on a groundwork of netting. The predominating color is red, but in three of them yellow was also present, and shadings of black in two. The Tahitian and Raiatean sashes were incomplete, as they were in continuous process of manufacture. In Raiatea, a piece was added on the accession of each new king. The Hawaiian speci-

[1] Tyerman & Bennet, Journal, vol. 1, p. 527, London, 1831.
[2] Cook's Third Voyage, vol. 2, p. 37; London 1784; and Ellis, Polynesian Researches, vol. 3, p. 180, London 1853.
[3] Mem. B. P. Bishop Museum, vol. II, p. 154, 1906.
[4] Mem. B. P. Bishop Museum, vol. VII, p. 34, 1918.

mens differed from the others in that they were complete; also they were finished with human molars. The proportional measurements of the four specimens varied.

The Hawaiian emblems have only come to light within the last few decades, and we have no information concerning the ceremony of investiture. The late King Kalakaua claimed that the cordon was one with which King Liloa invested his son Umi in the temple of Paakalana on the Island of Hawaii. This period was about 1500 A. D. In Tahiti and Raiatea the investiture was always conducted with one or more human sacrifices, and at each ceremony an addition of feathers was made to the sash. As an illustration of the alleged dynamic force transmitted through these specimens, I might mention that there was a needle attached to the Raiatean sash, with the tradition that no stitch was taken but thunder was heard in the heaven.

Peculiar sacredness is attributed to the island of Raiatea. Ellis states that it was the cradle of Polynesian mythology and the birthplace of the great Southern war god, Oro.

During a ceremony at Tahiti in preparation for war, the sash and the representation of the god Oro were wrapped up in similarly shaped bundles and laid side by side on the altar. There was as much veneration paid to the sash as to the idol, which latter was merely an uncarved log of wood with red feathers attached. On the accession of a new king, the heir was invested with the sash by the high priest. As the priest girded on the emblem, he prayed that the king's influence might be extended far over the sea. He then described the sacred nature of the girdle, concluding with the words, "This, O King, is your parent," meaning, as Ellis stated, that all the king's power was derived from the gods.

We have been able to trace this system of investiture back to the year 1250 A. D., when, as Percy Smith shows, Tangiia, a Tahitian chief, defeated in a battle in which his sons were killed, was in flight for Rarotonga. He was engaged in investing with the sash the son of a chiefly relative when the dreaded enemy came suddenly upon him, and the ceremonies were suspended. Tangiia finally settled in Rarotonga and had other sons, and undoubtedly the sacred emblem went with him. On account of this tradition I believe that the rite was continued in Rarotonga, but as the Hawaiians have been so secretive about their emblem of royalty it is probable the Rarotongan emblem has not come to light for a similar reason.

An earlier date for the custom was set by a Hawaiian tradition (borrowed from the South) as it is stated in a chant that Hema went to "Kahiki" (a portion of Polynesia not identified) to get the red-feather girdle, but he died instead. The period of Hema is set as the seventh century by Percy Smith, who places the date of the arrival of the Polynesians in the Pacific as only a few centuries earlier.

Tahitian myth carries the custom back to the beginning of time when gods begat kings by the common people, kings who on account of the plebeian adulteration were not entitled to wear the sacred emblem.

New Zealand was too large a country and its tribal interests too varied to be united under a single Polynesian monarch. Its chiefs also were probably too distant from the line of divine descent. This may account for the investure of an idol, instead of a human with a red-feathered fringe.

We get a continuity of form in the sash which is merely incidental and controlled by the manner in which the emblem must be worn. The material on the other hand is controlled by the religious purpose of the garment.

I have shown that the making of feather girdles was a very sacred undertaking. In Hawaii the manufacture of royal cloaks and helmets was also conducted under the tabu, but as far as known, was not accompanied by human sacrifice. The helmet was probably of greater regard than the cloaks as it was to come in contact with the head—the most sacred part of the body. The restrictions during manufacture of feather garments were probably general in Polynesia, as implied by the description of the mourner's robe in Tahiti.

I have been able to find no reference to the existence of the girdle in the other large Polynesian groups. The perpetuation of the custom would require a hereditary monarchial government of an island or group by very tabu kings. The topography of the Marquesan group would aid the independence of valley chiefs, tending towards tribal conditions as in New Zealand. In Tonga the necessary conditions seemed to have existed. In Samoa the idea of monarchy was recent. [5]

[5] Since reading this paper I have been informed by Dr. W. E. Safford that he was well acquainted with the Malietoa family and that he was sure that no custom of investiture with a feather girdle was in vogue in Samoa.

With the evidence at present available, we may tentatively conclude that the right of investiture with the girdle belonged to a Polynesian family of high tabu, centered in the Pacific in the Society Islands. The degree of sanctity attributed to the feather girdles, however, was probably far greater than that assigned to any other form of feather garment.

I now wish to emphasize points of difference between the northern and southern Polynesian helmets or headdresses. The former is represented by one general type, the Hawaiian helmet. The southern headdress was in general of frontlet form and retained this feature even in its greatest development—the Tahitian *fau* mentioned below.

The theoretical evolution of the southern headdress can without difficulty be traced from detached feathers used for head ornamentation as in New Zealand, but we need only follow it after it took on a frontlet form. It seems to have passed through one of two such forms, either a string of feathers bunched together as found in Tonga,[6] or in a bandage of coir holding erect plumes of feathers as in the Marquesan group.[7] Most likely it was from both. The combination may be illustrated by another specimen[8] from the Marquesas, where we have a feathered frontlet, widely extended, with strings on the inside for plumes.

To return to Tonga, one of the frontlets has just been mentioned but there was another,[9] very elaborate, worn only by the king. It was of the coronet type, a cap with long erect feathers around its border, reaching across the forehead and extending backwards. Small red feathers, in the manner of thatching, were fastened to each erect feather for its full length, and the result was a conspicuous headdress.

The caps of the Cook islanders, were broad bands with numerous feathers and high plumes. One form of those in the Austral Islands was described as well made and graceful, in comparison with the Tahitian specimen.. It was of cane-work and stiff cloth. The lower part of the front was of red and green feathers, and above was a line of tropic bird feathers fixed to a frame. The description conveyed the idea of a

[6] Cook's Second Voyage, Pl. XXI, fig. 1.
[7] Cook's Second Voyage, Pl. XVII, fig. 4.
[8] Mem. B. P. Bishop Museum, vol. 1, p. 448. fig. 77, 1899.
[9] Cook's Third Voyage, Pl. XVIII.

frontlet combined with a plumed fringe as illustrated by the *fau* mentioned below, but of more modest proportions.

The *fau*[10] of the Society islands, a war dress as were the others, was worn by only the most distinguished men. The wearers served as rallying points in battle. This high frontlet was of green feathers, bordered, in white, and fringed with the long tail-feathers of the tropic bird. Its support was a cylinder of open cane work, carried to a height, as described, of two or three feet. In Tahiti there was also a frontlet of cloth, with a bunch of tropic-bird feathers pointing forward from each end.

The only other examples from the South are from Easter Island, where there was a frontlet of numerous erect chicken plumes.[11] There was also a circlet of feathers for the head. The Samoan war headdress was principally of hair but with a few tropic-bird feathers placed erect. It did not convey the idea of a feather frontlet.

In the North, I can find but one resemblance to the frontlet, i.e. in the feather wreath called *lei* worn by women, and somewhat analogous to the Easter Island circlet. The Hawaiian feather helmets were in another class, of strong yet light wickerwork, close-fitted to the head, even to provisions for the ears. They were stout enough to withstand the blow of a club. The range of forms may be shown by two specimens, one comparatively simple in design[12] and the other with open supports for the crest.[13] The main feature is the crest, which has been taken by some as evidence of early Spanish contact. The Hawaiians were good imitators, as were Polynesians generally, and made feather hats exactly after foreign pattern. If a model of a Spanish helmet of the period were placed by the side of a Hawaiian helmet it would be seen clearly that one was not imitated from the other. Brigham, when discussing the origin in his account of the Hawaiian feather work[14] pointed with more reasons, in the direction of Melanesia, where the crest is found. He finally suggested a local Hawaiian development.

[10] Parkinson's Journal, Pl. XI, London, 1773. This plate should be examined together with Hodge's illustrations in Cook's Second Voyage, Pl. LXI.

[11] Cook's Second Voyage, Pl. XLVI.

[12] Mem. B. P. Bishop Museum, vol. I, p. 5, fig. 2, 1899.

[13] Mem. B. P. Bishop Museum, vol. I, p. 447, fig. 10, 1899.

[14] Mem. B. P. Bishop Museum, vol. I, p. 40, 1899.

The Hawaiians lost touch with their southern neighbors about the year 1300 A. D. so that they were left for 500 years to develop by themselves before Cook's arrival.

Some interesting features are suggested by the comparison of the girdles and headdresses. It is evident that contact of the Hawaiians with Southern Polynesia is shown by the girdle investiture, the custom having probably been borrowed from the Society Islands. The very sacred nature of the girdle would be sufficient to insure the continuity of the custom until modern historical times.

On the other hand the Hawaiian head-dresses, and other feather work in some degree, would imply a separation of long duration from the Southern groups. There was enough intercommunication among the Southern Polynesians to explain the continuity of the frontlet form of headdress, and there is little doubt that if the Hawaiian helmet had been evolved before communication ceased with the southern groups, its form would have been found in the latter islands. The last traditional departure from this group for the south was that of Laamaikahiki, about 1300 A. D. While I am inclined to believe that the Hawaiian helmet was locally developed since that date, it should be pointed out that there are traditions of the arrival here of more than one company of strangers between that time and the coming of Captain Cook. The sacred nature of the headdress was evidently of lesser degree than that of the girdles, or there would have been less variation.

The references to the girdles may also serve to place one of the localities known to the Hawaiians as "Kahiki" (Hawaiian form of Tahiti.) The Hawaiians claimed that they came from "Kahiki" but applied the name in general to any foreign country.

The Hawaiians have several groups of traditions, one to the effect that the first Hawaiian was Wakea (390 A. D., Smith's chronology) who introduced taro into the Hawaiian Islands. Another claim is that Hawaii-Loa (200 years earlier) discovered and settled these islands. There are no accounts of other immigrants until the twelfth century A. D.

Fornander[15] localizes these early Hawaiians elsewhere, and while suggesting in various parts of his work the probability of a very early settlement in Hawaii, makes with necessary reser-

[15]Polynesian Race, vol. 1, p. 168.

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vations the following propositions deduced from a study of the old traditions:

1. At the close of the first and during the second century A. D., Polynesians first arrived in the Pacific, establishing themselves in Fiji and spreading to Samoa, Tonga, and other groups eastward and northward. (Percy Smith's chronology, 390-450 A. D.)

2. During the fifth century Polynesians settled in the Hawaiian islands. (Smith, 650 A. D.)

3. During the eleventh century and for five or six generations afterwards parties from the Marquesas, Society, and Samoan groups arrived at and maintained an intercourse with the Hawaiian group. (Smith, 1100-1325 A.D.)

Percy Smith mentions the probability of two groups of Polynesian arrivals in the Pacific, whose periods might be divided by the year 450 A.D. "From the want of any direct traditions amongst the Samoans and Tongans, it is probable that they had preceded the others and were the first to enter the Pacific. They have been so long in their present homes that all traditions of their arrival is lost, and hence they have come to look on themselves as autochthones."[16]

Commencing approximately with the year 450 A.D. and continuing for some centuries afterwards, there followed other Polynesians who brought new customs, settled in Fiji, Tonga, the Samoan coastal region and extended through the Pacific. These people, called Maori-Rarotongans by Smith, were in time able to control all the earlier Polynesians, except the Samoans. According to Smith's chronological table, they reached the Marquesan group in 675 A. D.; Tahiti, prior to 850 A. D.; New Zealand 850 A. D.; Rarotonga 875 A. D.; Paumotu group 1000 A. D., and, as he infers, Hawaii in 650 A. D. The last was probably not until 1100 A. D.

The early Tongans were apparently overwhelmed by the later migrants, so that the lines of demarkation between the earlier and later cultures are not now distinct. The Samoan culture in the main survived, with such additions as contact would bring, as the Samoans were able to repel the later people.

If we compare the Samoan culture with that of the Society group, where the later migrants appeared to have had the greatest influence, we find in Samoa, among other features,

[16] Percy Smith, Hawaiki, p. 153, 1910.

platformed foundations for temples, and an absence of hereditary king-ship, of idols or images in worship and of human sacrifices. In the Society group, the last three features were characteristic, and the temples were walled enclosures except for such as may be traced to earlier influences.

The features mentioned above as Samoan were in existence in the Hawaiian islands prior to the twelfth century when the later migrants began to arrive in this group.[17] We may therefore consider the earlier people as of the same stock as those of Samoa though not necessarily coming from that group. I do not believe that the arrivals in Hawaii of 650 A.D., of which there are no Hawaiian traditions, were of the later migrants, and consider it more probable that they were of the earlier stock from the south who had previously spread through the Pacific and were being displaced through the pressure of the later migrants.

It is not difficult to choose the period to which the royal girdle investiture belonged, as the hereditary king-ship and the evident growth of priestly power, as shown by the change in worship, would mark it as the second period.

It was therefore an acquirement after the early migrants, now represented by the Samoans, had left the parent stock. But whether it resulted from contact with other people or from development of the idea of royalty it is difficult to surmise. It is equally difficult to surmise if its development took place in the Pacific. I will content myself therefore with the attempt to show that it became localized in the island of Raiatea and thence spread to some of the other groups.

It is more convenient to begin with Hawaiian traditions. In reading Fornander's account of the arrivals in Hawaii during the later period, we find among others the names of:—Nanamaoa, whose son Nanakaoko, a chief of considerable note on the island of Oahu, established the sacred chiefly birthplace called Kukaniloko; Paumakua, whose son Haho established the Ahaalii on Maui; Moikeha, the chief of southern extraction born on Hawaii who went to "Kahiki" and returned to the Hawaiian group, becoming king of Kauai through his marriage with the daughter of the Kauai king; and Pili-kaaiea, who became king of Hawaii (about 1200 A.D., Smith's chronology).

[17] Fornander, Polynesian Race, vol. 2, pp. 58-67, and Kepelino Ms. (Catholic Mission, Honolulu.)

As the girdle investiture has been attributed only to the island of Hawaii, the choice would naturally incline to the last mentioned. There are however other circumstances seeming to confirm this.

One of the arrivals of the later period was a priest named Paao, whose first reported action after landing on the island of Hawaii, was the building of two temples of the enclosure type. Finding that conditions were favorable for the establishment of a new king, Paao sent to "Kahiki" and induced Pili-kaaiea to accept the throne of Hawaii. The latter was installed in his new office without recorded opposition at the time from the island chiefs, a condition which can only be explained by the probability that an unusually high tabu family rank was claimed for him and that the claim was admitted by the resident chiefs.

As far as traditional evidence is of value, the circumstances as above mentioned, after considering the claim for distinction of the other arrivals, point to Pili-kaaiea as the king who introduced the girdle investiture into Hawaii.

It is sometimes dangerous to place reliance on coincidences in names, but I should point out that Fornander was in some doubt in regard to the spelling of Pili's name.[18] *Ka aiea* means "the fatigued," but *kaai* is Hawaiian for "girdle" and *ea*, "spirit, vital breath," so that the combination might with some slight stretch of the imagination be translated as "divine girdle." On the other hand, if the name were spelled Pili-kaaiia, it would mean "girdled Pili," and leave no doubt as to the significance of the name. Fornander's doubt as to the correct spelling of the name leaves the way open for this suggestion.

Fornander[19] was of the opinion that Paao and Pili-kaaiea came to Hawaii from Samoa on account of the traditions that Paao came from Upolu and owned lands in Vavau, (Tonga).

Percy Smith[20] in his researches has ascertained that Upolu was also one of the ancient names of Tahaa, the island of

[18] In the first volume of the "Polynesian Race" it occurred three times, twice Pili-kaiaea and once as Pilikaeaea. In the second volume, it was mentioned six times, with similar letters; three times as "Pili, surnamed Kaaiea," twice as Pilikaaiea, and once as Pili Kaaiea. There are four forms of this term, *kaai, kaei, kahai,* and *kahei,* the distinctions between which the best-informed Hawaiians of today cannot explain. Malo, the Hawaiian historian uses *kaai.* It was probably a term not in common use.

[19] Polynesian Race, vol. 2, pp. 33-35.

[20] Percy Smith, Hawaiki, p. 262, 1910.

Raiatea, and that Vavau was a former name for Polapola, about 20 miles to the northwest.

Ellis[21] has referred to the former importance of Raiatea and its sacred place of Opoa, from which "distant colonies are said to have proceeded," to which disembodied spirits returned, and offerings were brought not only from the Society group but "from the more distant islands to the south and southeast." It had an enclosed temple where "human immolation was frequent." Tyerman and Bennet[22] mentioned that Tamatoa, king of Raiatea, "was of the genuine royal blood which from time immemorial had supplied princes to all these [Society] islands, both windward and leeward." Percy Smith[23] shows that a colony has even proceeded from Raiatea to New Zealand.

These combinations of circumstances seem to point to Raiatea as the island from which Pili-Kaaiea came to Hawaii and that the "Kahiki" of the Hawaiians concerning this king referred to Raiatea, not Samoa as believed by Fornander.

It is probable that the Tahitian girdle-investiture previously described was adopted from Raiatea, but this matter cannot be cleared up without reference to Tahitian and Raiatean traditions which are not available here.

A previous reference to the time when kings[24] born in Tahiti who were not entitled by blood to wear the girdle may have referred to the early Polynesian period, or to a time before one of the Raiatean family was called to the throne of Tahiti.

[21] Polynesian Researches, vol. 2, p. 315, London, 1853.
[22] Journal, vol. 1, p. 519, London, 1831.
[23] Percy Smith, Hawaiki, p. 263.
[24] Chiefs(?) as the Polynesian terms are not always definite.

HAWAIIAN TEMPLE STRUCTURES

By Thomas G. Thrum

Among the various archaeological remains found in Hawaii probably the heiaus (temples) take first place as material for consideration, not only for their antiquity but for the prominence they held in all the islands of the group for both priestly and political power. No other reason can be assigned for the number of temple ruins yet remaining, and the vaster number revealed to us by history and tradition. This field of inquiry and investigation has been entered upon only within the past few years—and that not exhaustively—yet the pioneer effort has been rewarded by the locating of some four hundred and thirty heiaus and heiau sites on the islands of Hawaii, Maui, Molokai, Oahu and Kauai.

Tradition marks two well defined periods in the temple structure and worship of these islands determined by the advent of Paao, the high priest from the Southern Pacific, in the eleventh century.

The type of structure prevalent prior to his arrival differed outwardly by having a pyramidal truncated form, a few ruins of which were in evidence at the opening of this century, two on Hawaii, and one each on Maui and Molokai. Whether this was a universal type or a special form is not known. It is not unlikely the latter, for those that survived to share in the overthrow of idolatry by Liholiho in 1819 were above the average in size. It is quite possible that these may have been structures of the later period built after the ancient plan, as memories of the past, for it is beyond probability that structures of loose stones, without mortar or adhesive material, characteristic of all Hawaiian stone work, would survive several hundred years.

Tradition locates the erection of the first temple in these islands at Waolani, Nuuanu valley, to identify it with Wakea, ancestor of the Hawaiian race. The general plan of this original heiau is set forth by native historians, and is said to have been followed down to the time of Moi, a noted priest of Molokai, whose temple of Maniniaiake, at Pelekunu, conformed thereto. Under this early regime, the heiau with its presiding chief, officiating priest, and prepared sacrifices, were in plain open view of the assembled congregation, who heard the prayers and saw the sacrifices and could respond intelligently to the invocations of the priests.

Heiaus were of several kinds—all open to the heavens, never under cover—and it is somewhat remarkable that no two are found alike in all the islands, notwithstanding the original plan laid down. They not only differ in plan and size for the kind of service intended, but are affected by location, some being constructed upon carefully leveled ground, and pebble-paved, others conforming to the natural contour of a possibly advantageous hill site. This may not apply to the earlier period of open type structures.

Paao, already referred to, on his arrival landed at Puna, Hawaii, and there erected his first heiau known as Wahaula, a walled and paved structure of the *luakini* class, 72 feet by 132 feet, remains of which are still in fair order, owing to repairs at the hands of various kings down to the time of Kalaniopuu, its last renovator, about 1775. A high stone enclosure reaching nearly to the shore line gives it an extensive adjacent working area, most of which was at one time paved and pebbled. Its model, made to scale, showing a quadrangular or parallelogram form characteristic of the new regime, may be seen at the Bishop Museum. Paao's next structure was that of Mookini, at Puuepa, Kohala. It had massive walls, 135 feet by 267 feet still in fair condition. Both of these temples are of the human sacrifice class, and marked a new epoch, for with the introduction of this weightier of penalties to the temple services came also the introduction of several new gods, when worship of the visible image took the place of that which had hitherto typified the unseen deity. The new type of structure among other things, included the *lua pa'u* (bone pit), and the *hole-hole stone* whereon the flesh was separated from the bones of a victim. The bone pit of Mookini is within its seaward wall; this feature at Wahaulu is served by the nearby cove of the sea-coast, while the hole-hole stone is outside the walls of the former and within that of the latter. The massiveness of Mookini's walls is unusual, the height having been over twenty feet, with a width or thickness of eight feet on top and thirty feet at the base. Fornander says: "The stones of which it is built are said to have come from Pololu valley, some ten miles distant, which, according to tradition were passed by hand from man to man the entire distance, a feat requiring at least 15,000 men."

All the principal islands of the group show a number of extraordinarily large heiaus, indicative of priestly power, royal ambition, and a dense population. Among the more notable of these temples is that of Malae, in central Wailua, Kauai, a walled and paved structure 273 feet by 324 feet in size, of traditional Menehune construction, its corners buttressed with thirteen foot walls. Only two of this type have so far been discovered.

Oahu's most notable heiau is that of Puu o Mahuka, situated on the slope of Pupukea, overlooking Waimea. It is a walled temple, once paved, of double end-to-end structure, running 467 feet in length, the upper section being 127 feet in width by 281 feet in length, and the lower division 168 feet in width by 186 feet in length. Its internal features also differ in several respects from any other found.

Maui has the distinction of possessing two ruins of unusual interest; that of Loaloa in the Kaupo district, and of Kanekauila in the adjoining Kipahulu district. The latter occupies a clear space of 250 feet by 173 feet, on a knoll whose seaward face was built up and leveled with a considerable amount of stone work. The lower walls and much paving still survive, although the ancient temple features have been removed by time. Its site has been utilized the past fifty years or more by the Catholic church of the district.

But for size, amount of stone structure, and type (if it could be understood in its working order) the palm must be accorded to Loaloa, a walled, paved temple of two or more sections built up high at the point of a hill spur in the land of Kumunui, Kaupo, by three or four tiers of stone, the seaward face of which measured 101 feet. The full length of Loaloa could not be ascertained, its inner section being lost in the jungle; but measurement of the outer division gave a length of 264 feet for apparently the smaller half. Running nearly across the heiau some twenty feet from the higher and less disturbed section is a distinct path of broad, smooth stones, as in the temple of Puukohola, at Kawaihae, Hawaii. This structure is credited to King Kekaulike, about the year 1730.

Molokai's right to heiau distinction is in her temple of Iliiliopoi (referred to by Fornander as Iliiliopae) in the Mapulehu valley. It is built across the end of a ridge by retaining walls of several terraces, and is noted for its size, its age and traditions. It is much reduced from its original dimensions, a large section having been carried away by a heavy flood. It is said originally to have covered three times the present area and was of a different type, possibly a walled temple. Its reconstruction is credited to Kaalauohua, a ruling Molokai chief of the sixteenth century. Its ruins show a floor surface 85 feet by 268 feet, and a cruciform pavement similar to some temples on Hawaii ascribed to Umi.

Besides those of Paao on Hawaii, already dealt with, are several in the district of Kona worthy of note, for no less than thirty-seven heiaus have been identified in this historic district of kingly and priestly power, several of which are attributed to Umi, and are known by the peculiarity of his stone work. One such temple was erected on the top of Kukii hill, in the Puna district, the stones of which were so closely fitted that, according to native tradition, a spear of grass could not be inserted between.

The crowning structure of this ancient king is the Ahua a Umi, situated on the high plateau of Kona between the mountains of Hawaii on the slope of Hualalai, at some 5000 feet elevation. The ruins of today show much change from the plan given by Wilkes in the account of his visit in 1841, which may be readily accounted for. This structure, erected about the year 1520, is a walled memorial of several divisions, with eight stone piles surrounding it. What is termed the heiau, though tradition says Umi planned it as his monument, now measures about 74 feet by 93 feet, with walls seven or more feet high. The stone piles around the structure, some ten to twenty feet away, termed pyramids by Wilkes, were about twelve feet in diameter and from twelve to fifteen feet high. These were said to represent the districts of the island.

It remained for a later king to erect a more lasting memorial, the famous City of Refuge, at Honaunau, Kona, Hawaii, which, while credited to Kanuha in memory of one of the Keawe's, may properly have been built by Keawenui, about the year 1570. In form it is an irregular parallelogram, walled up on one side and at both ends, the other side being the sea shore. An early visitor described this enclosure as 715 feet in length and 404 feet in width, with walls twelve feet high and fifteen feet thick, in which were holes about four rods apart where large images had formerly stood. Within this enclosure were three heiaus, two of which were in bad repair, while the third was nearly entire, a compact pile of stones built up in a solid mass, 126 feet by 65 feet, and ten feet high. Many pieces of lava rock, of two or more tons each, were seen in several parts of the wall, raised at least six feet from the ground. There are also the Keoua and Kaahumanu stones, both of immense size, of squared form, near the lower temple. The whole premises have recently been put in order for preservation, and careful study is being made of their construction features.

Mention has been made of the dissimilarity of the heiaus throughout the islands. This is true especially of the internal plan. Malo and Kamakau list the heiaus as of four or more in kind or rank, but unfortunately their descriptions and statements of the purpose for which the temples were built are vague, and in some cases conflicting.

The most important heiaus were termed luakini, a class belonging to the king only, that is, erected by his order, to aid in war or to celebrate a victory. They were usually dedicated with one or more human sacrifices; hence we find the term *pookanaka* (man's head) applied to all temples of the luakini class.

The next grade of heiau, while belonging to the king, could also be built by the chiefs. These temples were known as *waihau*, and *unu*, and the offerings consisted of pigs, bananas and coconuts. The term unu has often been found applied to heiaus of the severe, human sacrifice class, which leads to the supposition that it refers to the structure as of platform rather than the walled type, instead of indicating a class of service.

Next in grade were the temples of the common people, of which there were several kinds for the farmers, the fishermen (Koas), and others. Hence the wide range in size from twenty feet square to several hundred. This however does not explain the diversity of shapes in those of the same class, and leaves us unfortunately in ignorance on important points of temple structure, and ceremonies attending the ancient worship of Hawaiians.

ANTHROPOLOGY OF THE PHILIPPINES

By A. L. Kroeber

I heartily endorse everything Dr. Wissler has said about anthropological method. I think it can be said to-day with complete fairness that there definitely exists such a method, which is as clearly applicable to the human problems of race and culture, as is the respective case for geology and botany. Just as no student of these sciences would assume to solve problems of the earth's crust or of the origin of plants by other than by geological or biological means, so no modern anthropologists would attempt questions of race origins or developments of civilization by any but his specific method. Dr. Wissler has covered this ground so well that I prefer not to dilate upon his point of view, but rather to give some of the results of this method as they have been worked out for a particular area—the Philippine Islands.

The Philippines lie on the border of the Pacific, as Hawaii is near the center. The two groups form part of the same general area, and further are connected in an ultimate relationship. The precise degree of this relationship remains to be ascertained, but the two archipelagos show a similarity probably in race, certainly in language, and very likely in culture. Consequently there seems some promise, if we apply to the problems of Hawaii and Polynesia proper the methods of attack which have yielded at least preliminary results in this related area at the fringe of the Pacific, that valid inferences can be obtained here also without undue difficulty.

The situation in the Philippines is this. There are, besides immigrants of recent centuries, three race elements of distinct origin. The earliest of these are the Negritos, a race of dwarf black people with broad noses, black skins, woolly hair, protruding jaws—in fact, Negroid in every respect except stature. In this trait their average is barely five feet, far below almost all races of mankind. According to every indication, the Negritos were the first occupants of the Philippines.

Later came a race of brown people: early Malayans or Proto-Malays, some authors have called them; Indonesians is another name for them. They came presumably from the west; possibly from Asia. They encountered the more primitive blacks, assimilated or exterminated them in the smaller islands, and drove them back to the interior of the larger ones, into the security of the central mountains, whereas they themselves occupied the fertile lowlands.

The third populational strain consists of a race closely allied to the Malays and Javanese, and whom we may call the Malayans proper. They were brown-skinned and lank-haired, rather similar to the Proto-Malayans or Indonesians and almost certainly related to them. But the Proto-Malayans or Indonesians are shorter statured, broader nosed, and longer headed—sufficiently different to enable us to distinguish these two brown races. Now the later Malayans took much the same historical attitude toward the Proto-Malayans that these had taken toward their predecessors, the Negritos. They may have been more or less numerous, but they certainly possessed superior arts and a more advanced culture. Thus they drove the Proto-Malayans inland. The result is that in the larger islands, where aboriginal conditions are best preserved, we find the race map disposed much like a target. The bull's eye is a little group of Negritos in the inaccessible mountains. Surrounding them is a ring of Proto-Malayans, more civilized than the Negritos, but less so than the Malayan coast people. These in turn form the outer circle, holding the best of the land along the shore and in the plains. Such is an outline of the salient facts as regards race.

The language situation is very much simpler on its face, but in a way perplexing too. All three races now speak what are only dialects, surface varieties as it were, of one fundamental tongue. Now the Negritos must once have had a language of their own; and, the two brown racial elements having been separated long enough to develop the physical differences referred to, we might expect that they would have been differentiated also in speech. Yet, strangely enough, no such basic division is apparent. The difference between the dialects of Proto-Malayans and later Malayans is often no greater than that between two Proto-Malayan or two later Malayan groups. As regards the Negritos, it must be that because of their numerical and cultured inferiority they have gradually given up their old tongue and adopted that of the more powerful brown peoples surrounding them.

When we come to culture, in other words the arts, customs, institutions, religion, that whole body of human knowledge that makes up the civilization or mode of life of peoples, we find conditions more complex than either in race or language. As we review the many nationalities of the islands we can trace at least half a dozen groups of factors that have gone into the building up of their culture. We can even proceed as a geologist would, beginning with the latest and working backward in time to the earliest, discovering so many strata of deposition, as it were.

The first or topmost of these cultural layers is that due to the Spaniards, who introduced, to the majority of the natives at least, Christianity, coherent political institutions patterned on those of Europe, the Roman alphabet, trade, many new arts, and certain food plants, notably maize and perhaps camotes. This Caucasian civilization is so well known to us that we may pass it by to penetrate to the others that underlie it.

Not quite two hundred years before the Spaniards reached the Philippines, the Mohammedans had come. These may have included some Arabs, but consisted chiefly of Malays who had been converted to Islam. Wherever these Mohammedians obtained a foothold, they established little kingdoms or sultanates, introduced new laws, brought in Mohammedanism, and in connection with it the Koran and Arabic script. They also introduced firearms. In many other respects they did not work very material changes because they were themselves rather thinly veneered with Mohammedan civilization. Also, being conquerors few in number, they were not particularly concerned in changing the mode of life of their subjects, but left them free to remain as they wished as long as they paid tribute. Further, the Mohammedan conquests and conversions never extended much beyond the southern part of the islands.

Preceding this Islamic one, there was a much more important wave of civilizational influence: on the whole, the most important of the several that have reached the Philippines. It emanated from India, and involved religion, knowledge, and many arts. These elements of culture were probably not carried to the Philippines by the Hindus themselves, but imported from Java, or other East Indian islands, where a strong Hindu influence began to be established about two thousand years ago. Brahminism as such seems never to have been introduced into the Philippines, but any number of its ideas and forms did reach the archipelago; and with them many words of the Sanskrit language, and the first system of writing—not yet wholly gone out of use—to be employed by any Philippine peoples. Of inventions, the technique of iron working is probably the most significant.

There is another group of culture elements that can be definitely traced to the outside: those of Chinese origin. China lies nearer the Philippines than does India, and its civilization was equally ancient and advanced. Chinese ships are known to have reached the archipelago some seven hundred years ago and may have visited it long before. Yet, it is illustrative of the temper of the two nationalities that whereas the Hindus gave liberally of their civilization, particularly on the religious and spiritual side, the Chinese chiefly brought in trade articles. To-day some of the interior mountain tribes possess jars manufactured in China some four to six hundred years ago. Certain of these half-naked Igorote "savages," who from our point of view are almost poverty stricken, treasure these heirlooms so that they will not sell them for thousands of dollars. But aside from such objects and possibly some manufacturing processes, the Chinese seem to have given little or nothing to Philippine culture.

Before the Hindus and Chinese came there must of course have been something of a native culture; although at present most of what we know about it is through the process of subtracting everything that we know to be European, Mohammedan, Hindu, or Chinese. What is left we find to be a type of culture that in its general aspects is not so very different from that of Polynesia at the time of discovery. I do not mean to say that the Polynesians came from the Philippines, but that the native cultures seem to have something in common. To mention only one point, there is the status of woman. Women were more nearly on a level with men in Polynesia than in any primitive society beyond the Pacific ocean. This shows in kinship reckoning, inheritance, marriage laws, and many other ways. Now in this fifth from the top of the strata of Philippine culture—which is apparently best preserved among some of the Proto-Malays of Luzon—we find almost exactly the same conditions prevailing. Where this status no longer prevails in the Philippines, we can virtually prove it to have been lost under the influence of the Hindus, Mohammedans, and Spaniards.

Back of all the above there must have existed a very simple culture of the Negrito. But he has apparently done very much as in the matter of language, that is, borrowed parasitically and incompletely from the more numerous and advanced peoples around him. It is entirely possible, however, that with more exact ethnological data we may yet be able to reconstruct something of this most primitive or Negrito stratum of Philippine culture.

Now, on reviewing these results, we find this situation: There are in this one group of islands three recognizable racial elements, a single parent language, and at least six different streams of culture. This emphasizes a lesson that anthropologists have been taught by force of necessity time and again, namely, that to argue from the physical heredity or blood of a people to their language or culture, or reversely to infer a dissimilarity of racial origins from a diversity of customs or speech, is one of the most risky and misleading things that can be done in science.

When we apply our Philippine determinations specifically to Polynesia, we find that probably both the brown races of the Philippines and the Polynesians are related in physical type: how closely, it is not yet possible to affirm, and yet the basic fact is scarcely to be doubted. As regards language, the studies made during a whole century have shown conclusively that relationship is close. In the complex domain of culture, knowledge is still too little systematized for any opinion to be worth much: but features such as the position of women that has been referred to indicate much. Besides, it is possible that certain elements of Polynesian thought may prove to be a locally remade radiation of East Indian civilization after this had begun to undergo Hindu influence. Mythology is especially suggestive in this regard.

There is one caution that I should like to utter. If the problem of man in the Philippines had been approached wholly from a Philippine standpoint, without reference to the rest of the world, it is obvious how confused the results of Philippine anthropology would be. It is by segregating Christian, Mohammedan, Hindu, Chinese, later Malayan, and early Malayan elements, that the history of what happened in this one group of islands can be unraveled in outline instead of remaining a jumble without perspective. It is through the assumption that there is no Philippine problem pure and simple, but that the history of man in the group is only part of his history over much wider areas, that analysis is possible which carries us back to India, Babylonia, Arabia, and allows a reconstruction that is founded in fact instead of merely speculative. Now we must know Polynesia before we can understand it; but, once having the facts, we can no more explain them on a purely Polynesian basis than we can in the Philippines. It is outlook that counts, and interrelations. But with this precaution observed, and a strict adherence to the analytic comparative method before any theories are propounded, the mystery-shrouded questions as to the whence and when of the Polynesians, as to the source of their strangely barbaric and yet refined civilization, are surely answerable.

COMMENT BY MR. SAFFORD

I lived for a year on Guam, an island which might be called a stepping stone between Hawaii and the Philippines. The ancient culture of its inhabitants may be considered intermediate between the culture of the Polynesians and certain mountain tribes of the Philippines. Students of Polynesia are familiar with the laws by which the words of the various dialects are interchanged. In studying the language of the Easter Islanders more than thirty years ago, I found that there was a regular system like a Grimm's law by which every Easter Island word could be changed to a Hawaiian word. Later I found that this applied almost equally well to the Samoan and Maori languages. Still later I discovered resemblances not so apparent between the language of the aboriginal inhabitants of Guam and the Polynesian dialects. In many cases the identity of the words was concealed by terminal consonants or by reduplication; and many Spanish words have been adopted in the modern language of the island. The Polynesian *ala,* road, becomes *chalan* in the Chamorro language of Guam, and *djalan in* Malayan, *i'a,* or *ika,* fish, becomes *guihan; ahi,* or *afi,* fire, becomes *guafi; mai,* the directive particle "hither", and *aku,* or *atu,* "hence", or away from the speaker, become *magi* and *guatu.* The inclusive and exclusive plurals of the first person pronoun correspond with the Polynesian, but in the language of Guam there is no dual number. Many of the words are obscured by reduplication and infixes and by the modification of the vowel of the tonic syllable. Thus *kolat,* fence, derived from the Spanish *corral,* when preceded by the definite article becomes *i kelat.* and *resibe,* from the Spanish word for "receive" by reduplication becomes *resisibe,* and by the infixing of *um, rumesibe.*

In these features the language of Guam resembles the various languages of the Philippine Islands, and the culture of the aboriginal inhabitants was very similar to that of the modern Igorotes of Luzon. They had the same belief in *aniti,* or spirits, the same system of cutting off the heads of the dead and keeping them in baskets in their homes. Indeed when they fancied they saw ghosts in the woods or fishing on the reefs they declared that these were headless. They also had the great houses in which bachelors lived.

Indeed the Philippine area should be extended eastward to include the Marianne Islands, and in my opinion there should be four instead of three elements recognized in Malayo-Polynesian ethnology: (1) the Proto-Malayan, whence the true Polynesians came, bringing with them the 'ava plant (*Piper Methysticum), the taro* (*Caladium esculentum*) from which poi is made, and the paper mulberry, from which kapa, or tapa, is made; (2) the element having the culture of the Igorotes of the Philippines from which the aboriginal inhabitants of Guam came, not leaving their ancient home until after the introduction of rice and the betel pepper (*Piper betel*) from India; (3) the lowland tribes corresponding to the ancestors of the Tagalogs and Visayans and (4) the modern Filipinos. It is interesting to note the absence of any Indian or Mohammedan influence upon the culture of the Guam aborigines, which indicates the relative time of their departure from the cradle of their race.

In conclusion I wish to express my appreciation of all that Dr. Wissler has said. It is methods pursued by him that lead to ultimate success in solving ethnological problems.

ANTHROPOLOGY IN JAPAN, NEW ZEALAND, AUSTRALIA AND THE PHILIPPINES

NOTE:—The following information as to institutions and activities of anthropologists in Japan and New Zealand is abstracted from the Proceedings of the Pan-Pacific Scientific Congress held in Honolulu, August, 1920. The review of the status of anthropology in New Zealand was prepared by H. D. Skinner, Lecturer in Ethnology in the University of Otago; for Japan by N. Yamasaki, Professor of Geography in Tokyo Imperial University; for Australia by Frederick Wood-Jones, Professor of Anatomy in the University of Adelaide. The statement for the Philippines is compiled from the stenographic report of remarks by Elmer D. Merrill, Director, Bureau of Science, Manila.

NEW ZEALAND

In the field of Osteology a large number of measurements have been recorded in different scientific journals, but the only work on any considerable amount of material is that of the late Professor J. H. Scott, who gives measurements of eighty-three skulls, and of a much smaller number of body and limb bones. In the thirty years which have passed since Professor Scott's research, a large amount of osteological material has been collected, especially in the Anatomical Museum of the University of Otago, but no attempt has been made to work it up.

The only work on the bodily measurements of living subjects is that recently undertaken by Dr. Peter Buck, himself of Maori descent. This research promises to be of the very highest importance.

In Sociology the outstanding work is that of Mr. Elsdon Best, who, coming late into the field, has far surpassed all other workers in the volume and value of the material he has collected. There is still scope for intensive work among the tribes not touched by Mr. Best, especially those of the Taranaki and Whanganui district, and of the peninsula north of Auckland. Mr. H. Beattie has recently collected with unexpected success among the scattered remnant of Maori on South Island. Mr. S. Percy Smith, doyen of New Zealand anthropologists, has recorded an amount of traditional material unequaled by any other worker in the Pacific, but it is unlikely that any considerable amount of new traditional material will become available in the future.

In the field of linguistics, three generations of the Williams family are preeminent, and no great advance in amount at any rate, is likely to be made on the fourth edition of the Maori Dictionary, edited by Archdeacon Herbert Williams. There remains, however, much work to be done on Maori dialects, for which research a good deal of material is still available in the spoken language and in manuscript in libraries and private hands. The importance of work in this field is indicated by the fact that the phonetics of the Kai-tahu dialect differ from the phonetics of dictionary Maori more than do the phonetics of Easter Island. The collection of phonographic records of songs and speeches has been begun by Mr. J. McDonald of the Dominion Museum.

Though in the field of material culture, as elsewhere, material is rapidly disappearing, a great amount of profitable collecting may still be done by the right kind of worker. Almost any middle-aged Maori can give information never before recorded regarding fishing, fowling, and similar aspects of the life of his tribe. Considering the inherent attractiveness of this kind of material and the excellence of Maori craftsmanship and decorative art, it is remarkable that so little information about it has been collected. Outstanding researches are those of Mr. Best on the working of stone, of Dr. Buck on weaving, of Archdeacon Williams on the Maori house, and of Mr. Downes on eeling. Mr. Anderson's record of string games should also be noted.

Work in the past has been sporadic and of varying quality. The chief encouragement to research has been the existence of the Polynesian Society which, through its journal, edited for thirty years by Mr. Percy Smith, has guaranteed the rapid publication of original work. The same function has been performed, but to a lesser degree, by the New Zealand Institute, through its *Transactions*, and during the past three years by the *New Zealand Journal of Science and Technology*.

The institution by the University of New Zealand of a Certificate in Anthropology has been followed by the appointment of a lecturer in ethnology in the University of Otago, and it is hoped that the three remaining colleges affiliated with the University of New Zealand will also undertake the teaching of the subject. The University of Otago has supported field-workers for brief terms among the South Island Maori and at the Chatham Islands. The New Zealand Institute has also aided the former work.

Only one museum has thus far carried out anthropological work on any scale. Members of the staff of the Dominion Museum have in recent years made some of the most notable of all contributions to the study of Maori ethnology. Other museums have confined their activities to making ethnographic collections, but there is now a reasonable prospect of some of them taking up field-work of other kinds.

The New Zealand Institute makes grants to research workers.

From this brief survey it will be seen that sporadic work by individuals is slowly yielding to systematic work by three classes of institutions: the university colleges, the museums, and the New Zealand Institute. The intensification of work by all three is prevented solely by lack of funds.

Nothing has been said in this report about field-work in the New Zealand dependencies in the Pacific. Our obligations in this regard are obvious.

JAPAN

The Anthropological Institute and professorship of anthropology in the College of Science in the Imperial University of Tokyo were established in 1892. From that year until 1912, Dr. S. Tsuboi was professor of anthropology, but since that date the position has been vacant. However, there are two lecturers: R. Torii, S. Ishida. The rich collections of anthropological, ethnological, and archaeological specimens from all parts of Japan, China, Mongolia, Manchuria, the South Sea Islands, etc., are in charge of the curator, A. Matsumura. The reports of the principal explorations conducted have been published in the *Journal of the College of Science,* in English or French. Reports on Formosa, China, Mongolia, Manchuria, and the Kurile Islands have been published by R. Torii and on the Caroline Islands by A. Matsumura.

In the College of Literature, S. Harada is the lecturer in archaeology.

At the Imperial University of Kyoto there is no chair of anthropology, but B. Adachi, professor of anatomy, is a lecturer, and K. Hamada, is professor of archaeology. Prof. Hamada has published the following in English: Stone Age Relics of Ko, Ancient Caves in Higo, etc.

No professorship in anthropology is maintained at the Imperial University of Sendai, but the College of Science has a professor of anatomy, K. Hasebe. H. Matsumoto is lecturer in anthropology. The College has many good collections from northern Japan, while a great shell-heap on an island of the Matsushima group is reserved for study.

In the department of history of the Imperial Museum of Tokyo there are excellent collections, in charge of the department director, Prof. Y. Miyake; the curator and his assistants are: K. Takahashi, Wada, and Goto.

The Anthropological Society of Tokyo was established in 1886. Its present membership is 313. The Society meets monthly at the Anthropological Institute of the Imperial University, except during July and August. It has published since its organization thirty-five volumes, in 394 numbers, of the Journal of the Tokyo Anthropological Society. The presidency is vacant; there are twenty councilors, whose acting director is Prof. R. Koganai; the secretaries are R. Torri, S. Ishida, and A. Matsumura.

AUSTRALIA

Australia has no federal bureau nor any institution in any individual state that maintains a properly staffed and equipped department for the conduct of anthropological work.

The establishment of a chair of anthropology in one of the large universities having teachers and research facilities is a greatly needed desideratum. The present writer feels very strongly that plenty of competent young men would be ready to take up the work were a chair of anthropology established in one or more Australian universities. It is hoped that the deliberations of the Congress will serve as a stimulus to the Australian delegates and enable them to influence public and official opinion in Australia and so lead to the establishment of a chair of anthropology in one of the universities of Australia.

In the museums of Perth, Adelaide, Melbourne, and Sydney there is a large amount of anthropological material, both physical and cultural, which should be worked over along modern scientific lines. More especially is this want felt in regard to the examination of the skeletal remains of the peoples of Australia and the surrounding Pacific regions.

The museums mentioned above are not directly attached to the universities and it is much to be desired, pending establishment of a chair in anthropology, that coördination of effort be brought about by the appointment of university teachers interested in anthropology as honorary curators of anthropology in the museum. A large amount of anthropological material is in the hands of private collectors in Australia; this private appropriation, especially of large series of crania, should be emphatically discouraged.

THE PHILIPPINE ISLANDS

The Philippines include three racial types. Negrito, Indonesia and Malay, and more than forty languages are represented. Government support for anthropological work in the islands was at first given to the Bureau of Non-Christian Tribes and later to the Division of Ethnology of the Bureau of Science. Recently official support was withdrawn by the legislature which questioned the propriety of publishing photographs illustrating primitive customs. Valuable research is now being carried on privately by Professor H. Otley Beyer, Associate Professor of Anthropology, University of the Philippines, who has prepared a comprehensive "Outline of a Proposed Ethnographic Survey of the Philippine Islands." [This outline read by Mr. Merrill in the form of an official communication is not available for publication.]

RECOMMENDATIONS FOR ANTHROPOLOGICAL RESEARCH IN POLYNESIA

PREPARED UNDER THE DIRECTION OF THE SECTION OF ANTHROPOLOGY, FIRST PAN-PACIFIC SCIENTIFIC CONFERENCE

NOTE: The Section for Anthropology of the First Pan-Pacific Scientific Conference found it impossible to complete the formulation of a research program before the date of adjournment. Accordingly, it voted to request the National Research Council of the United States to undertake the final formulation of its report. The Research Council accepted this obligation, referring it to the Division of Anthropology and Psychology by which the undertaking was brought to a conclusion.

In the preparation of this report the following contributors and members of the Council have taken part:

Roland B. Dixon, Harvard University; Gerard Fowke, Bureau of American Ethnology, Washington; A. E. Jenks, University of Minnesota; A. L. Kroeber, University of California; R. H. Lowie, American Museum of Natural History; W. H. R. Rivers, St. Johns College, Cambridge, England; L. R. Sullivan, American Museum of Natural History and Bishop Museum; L. M. Terman, Leland Stanford University; J. Allan Thomson, Dominion Museum, New Zealand; Thomas G. Thrum, Bishop Museum, Honolulu; A. M. Tozzer, Harvard University; Frederick Wood-Jones, University of Adelaide; N. Yamasaki, Tokyo Imperial University.

INTRODUCTION

Anthropological research in the area of the Pacific is still in the formative stage, having just passed through the necessary period of preliminary exploration and superficial surveys. The area is a large one, which for practical reasons we may consider under the following heads:

I. Insular Areas
   1. Polynesia
   2. Micronesia
   3. Melanesia

II. Continental Areas
   1. The Philippines and the Malay Islands
   2. New Guinea
   3. Australia

Research in all of those areas is of great importance, but we consider the Polynesian problem as the immediate primary undertaking, since Polynesia comprises the heart of the Pacific, and particularly because this area is now about to become the field of operation by the Bernice Pauahi

Bishop Museum in Hawaii. While this institution has projected immediate field-work upon an extensive scale the problem is, nevertheless, a complicated one, whose ultimate solution must depend upon collateral work in all parts of the Pacific. For this reason, some kind of cooperative research is absolutely necessary and it seems in keeping with the spirit of this conference that all institutions and individuals working in this area, should, as far as possible, cooperate to the extent that all results of field-work may be of the greatest service. It is with a view to facilitate such cooperation that this outline of scope and methods, which in our judgment best apply to Polynesia, has been formulated.

I. STATUS OF ANTHROPOLOGY IN POLYNESIA

Anthropological study of the quality and character which has been exemplified with such gratifying results in other parts of the world during the last two generations, has for Polynesia hardly yet begun. The greater part of the data at present available has been gathered by untrained observers and in an unsystematic manner. For some portions of the area, relatively abundant material of this sort exists; for others, there is little or nothing. The following brief survey of the status of our knowledge may serve to show the character of information needed to enable us to work out the problems which the area presents.

Physical Anthropology

Cranial and skeletal data. Only for Hawaii, New Zealand, and Easter Island is any reasonably adequate material available. For the first two, much more extensive regional collections are much needed, however. For the Marquesas, Paumotu, Society, Cook, and Austral groups, the existing data are meager and need to be largely increased, with special attention to securing well authenticated material from the various separate islands in each group. For Samoa, Tonga and the scattered and isolated islands, there is practically no material at all.

Measurements of the living. Except for a small number of scattered observations, no data at all are available.

Material Culture

The fullest data are from Hawaii, New Zealand, Chatham Island, and Samoa. Little or nothing in the way of systematic investigation has been made elsewhere.

Social Organization

Little investigation of the modern sort has been made as yet anywhere. For Samoa, Tonga, Society, and Hawaii, we have considerable more or less undigested material in the older literature, but many important sides of the question are as yet untouched.

Religion

The fullest material available is from New Zealand and Hawaii, from both of which much ceremonial and mythological data have been collected. For Samoa, Tonga, and Society we have some material on the ceremonial side, but it greatly needs amplification. For the Marquesas, Paumotu, Cook and Austral groups the existing data are very meager.

Linguistics

Lexical, grammatical, and biblical text materials are in print from practically all the Polynesian dialects and languages. What is most needed at present is a more adequate knowledge of the etails of phonetics, and a collection of native texts of mythological or her nature, to supplement the missionary material already available.

II. PROBLEMS TO BE EMPHASIZED IN THE POLYNESIAN AREA

The following statements and recommendations should not be taken as an attempt to present a complete, well balanced outline, applicable equally to all parts of Polynesia, but as a sketch of the problems which from the present state of our knowledge should be stressed. Recognizing that the collection of full data from even a single group of people, is a task of huge proportions and that there are subjects and occasions where those with little experience may have opportunities for observation denied the professional investigator, we have included some of the less obvious cautions. Naturally, each investigator must carefully analyze the local conditions about him and adjust his program accordingly. Further, since the field of anthropological research is so vast and complex, that one must perforce specialize in some small part of it, each investigator must depend upon others for specific suggestions as to what is important from their points of view.

1. ETHNOLOGICAL RESEARCH

At the outset we recognize that for practical reasons the investigations under this head must be pursued by the group (or tribal) method rather than by the topical. In the usual course of events, the field-worker first acquires some knowledge of the language of the group he visits and then systematically collects data on all the obvious phases of culture manifest therein. According to his inclination, he may specialize more or less upon the different phases of culture. The time required to cover the whole subject of culture even in this unsymmetrical way is quite considerable and in most cases prohibitive, so that what usually happens is that the field-worker concentrates upon one or more of the large divisions of culture. Linguistics and music, because of their highly technical nature, are most frequently left for a single investigator, but not infrequently the line of further specialization falls between material culture and the less material traits. Further specialization is possible, but in our opinion not compatible with the best results. Taking in consideration the distances to be traveled, the inaccessibility of many islands, etc., we recommend that expeditions be so planned that two men can handle the whole of archaeology and ethnology, exclusive of linguistics.

A. MATERIAL CULTURE AND ART

In material culture, especially, the most approved method is to deal with what are called complexes. For example, the investigation of fishing is the study of a complex, including the mechanical technique of the art, practical knowledge, social position of the fisherman, the beliefs controlling fishing, and the ritual and religious sanctions upon which the natives believe the whole to be grounded. The ideal of the investigator should be to follow out completely all the most important complexes functioning in the group he investigates. Naturally some complexes are of more importance than others; thus, in the study of a Polynesian group, the following should be stressed:

Fishing and marine foraging
Agriculture and domestication
Canoe building
Tapa, textiles, and feather-work
Work in wood and gourd
House, temple and other building.

It goes without saying that in the end nothing should be overlooked, but since it is rarely possible to carry a unit of field-work to such a conclusion, one should make sure of covering fully the groups of complexes just enumerated.

Further, it is well to bear in mind that we have in some parts of Polynesia, at least, a high development of the artisan cult with definite religious sanctions; hence, this should be made a special topic of inquiry.

Attention should be given to such specific traits of culture as have distributions in other parts of the world. Thus, the use of stilts was once reported by K. von den Steinen for the Marquesas. In all probability they have now disappeared everywhere in the islands, but it would be well to inquire in different localities whether, how, and for what purpose they were formerly employed, especially whether in pantomimes or dramatic performances, as in some contiguous parts of the Old World. In the same way evidences of the kite and all its forms and uses should be carefully sought.

While, as stated under the head of language, the worker in culture is not to be expected to collect language data, it is important that he acquire some familiarity with the speech of his informants and exercise care in recording the native names for all important phases of the several complexes.

One caution, applying to all sections of this report, should be noted. No topic enumerated here should be taken up in the abstract and the investigation guided solely by the associated concepts. Thus, the topic *fishing* does not mean that fishing, as such, is the object for investigation, but that the problem is to find out how specific fish are caught, how a given fisherman prepared for fishing, etc. The formulation of abstractions may be left to the future; they have no real place in field-work where concrete fishing processes should be the subject of investigation.

In most parts of the world, data on material cultures have an intimate relation to those resulting from archaeological inquiry. The relative dearth of stone objects in Polynesia tends to weaken the association, but there is partial compensation in the homogeneity of the historic and prehistoric cultures of the area. When a people have become extinct or greatly modified in culture, data concerning them tend to become materially objective, so that the remains of material cultures and art often form the sole basis for the reconstruction of the past. Hence, in Polynesia it seems inadvisable to separate those subjects (material culture, art, and archaeology) in field-work.

Navigation. Special attention should be given to this topic, that is, to the gathering of data bearing upon the technique of navigation. One of the crucial problems in the spread of the Polynesian is his mode of navigation. Very little good data have been collected and no doubt much has been lost, but its importance demands the greatest diligence on the part of the field-collector. Astronomical, geographical, and meteorological lore should receive the closest attention in this connection. The mystery that now hangs over the voyages of the Polynesians is merely one of ignorance; that they did reach the distant islands we know; hence, it follows that they had a technique of navigation commensurate with the result. The problem now before us is to secure as much of this technique as is still known to the Polynesians now living.

Museum Collections. The day of profitable collecting among the Polynesians has passed, but every field-worker should comb over his territory to make sure that nothing remains. No doubt many homely utensils and ornaments survive particularly in the out-of-the-way places. Also many rare things may be found in private collections where they may be studied to advantage.

The collection of models and restorations is advisable. A native model may be crudely made, but it has value to the field-worker gathering data upon the complex in which it is found. Every possible means should be taken to objectify the data upon culture traits.

Use of Photographs. The field-worker should study the collections in our museums from the group he is to visit. He should be equipped with photographs and drawings of all typical objects—prints from line drawings are usually better, as the natives can interpret them much more readily. As far as possible, the objects represented should be identified by informants and the existing data as to their functions recorded. Such a collection of drawings will be of great service in holding the interest of informants.

Most of our museum collections are without data of any kind, so that the use of this method may greatly enrich our knowledge and make these collections of much greater value.

Art. Collections in museums have made us familiar with the chief characteristics of Polynesian art. It is to these collections we must now go, because little of a satisfactory character remains in the hands of the natives. As these collections are in safe keeping, their study may be left for the next generation; but some aspects of the subject should receive immediate attention. Photographs and drawings of tapa, tattooing, and carved patterns should be taken to the field and information concerning them sought from the old people.

A subject worth recording is the adjustment now being made to our own decorative art. Data and collections showing the mechanisms of this adaptation will be of value in the future.

Ethno-zoology. In Polynesia the origins for the varieties of domestic animals and plants are of unusual importance, since the history of these varieties will be, in the main, the history of the human fauna. These biological problems are, however, intricately bound up with those of the domestic fauna and flora of the world as a whole. Thus the investigation of the pig, chicken, and dog in Polynesia will require the thorough study of the history of domestication for these animals in the world at large. Each of these topics is sufficient to occupy the spare time of an investigator for many years, but in our opinion they are best handled as side lines for enthusiasts. In the meantime, however, some special collections of material and data from the several islands are desirable. Such material will be of great value to future investigators and should be given some attention by all field-workers.

Since ethno-botany has received special treatment by the Botanical Section of this congress, the reader is referred to that portion of the report. However, we wish to stress the importance of these investigations and to urge that close attention be given to the domestic species usually neglected by botanists.

Exact data regarding the distribution and importance of the cultivated plants introduced from America are required for all islands. The data available are exceedingly vague and meager and leave important points unanswered. It is not sufficient to note, e.g., that maize is cultivated in a certain region; we want to know what variety or varieties (all the different corncobs from each locality should be collected), whether merely as a garden plant or in fields, whether alone or together with other crops (e.g., beans), process of the cultivation, what importance attaches to it in the native household, how the corn is utilized, how it is ground, prepared, cooked, etc., what the people think about its usefulness, traditions regarding introduction, etc. Careful inquiries should be made as to tobacco, method of preparation and consumption (cigar, pipe, chewing, snuff). Indigenous species of Nicotiana are reported from Australia (*N. suaveolens*), New Guinea (species unknown), and Norfolk Islands (*N. fragrans*); some suppose, although on insufficient evidence, that tobacco was anciently used in those regions before European contact. If so, was there any prehistoric trade in tobacco in the South Sea? Possibly one or other of the species named or other species of Nicotiana may be discovered in Polynesia. At any rate, it may be worth while to search or inquire. Careful observations should be made concerning manioc, arrowroot, the various species of Phaseolus, Capsicum, gourds, potato, sweet potato, peanut, pineapple, guava, papaya, tomato, sunflower, etc.

Of plants native or supposed to be native, special attention should be devoted to coconut, banana, *Broussonetia papyrifera, Coix lacryma* (Job's tears), and all species of Dioscorea. Uninhabited localities where coconuts grow should be carefully mapped. The numerous varieties of banana should be noted.

The distribution of domestic swine and the whole economy connected with it appear to be one of the fundamental problems in Polynesia. Note whether white and so-called masked pigs occur, observe and describe the different breeds and crossings, collect skulls of wild, domestic and half-wild ones (which have escaped from domestication to live for themselves in the wilderness).

B. MYTHOLOGY AND RELIGION

Mythology. The mythology of Polynesia has for many years attracted the interest of scholars, yet except for New Zealand and Hawaii, no extensive collection of material has been made. Although from these two groups and especially from the former, a large body of data is in existence, there has been even in these cases, little attempt to make the collection really systematic. For other parts of Polynesia the material is in general very meager, and every endeavor should be made to gather what survives before it is too late.

Local variants within island groups and even within single islands should be carefully sought for. The importance of such variants has long been recognized, but their value in the Polynesian area is probably more than ordinarily great. The cosmological side of Polynesian mythology has always attracted the most attention, but much additional material of this kind will be needed to make it possible to make clear the development of the peculiar system and trace its origins. Another point to receive consideration is the distinction frequently made between the mythology current among the aristocracy in contrast to that of the common people.

When so much material needs to be gathered, it is rather invidious to mention particular groups as requiring special attention, but it would seem that the Marquesas and Paumotu, the Austral group, and the Ellice and other small islands in the western portion of Polynesia might be singled out as being at present least known.

Religion. In the pursuit of this topic the less experienced worker cannot too often be reminded that he is to study religion as a concrete function and not as an abstraction. Thus, in Polynesia the burial complex is important under this head, but it should be dealt with as a reality and described with great fidelity of detail. Religion, apart from culture activities, tends to become the subject matter of philosophy rather than of science; hence, inquiry into religion will center in the study of specific complexes in which superhuma sanction and ritualistic control are plainly present. In such interpretation the precise definition of religion is unimportant, since con-concrete activities are the objects of observation.

Some of the other complexes for which the fullest possible data should be sought, are:

a. Shamanistic practices. All kinds of magic should be recorded, not overlooking the more widely diffused folk magic.
b. Doctors. Concrete facts bearing upon the relations of this function to that of shamanism should be sought as well as upon the technique of medical practice. In both this and the preceding careful inquiry should be made as to the ideals, training, social distinction, etc., pertaining to these professions.
c. Priesthood. In at least some parts of Polynesia, a highly organized priesthood has been observed, with temple observances. This should be made a subject of exhaustive inquiry. Particular attention should be given to the relative importance and functions of official or public priests, family-head priests, heralds or assistants, women associates, seers, shamans, etc., in the group. Ritualism is another important phase of the priestly function and one concerning which new data are needed. Rituals may be almost too simple to attract attention but may also be elaborate. The types should be sought and examples of each recorded as fully as possible. Attention should also be given to the use of genealogies as religious formulae. Finally, the priestly practices concerning sacred groves, caves, seats, etc., should be studied.
d. The investigation of special cults. Fertilization cults; agricultural rites, ancestral cults, animal cults. Seasonal factor in ceremonials.
e. The taboo. This is one of the most important aspects of Polynesian culture and one whose general characteristics are known; but the available data often do not form a clear picture of the working of the taboo and the involved psychological attributes remain ambiguous. For this reason careful investigation of the specific taboo systems for the islands visited promises to be valuable.
f. Cannibalism, head hunting, war dances, etc.
g. Ideals of souls, spirits, death, and cosmology. Systems of heavenly strata should be enquired for, likewise a hades. Distinctions between the souls of men and other objects may appear and prove of comparative value, also beliefs on transformation, incarnation, etc. Concrete data under this head will for the most part be limited to statements of individuals as to their opinions and beliefs.

The opinion is often freely expressed that all the correct knowledge of these subjects has vanished from Polynesia. Experience in other fields has shown that when language survives a surprising amount of data can be secured. We can state, therefore, with reasonable certainty, that even in Hawaii and New Zealand, a competent investigator will find no dearth of important data. On the other hand, each year is diminishing the available data and rendering the collection of what remains more difficult and more expensive.

The preparation of manuscripts by native Polynesians should be encouraged in every possible way. An effort should be made to collect frank and full autobiographies of old men and women. The skilful use of this method has brought such important results in other fields that it is now being recognized as one of the most productive procedures. The value of these narratives, lies not in the personal adventures of the narrators, but in the circumstantial settings to these adventures in which are to be found vivid portraits of everyday social routine. For example, a good story of a fishing excursion or a courting adventure may be highly exaggerated as to plot, but will, in its setting, give the plain, essential details of native life.

C. SOCIAL ORGANIZATION

The investigation of social organization presents certain inherent difficulties and thus warrants a more detailed statement than has been accorded other topics in this series. The following outline will also make possible concrete observations by such casual visitors and residents in the islands as may have sociological interests.

Castes and Government. The most salient phenomenon in the social life of the Polynesians is the organization of society into rigid castes founded on the theory that the chiefs and aristocracy are descended from the gods. Pride in pedigrees is so universal among mankind that there is a strong likelihood that the sentiments associated with this aristocratic system are still in full rigor in parts of Oceania. Hence, a resolute effort should be made to collect as much relevant information as possible. A pitfall to be avoided is giving attention exclusively to the nobility: ethnologically the attitude maintained by the lower ranks toward their superiors is quite as interesting as the reverse and special attempts should be made to ascertain the precise facts in the case. Was the prevalent frame of mind one of cringing servility, or of rebellion, or of an overwhelming desire to extricate oneself from the pariah's status wherever that was feasible? The answers will doubtless vary in different localities, but everywhere this somewhat elusive problem should be attacked by interviews with as many native informants as possible. Among the questions to be asked should be included queries as to the precise status of such honored professional men as tatooers, sorcerers, canoe builders, house builders. Did their occupation bestow a definite rank? If so, how were they graded?

The matter of government, while intimately related with that of the caste system, must not be confounded with it. The example of Samoa shows that a very high social regard for the chiefs may go hand in hand with the chief's practical impotence when opposed by his council of landed gentlemen. The theory has been advanced that such a condition was secondary to an earlier stage in which the divine chief wielded practically despotic powers. Any concrete data suggesting that the historical development in a particular group is corroborative of this scheme, would be highly welcome.

Sexual Division of Labor. In every case the investigator should determine the precise division of labor between the sexes. Where the men are found as cooks, does this mean that they cook for the women or merely for themselves? Are women permitted to practise medicine or sorcery? What relative part did the men and women take in the cultivation of the soil? This question is one of great theoretical importance.

Segregation of Bachelors and Sexes. It is important to note whether the unmarried of either sex were segregated either in their sleeping-place or in their social life generally or both. This segregation may be limited to a separate allotment of space in the common dwelling, such as has been reported from Tahiti; or it may involve occupation of a separate bachelors' dormitory. In the latter case the other functions of this structure should be investigated. Did it serve as a lounging place for the married as well as single men during the daytime? Was it a guest house for strangers? What, if any, religious associations existed? Were women rigidly excluded at all times, or on special occasions? In general, inquiries should be made as to the social intercourse of the sexes. Did men and women, e.g., eat together and dance together or separately? Were there any buildings beside the possible bachelors' hall, or men's clubhouse, from which women were barred?

Position of Women. This topic is partly merged in the two preceding ones. In addition all taboos affecting the female sex must be ascertained. Were women, e. g., not permitted to use canoes, as reported by Melville for the Marquesans? Were certain kinds of food tabooed to them? Did women participate in the tribal council? Could they inherit the chieftaincy and exercise property rights? Were they as free as men to take the initiative in divorce? Did they occupy a special hut or compartment during menstruation and confinement?

Sexual Life and Marriage. An important point to remember is again that the usage of lower and higher castes may have varied and that the customs of the commoners are scientifically quite as important as those in vogue among the blue-bloods. Hence a variety of informants should be used, including if possible several representatives of each social class.

To what extent was there looseness before matrimony? Was it limited to the lower caste? Did the young men have access to the spinsters' dormitory? Were there men who dressed and acted as women, as has been reported from Tahiti? Were these invested with a sacred character as in the Malay Archipelago and sometimes among the North American Indians?

Were there childhood betrothals? Were women permitted to propose? Whose consent was necessary to a union? Was there a real or pretended capture of the bride? Were gifts to the parents obligatory? Was there a dowry? Was a religious ceremony desirable or requisite?

Was there any preferential mating between individuals of fixed relationship? Did a man regularly prefer marrying a cousin? If so, define the exact relationship (e. g., mother's brother's daughter). Was the levirate in vogue, i. e., did a man inherit a brother's widow? If so, was he limited to an elder brother's widow? Was the sororate practised, i. e., did a man frequently marry his deceased wife's sister or might he be married to two or more sisters simultaneously? Did a man acquire marital rights over his wife's brother's daughter?

To what extent was there polygamy? Was it limited to the aristocracy? Was the first wife necessarily the principal one? Was there polyandry such as has been reported from Nukuhiva? Was there a limited group of men and women within which all males exercised marital rights over all females? For example, did this hold for a group composed of a man and his brothers on the one hand and a woman and her sisters on the other? Or did comrades share or exchange wives? Did the chief exercise marital rights over the women of his subjects?

What was the cause for divorce? Which parent was followed by the children? What was the punishment for adultery?

Rule of Descent. Though sibs (clans of British anthropologists) are generally lacking in Polynesia, they occur in Easter Island and their presence should be inquired into in the investigation of the less known groups. Although even in Easter Island they are not exogamous, the investigator should be on the lookout for evidence suggesting former exogamy.

Apart from a sib system, a definite rule of descent may hold as to the decent of property (for which, see below) and of rank. Is rank primarily inherited through the father or the mother?

Children. Was infanticide practised? If so, was it limited to females? Was it practiced only or mainly by special classes of society, such as the nobility or a secret organization?

At what period did the child receive a name, and on what principle? How was its education conducted? Were there special schools, ecclesiastic or secular, as in New Zealand? How was instruction given in the different arts of tattooing, canoe building, and house building?

What customs were observed at or about puberty in the case of both sexes? Was tattooing or circumcision regarded as a necessary preliminary to marriage?

Property. Two topics should be investigated with special care,—the kinds of property and the rules for their transmission. More particularly, were there forms of incorporeal property, e. g., were certain privileges such as that of reciting a poem or chant more or less copyrighted? It is not at all necessary that the same rules of inheritance should hold for all kinds of property; hence, special queries should be made for each kind. To what extent property was held by individuals, by the community—or by minor groups, is an important problem.

As regards land, the same area may be held by different people for distinct purposes, as in New Zealand; one man may have the right to its vegetable produce, another the prerogative of hunting on it, etc. The best way to examine the subject is to proceed as concretely as possible: to take definite plots of land and to study their individual history with all the rights connected with it and their precise mode of transmission. This will involve a close study of the subject of kinship.

Kinship. By obtaining in each community studied a series of genealogies the field-worker should ascertain as accurately as possible the use of the existing kinship terminology. Where complete genealogies are not available, pedigrees of limited scope may prove useful and are always preferable to direct questioning. That is to say, except, perhaps, for the very simplest terms such as father and mother, the field-worker should avoid asking how such and such an English term is rendered in Polynesian. Taking for his basis the pedigrees previously recorded, he should ask: "How do you address John?" The genealogy will show that John is the informant's father's brother, and the answer can then be checked by asking other informants to designate corresponding kinsmen.

In connection with the kinship terms must be investigated the kinship usages, i.e., the special forms of social intercourse laid down for certain relatives by blood or connections by marriage. For example is a man's future spouse selected by his father's sister? Is a girl's mother's brother entitled to a share of the bride-price? Is a man entitled to claim part or all of his maternal uncle's legacy? May he marry his maternal uncle's widow? May he play tricks on his maternal uncle? May the children of a man jest freely—and even obscenely—with the children of his sister, and vice versa?

On the other hand, are there taboos regulating conduct, e.g., is a man forbidden to hold conversation with his mother-in-law or utter her name? Is an adult brother forbidden to chat with his adult sister? Is a man forbidden to speak with his daughter-in-law?

Attention should be paid to the correlation of certain of these usages with certain others. For example, may a person jest with those individuals of opposite sex whom he may marry? Must he refrain from speaking to those he may not marry?

D. LANGUAGE

Four facts stand out in regard to Polynesian philology:

(1) The speech of the entire region consists of a group of essentially similar and closely related dialects.

(2) There exist printed grammars, dictionaries, vocabularies, or texts for nearly every part of Polynesia.

(3) Scarcely without exception natives, or many of them, are able to write their dialects correctly, besides sometimes furnishing translations into European languages.

(4) The Polynesian dialects are only part of a much larger family, the Malayo-Polynesian or Australasian, which includes all the languages of the Pacific (excepting those of New Guinea) and perhaps extends into the mainland of Asia.

From these considerations it follows that Polynesian philology has passed through the explanatory or descriptive phase, at least in the main. What is needed is coordinating synthetic work. This means a reconstruction of the genuine or original Polynesian tongue; the determination of its place in the larger Malayo-Melanesian-Polynesian family; the nature of the changes which the various branches of this ancient family have undergone in the course of a thousand years; the causes of these changes; and the continental families with which this Oceanic cluster of languages was connected in the dim past. These are problems which can positively be solved if they are attacked deliberately. But they can be solved only by a philologist acquainted with philological methods and endowed with capacity to use these methods in more than a mere routine manner. The right man, assured of the opportunity to devote himself uninterruptedly to the task from five to ten years, could solve the above problems in great part. Though he might not be able to answer all questions, he would, at any rate develop them to a point from which other competent students could carry on the research where he left off, and leave Oceanic philology as an organized, usable body of knowledge, where now it is but a mass of data. The method being a historic one, it can be predicted without hesitation that the findings would much transcend the linguistic field and would be hailed by students of race and culture origin as indispensable contributions to their problem.

More than one man would not be necessary, in fact not desirable; but this man must be thoroughly competent. Opportunity for field investigations should be provided when needed, but would be only a secondary consideration. It probably would develop now and then that some group—say the Paumotus—was insufficiently represented in the available data. In such case it should be possible to arrange for the prompt collection on the spot of the data needed to fill such a gap in comparative knowledge. This could often be done by engaging natives to write out what was wanted. But a linguistic survey of the entire Polynesian area *de novo,* when there already exists a wealth of data scientifically undigested, would be an unwise expenditure of time and money. This available literature, so far as it is worth while or necessary, should be mastered and made the basis for a synthetic study of the whole group and beyond. Of course the linguist may and is likely to want to make a fairly rapid field reconnaissance himself, so as to get a sound phonetic basis and find himself in a position to interpret the published data rightly. Experience in such matters has shown that an overhauling at first hand of work done by others is apt to be unexpectedly profitable. There is, after all, no substitute for direct impressions in linguistics. It is like art. In both fields one may talk a deal around the subject and, failing direct contact with the source, go far afield. However, such rapid field reconnaissance would not entail very intensive work at many points. It would give point of view, perspective, and vantage point from which to evaluate what is already more or less adequately recorded.

Again, it should be noted that the linguistic problem of Polynesia is an integral part of the larger question of Malayo-Polynesian and the still larger Australasian group. It is greatly to be desired that the investigators have that complete grasp of linguistics essential to a perspective treatment of the languages in and about the Pacific.

Inasmuch as the work should be in the hands of a philological specialist, there would be nothing gained by setting the members of ethnological exploring parties, who would ordinarily be without specific philological training, to the task of compiling grammars and vocabularies. Their work and linguistic research should be divorced as far as possible. It is true that an ethnological explorer needs a working knowledge—a *speaking* knowledge—of the dialect of his area if he is to do his ethnology in the best possible way; but it should be clearly understood that what is a temporary *tool* to him is an *end* to the philologist and that the latter cannot depend on the by-products of ethnological investigations. Only by separating the two sciences of ethnology and philology can each be specialized to the degree of exactness necessary to new valid conclusions.

E. MUSIC

Collections of songs, chants, etc., can usually be made with little expenditure of time or money. The chief expense is the slight cost of phonograph cylinders. The securing of several hundred records from each group would assemble a notable and unique collection of Polynesian native music in a few years, at a total cost of probably not exceeding one thousand dollars. This would make possible at any future time an exhaustive comparative and analytic description of Polynesian music by a trained specialist.

The technique of phonograph recording is simple and readily acquired after a few trial records are made. A few hints follow:

(1) Part or choral singing should not be wholly neglected in favor of individual voice; although more difficult, fairly adequate records of several simultaneous singers can be obtained.

(2) Rhythmic accompaniments are often an integral part of songs. They are usually impossible to record with full intensity, but cover a point that is invaluable to the student of music.

(3) A fair proportion of the cylinders should be devoted to repetition of songs by (a) the original singer at another time, and (b) other singers. Primitive music, being noteless, is more fluid than ours, and for an accurate study the variations are as important as the basic themes. A hundred records bearing a hundred different songs are less valuable than fifty songs obtained once each, plus ten obtained twice from the same singer, plus ten obtained twice from a different singer, plus one obtained from ten singers.

(4) Identification numbers should be cut at once into the edge of wax cylinders instead of being written on the box.

F. HISTORICAL RESEARCH

In order to appreciate the cultural and ethnological characters which were the original possession of the Polynesian peoples, it is necessary to define, with as much accuracy as is possible today, those contacts which have been made with Polynesia by each voyager. It is not only desirable that we should know the exact cultural phase of the peoples of Polynesia before the advent of the British navigators of the later portion of the eighteenth century; but it is essential that we should be in a position to appreciate their condition before any contact had been made with the earlier Spanish and Dutch navigators and with the Pacific whaling fleets. In order to obtain this very necessary knowledge, a great deal of historical investigation must be made. A well-qualified student of history, equipped with a working knowledge of Latin, Spanish, and Dutch, could work with advantage in any of the large centers of learning where good library and research facilities are available. But such research should be supplemented by the examination of archives in Spain, Mexico, and Manila. An exhaustive study of the existing records of early Pacific voyages is a great desideratum at the present time: its findings would yield results of importance to botany and zoology as well as anthropology in its widest sense. It should therefore be undertaken with the definite aim of meeting the requirements of these different branches of science. In order to make the knowledge gleaned from such a research available to the student it is suggested that all references be prepared in such a way as to make possible their incorporation in a card-index system.

Manuscript material in general could doubtless be enriched by collections of letters and papers from early missionaries and travelers. Possibly the files of the Linnaean Society and similar organizations contain papers of importance, but a field of special promise lies in the records of courts where native custom must have received consideration.

2. ANTHROPOMETRIC AND ANATOMICAL RESEARCH

The Polynesian problems under this head are of two sorts: local and general.

Local Problems. As an illustration of local problems we may use the Hawaiian islands, for with various modifications due to the size of the population and the number of racial types involved the same problems are found elsewhere in Polynesia.

(1) The first local problem is the accurate definition and description of the Hawaiian type or types. This involves the study of living natives and a representative collection of skeletal material systematically collected. Such a study should result in conclusions as to the racial affinities of the Hawaiians, point out their specializations or local characteristics and indicate their homogeneity or heterogeneity.

(2) A second local problem is the modern intermixture of racial types. For this problem the Hawaiian Islands are an ideal laboratory. Beside yielding general information on the laws of heredity, such studies should give answer to such practical questions as to what races produce the most homogeneous crosses and what effect such intermixture has on the human groups. Are the results desirable or undesirable mentally, morally, and physically? Are the half-bloods more or less fertile than the pure race?

(3) A third and very important local problem is the question of growth. The schools of Honolulu offer the opportunity of studying, side by side, large groups of Hawaiian, Japanese, Chinese, and Portuguese children, and various types of crosses all growing under the same environmental conditions and as nearly as possible of about the same social and economic status. The conditions for this experiment are as nearly ideal as we may hope to find anywhere. Such a study should include medical and dental investigations and promises to be of direct economic interest to the Territory.

(4) Closely related to the question of growth is one more purely environmental. In the Hawaiian Islands we have an opportunity for studying Japanese born in Hawaii and Japanese born in Japan, Chinese born in Hawaii and Chinese born in China. We have an excellent opportunity for testing the stability of these types under different environmental conditions.

The four problems outlined above are, in our opinion, the most important local researches demanding immediate attention in the Hawaiian Islands. Any one of them involves serious research on the part of one or two men for at least a year. With some modifications the same problems exist in other Polynesian Islands. For example, in Samoa and Tonga we encounter Melanesian intermixture in place of Chinese. Thus the same general recommendations will apply to all.

General Problems. Problems concerning the racial affinities of the Polynesians, their inter-relationships and the probable extent of their physical contact with other races in the course of their migrations, belong to a different category. The satisfactory solution of these questions, in a reasonable length of time and with a reasonable outlay of money would necessitate the investigation being undertaken by one man or at most two or three men working in the closest coöperation. We think it is fairly obvious that these men should be trained and interested primarily in physical anthropology. While in a short space of time it is possible to train an ethnologist or archaeologist to fill out set forms of anthropometric records, it *is* impossible in a week, month, or even a year to equip him to carry on intelligent research in physical anthropology. A blank covering all the essential points would be too cumbersome and staggering to yield desirable results. This statement should not be taken as questioning the ability of ethnologists or archaeologists to do scientific work, for we believe that physical anthropologists are equally unfitted to do ethnological or archaeological research. We make no specific recommendations as to technique because it is taken for granted that the men selected to carry on these specific researches will be properly equipped.

Further, the prosecution of the physical problem in Polynesia is of such nature that it is desirable to separate it entirely from other phases of anthropological research. The general plan of procedure should be to provide for a year's study in one of the larger and preferably outlying groups for purposes of orientation and foundation. After a fairly thorough study of one group on which to build, he could proceed rapidly with other selected islands and determine the modifications encountered. The logical starting point would be any one of the areas which we believe to be most distant from the point of dispersal and which presumably contain end types. Under this head come the Hawaiian Islands, the Marquesas, Paumotu, and New Zealand. From these marginal areas the studies should be continued in the Society Group, Samoa, Tonga, and Fiji. Our knowledge of the Polynesians will be incomplete until at least one Melanesian group, preferably the Fijian, has been studied. For a complete rounding up of the problem either the Marshall or Gilbert groups should be visited. If it should not be possible to carry out this program in full, the most profitable procedure would be to confine the study to one marginal group and proceed to the assumed points of dispersal, Tahiti, Samoa, Tonga, and, if necessary, Fiji. The scheme can be expanded or contracted to meet the requirements of time and expense.

Collection of Data. As the Polynesians are on the road to extinction and assimilation, the collection of photographs, plaster casts, skeletal materials, etc., is of the greatest importance. While such collection is best done by a specialist in physical anthropology, it may be profitably supplemented by field-workers in other lines. This is particularly true of plaster casts, which may be successfully taken after a brief period of training.

3. ARCHAEOLOGICAL RESEARCH

In the insular areas of the Pacific, the fundamental problems are the origins, migrations, and external contacts of the inhabitants. Our chief interest in this connection centers in Polynesia. Since the Polynesian race is still represented in the flesh and shows, through its traditions, continuity from the present to the time of its residence outside the Pacific, it is difficult to consider the problem from an archaeological standpoint alone. Kitchen middens and other features suggest earlier habitation in the Pacific, but as the case stands today there are no good grounds for presupposing the presence of a race prior to the Polynesians. It follows then that while archaeological work must necessarily be limited to the specially versed in the field technique of the subject, Polynesian archaeology requires a comprehensive knowledge of Polynesian culture. As stated under an earlier section of this report, we recommend that material culture and archaeology be placed in the hands of a single investigator. Further, since in a number of the Islands the most important remains are of structures for religious purposes, the archaeologist must at least work in close coöperation with the students of culture. We commend the present plan of the Bishop Museum, Honolulu, to send two men to each group, one to investigate material culture and archaeology, the other to give his attention to religion, mythology, social organization, etc., thus recognizing the complementary relation between ethnology and archaeology in Polynesia.

Since Polynesian archaeology is in most respects a virgin field, the first problem is to make island surveys. So far as our ethnological data go, the rule in Polynesia was for each island to be a political unit, governed by a chief or group of chiefs as the case might be. The exercise of absolute authority by these primitive monarchs enabled the undertaking of public works upon a relatively large scale and the development of insular individualities. Hence, both from cultural and geographic standpoints island unit surveys are to be recommended.

The order of proceedure on a particular island might be as follows: Location and plotting of village sites, and in relation to these, the water supply, cultivated fields, irrigation ditches, temple sites, fish ponds and weirs, all other evidences of native industries, and burial sites. As a rule Polynesian temple sites require careful plotting in detail to reveal possible differences in type.

Such a survey should not only reveal the content of the archaeology for the island examined but should give hints of time relations and local variations. Typical sites should then be chosen for careful study, with excavations where needed.

The investigator should bear in mind that the fundamental objective of this research is chronology, or relative time-relations. Having differentiated types of temple ruins, for example, he should then seek for evidences of difference in age. Superposition being the ultimate proof of time-sequence, careful search for such should be made. This applies particularly to shell-heap investigations where sections should be carefully taken, recording the depth and position of the various objects found. Since the fauna must also be worked out with great care, it is advisable to take up these sections in layers along arbitrary levels and all of the shells and bones worked over with great care. This will require ultimately the service of several specialists, but until typical deposits have been treated in this way no great confidence can be placed in the result.

To these general recommendations we add the following comments:

Structural Remains. The mecca of Polynesian archaeologists is Easter Island, which has been known to Europeans for two hundred years, but seldom visited. The problems here are the gigantic stone images, stone sculptures, and stone platforms. In the last decade, several expeditions have visited this spot, and the partial reports received indicate that the stone work pertains to the ancestors of the present people, generally recognized as Polynesians. Yet, until final reports are received, it would be well to postpone any recommendations in regard to Easter Island.

Remains of Polynesian villages, temple sites, forts, graves, fish ponds and weirs, and water courses are reported in the following islands still inhabited by Polynesians: The Hawaiian, Marquesas, Gambier, Society, Austral, Cook, Tonga, and New Zealand, to mention the principal groups—in general the high or volcanic islands, or those of greater size, where the country furnished the wherewithal to build. With the onrush of civilization, such remains as are not entirely destroyed are rapidly disappearing, and only prompt work can save for posterity the data which are sought.

In Hawaii, most of the temple sites have been located and described. In the Marquesas little has been done. In Tahiti and the neighboring groups we have descriptions and illustrations of the more important archaeological remains from the accounts of the early voyages and missionaries. In Tonga we have accounts by Mariner of certain features which give an understanding of the remains now found. In New Zealand, much work has been done but since intensive search frequently reveals what is not at first apparent, the New Zealand field invites further research. In connection with the temples or other forms of worship there were stone images not as large as those in Easter Island, which have been reported as remaining in the Marquesas and Austral Islands. The fullest inquiries should be made about these without delay.

There is a famous trilithon at Haamonga in the Tongan group, and while formerly supposed to have been prehistoric, it has latterly been shown, through traditions, to have been of Samoan origin. However, the like has not been found in Samoa, so that the matter remains to be settled by further investigation.

Shell-heaps and Middens. Kitchen middens have been referred to and are frequently associated with rock-shelters. Both have been found and worked in New Zealand. They belong to temperate climates, where food would be gathered in quantity and taken to a shelter for eating. In tropical sections, where the balance of the Polynesians are to be found, conditions were different. There was no urgent need for shelter, and much of the molluscan food was eaten where gathered. On this account, we should expect few kitchen middens in the tropics. In rare instances, caves and shelters have been used by Hawaiians for dwellings and workshops, and where found have furnished valuable material. They have only been revealed by detailed search; hence by the same method, they may be brought to light in the southern groups.

It is chiefly from such remains as these that we get the most definite data for the time sequences of culture. Owing to the fact that New Zealand seems to be the part of Polynesia where such remains abound, we must look to the archaeologists of that country for the last word upon the subject.

Burials. The Polvnesian system of sepulture varied, bodies being placed both in caves and underground. No systematic work has been done in the way of collecting skeletal material in the Pacific; but as this material (the most valuable for the determination of the Polynesian area) deteriorates with great rapidity in the countries of deposition, we would regard its collection as a matter of paramount importance.

Uninhabited Islands. There are many other islands regarded as having been inhabited by Polynesians which were found deserted at the time of their discovery by foreigners. We state they were inhabited by Polynesians, merely by inference, on account of their geographical relation to the inhabited islands. These islands contain much archaeological material, the real origin of which we do not know . Among them are Sala-y-gomez, Pitcairn, Oeno, Malden, Christmas, Fanning, Washington, and Necker Islands in Eastern Polynesia. In the west is the Kermadec group, and no doubt better acquaintance with the outlying islands would reveal others of similar interest. Archaeological research should be directed at once to certain of these islands which are now inhabited by workmen brought in for commercial purposes, before more damage is done by unscientific workers. These islands would be expected to furnish valuable evidence as wayports of the Polynesian migrants.

Preservation and Restoration. Archaeologists in this field should endeavor to create a public demand for the establishment of parks enclosing the most important remains. The Territorial Government of Hawaii has recently initiated such a policy and placed the examination and restoration of the remains under the direction of the Bishop Museum. We hope that the governments in control of the islands of the Pacific will take steps to preserve for scientific investigation all *large* structural remains within their respective provinces, and, in addition, one example of a village site in each island, if it can now be found. There is need for urgency in this recommendation, as has been shown in the Hawaiian Islands and as is further illustrated by the reported destruction of a very famous temple site in Tahiti. (This is the oblong stepped pyramid at Papara, illustrated and described by Cook and other voyagers and therefore made of world-wide interest.) Of equal importance is the need of governmental aid in securing skeletal material. We regard the New Zealand law restricting exportation of anthropological specimens as of benefit to science and hope to see its provisions extended throughout the island section covered in this report.

Archaeology in Other Areas. While this section of our report is limited to Polynesia, the recommendations we have made apply almost equally to Melanesia and Micronesia. The satisfactory interpretation of a chronology for Polynesia, for example, must await similar data for the adjacent islands. Micronesia promises to be of the greatest importance, for there we find conditions similar to those in Polynesia—monarchial governments powerful within their island spheres, and large structural remains. Two places may be mentioned in particular, the ruins of Metalinim at Ponape in the Caroline Islands and the stone avenues at Tinian of the Marianas, and there are others. These are prehistoric as far as the present Micronesian traditions are concerned and have partly developed on Ponape. They present no analogy to the work of Polynesians, though they have been suggested as the evidence of the routes of Polynesian migrations. There are also stone graves in this section reminiscent of those in Tonga, and they should be investigated for possible connections. The point is awaiting solution.

Fish ponds, or weirs, are present as in Polynesia. These structures extend throughout Polynesia, Micronesia, and Melanesia, the Philippines and the Malay Archipelago to the southeast, and southern portions of Asia. The exhaustive investigation of this culture trait is recommended.

4. PSYCHOLOGICAL RESEARCH

Research in race psychology is as difficult as it is important. There is scarcely a subject in regard to which dependable knowledge would be of such profound applicability in social, political, and economic relations. Yet actual scientific data of incontestable interpretations are scant; so scant in fact that the world at large scarcely realizes that the ignorance exists or that its dissipation would be of intensely practical value. One of the chief obstacles in the way of progress in understanding of the psychology of races has been the fact that any community or nationality is always the product of two sets of factors: (1) the inherent psychical endowment of the individuals composing the group; and (2) the culture or traditional accumulation of mental products characteristic of the group as a group. Psychological tests have been devised to ascertain with considerable accuracy the mental traits and capacity of separate individuals as compared with other individuals *within the same culture.* Used with individuals belonging to *different* cultures, the large majority of intelligence tests yield ambiguous results as it is extremely difficult to determine what in their findings should be referred to individual hereditary equipment and what to mass culture. Progress in this problem can therefore be achieved only through a technique which discriminates the individual psychologic and the group cultural elements in the living material investigated. This means, apparently that the beginnings must be made by a coöperation between experimental psychologists, who are experienced in dealing with the individual qua individual, and field-trained anthropologists, who through primary concern with social data as such have developed a "feel" and power of instinctive recognition of what is of cultural origin. The complete surmounting of the language barrier, important as this is, would be only a first step toward the accumulation of real data on comparative race psychology. Coöperation between the two sciences, in the form of jointly conducted investigations—not merely parallel or simultaneous but actually collaborative—thus seems called for.

As regards Polynesia, two openings present themselves for attack. The first would be an investigation, by a psychologist and ethnologist working hand in hand, of some of the least civilized and missionized native groups in the Pacific Islands. Except for the Torres Straits Expedition twenty years ago, when intelligence tests were still in their infancy, no serious attempt of this kind seems ever to have been made. The results of an expedition therefore promise to be rich if the work is entrusted to properly qualified men. It would be necessary that these men control not only their own techniques in most modern form, but that they possess an active understanding of the problem, versatility, and imagination.

A second line of attack would seem to be furnished by the present inhabitants of Hawaii, who are of notoriously diverse racial and cultural provenience but rapidly assimilating toward a uniform Caucasian mode of life. Their children especially must now be exposed to nearly uniform cultural influences, while six or eight racial types are represented in frequent racial purity—Polynesians, Mongolian, Chinese, Japanese, and Koreans, Malayan Filipinos, Caucasian Porto Ricans, and Portuguese, etc. Here, while conditions are "artificial" in the sense of being no longer national or aboriginal, the complications caused by the mingling of the indeterminates, culture and heredity, would be at a minimum, and less intricate checking would probably be required. Besides, abundant material could probably be made available through the school authorities.

In this discussion it has been assumed that the psychological research of greatest interest would be that relating to general intelligence. Certainly the present status of mental testing points to this line of attack as the most promising. In general, methods for the isolation and measurement of special abilities are still in a very backward state. It is probable, however, that something could be done in this field. In the schools of Hawaii, for example, measurements could be made which would gauge the relative sense with which native children master the different subjects of the school curriculum. In particular, mathematical and musical ability could perhaps be fairly accurately measured. In the case of mathematical ability comparisons would of course have to be limited rigidly to racial groups which had had equal opportunity and incentive for learning the subject. Music, on the other hand, offers a relatively simpler problem if, as Seashore's data seem to indicate, the elemental traits which underlie musical ability are practically non-improvable by training. Seashore's tests could probably be applied to the most primitive Polynesians, with only minor adaptations, and the results could not fail to be of great interest.

The measurement of racial differences in general intelligence is of course extremely difficult and will demand the most cautious and painstaking labor, but it would not seem to be impossible. The problem is primarily that of devising tests which would bring into play all the important intellectual processes but which would be relatively little influenced by differences of cultural status. In judging the validity of a mental test with reference to this point it is unnecessary to rely upon personal opinion, even of the most competent. Investigations have shown that within certain limits of error it is possible to determine the extent to which the results of a given intelligence test are subject to cultural influences. The method is to compare the results of a given test for two groups of individuals differing only in cultural status; one group primitive, the other considerably modified by alien culture. Tests which yield similar results for the two groups while at the same time bringing out the individual differences among the members of each group taken alone, must be regarded as valid.

Accordingly, the first step would be to make a selection of the existing tests which came nearest to meeting this criterion and to devise new ones which would seem to promise well in this regard. The second step would be to submit the entire collection of tests to trial in order to secure co-efficients of cultural influence. The least satisfactory tests could then be eliminated and the best retained and improved. These preliminary investigations for the purpose of preparing suitable psychological methods would require the full time for at least one year of a well-trained psychologist and an assistant aided by a committee of psychologists acting in an advisory capacity. While such preliminary investigation would entail a good deal of expense, it is absolutely necessary if worth-while work is to be done in the comparative study of racial intelligence. Attention is called to the fact that when satisfactory test methods have been perfected for the study of Polynesians they will probably be found to have wide applicability in the study of other races.

To indicate in detail the types of tests which would probably be found useful for the present purpose is outside the purpose of this statement. A few general principles, however, may be laid down.

In the first place, the methods should be prepared with a view to individual rather than group examining. While the method of individual examination would limit greatly the number of individuals for whom measurements could be secured, this would doubtless be more than compensated by the greater reliability of results. With proper attention to the errors of sampling, careful measurements of a few hundred individuals of each of the races to be compared would give a reasonably satisfactory basis for conclusions.

Secondly, the tests would have to be absolutely independent of the language factor. Psychological work in the army has demonstrated that this criterion can be met. It was met by several tests in the Beta scale and by a majority of the tests in the so-called "performance scale" which was used in the individual examination of illiterates and foreigners.

Independence of language, however, is not sufficient. It will also be necessary, in the third place, to avoid the use of tests making demands upon mental processes which the life experience of the individuals have not brought into play. This criterion is obviously harder to satisfy. It is not satisfied by a majority of the Beta tests, or in general by any test of the "pencil and paper" variety, even those which require merely the completion of pictures or forms, reproduction of drawings, and similar responses. A few of the ten tests in the individual "performance scale" are less objectionable in this respect, but it is probable that few if any existing tests can be taken over without greater or less modification of both content and proceedure. Caution will especially have to be exercised in the use of tests involving pictures, as pictorial representation is always highly conventionalized. The same holds for tests involving the use of mazes, geometrical forms, form boards, etc., though the problem here is not quite so serious. It would seem possible to devise performance tests of the following types which would be relatively free from the influence of training: a maze test, a memory span test, a substitution test, a form board test, a block design test,[1] and other tests of "combinative" ability (i. e., tests involving intellectual synthesis).

The most serious fault of most existing tests of the above types is that they do not make sufficient demands upon the higher mental processes, but this fault can doubtless be largely eliminated. The necessity of improving existing performance tests in this direction cannot be too strongly emphasized in the present connection, for all the available data indicate that the decisive intellectual differences between "superior" and "inferior" races, or between "bright" and "dull" individuals of the same race, concern chiefly the higher thought processes of abstraction, reasoning, and judgment; the synthetic abilities generally. It is these processes which have made civilization, as we know it, possible. While it may be desirable for the sake of completeness to include tests of motor coördination, reaction time, sensory acuity, perception, etc., we are not warranted in attaching anything like as much significance to differences on these lower levels as to those found on the higher levels. Indeed, large differences between races on these lower levels may be practically non-existent.

When suitable methods have been prepared they should be applied to three hundred or more "unselected" adult individuals of each of two or three primitive groups of Polynesians, and if possible to an equal number of each of several Hawaiian groups, including less primitive Polynesians, Chinese, Japanese, Malayan Filipinos, Portuguese, and Americans. Six or eight groups of three hundred individuals each would give a solid basis for comparison.

A year would probably be required for the preparation of methods, another year for administering the tests, and a third year for the working up of results. For the entire period a psychologist and from one to three assistants would be necessary.

In emphasizing the importance of research on racial differences in intelligence it is not implied that other lines of psychological research may not be desirable or feasible. The emphasis has been determined chiefly by the status of existing methods. Even if the main purpose of the research had to do with intelligence it could be expected that during the progress of the work systematic observations would be made on instinctive, emotional,

[1] On the order of one devised by S. C. Kohls of Stanford University, and described in a doctor's dissertation not yet published.

and volitional responses and attitudes. It might even be possible to arrange a worth-while test for certain non-intellectual traits, taking as a point of departure such tests as that of Woodworth (for detecting psychopathic traits) that of Pressey (for measuring emotional reactions), and that of Voelker (for measuring reliability). The use of such tests with natives would of course have to be confined to those who had had educational opportunities similar to those enjoyed by children in the average city of the United States.

Psychoanalysis. Suggestive parallels between the mental products of civilized psychopathic or neurotic individuals and primitive social groups have been repeatedly pointed out in recent years. These analogies are no doubt important but can as yet be interpreted only speculatively because almost nothing is known of the manifestations of individual psychopathology in uncivilized life, and not much more of the forms taken by the subconscious of the normal uncivilized individual. Data on these matters would therefore be unsually valuable, and Polynesia probably offers at least as good a field for research as any other area. If the work is undertaken by psychiatrists or psychologists, they should be thoroughly familiar with the milieu; and reciprocally as regards abnormal psychology if the research is entrusted to anthropologists. A joint coöperative investigation would best meet the requirements of the problem.

III. SYNTHETIC RESEARCH

Field-work in the Pacific Islands and elsewhere is largely concerned with the compilation of scientific data. The collection of such data for a single group of people is a task of such proportions that it will consume the greater part of a lifetime. Hence, the field-worker can be expected to do little more than faithfully report and systematize the data he has collected. It follows, then, that a comprehensive view of Polynesian culture and its relative position in the culture of man as a whole is a problem of much greater breadth than any of specific undertakings of the field-worker. We recommend, therefore, that as soon as practicable, provision be made for the support of two or more competent investigators able to give several consecutive years to the highest kind of synthetic research in this area. We recommend that at least three high-grade research fellowships be established, one for each of the following subjects: Polynesian linguistics, cultural history of the Polynesians, racial affinities of the Polynesians. In our opinion, the above order represents their relative urgency. It is a matter of common knowledge that linguistic research, when properly undertaken, throws more light upon the origins of cultures and peoples than any other single line of investigation. For specific recommendations on this subject, see the section on Language.

It is our opinion that the establishment of such research fellowships under the auspices of research institutions in and around the Pacific would lead to results of the highest importance.

HAWAIIAN FLORA AND FAUNA

SALIENT FEATURES OF HAWAIIAN BOTANY

By Charles N. Forbes

(Unrevised manuscript.[1])

Botanical research in Hawaii has been mainly confined to the collecting and naming of plants, and to general accounts of the flora, but no results of careful ecological work have yet been published. Since the publication of Hillebrand's comprehensive flora in 1888, several large collections of Hawaiian plants have been made and as a consequence the distribution of most of the endemic genera, and many of the species have been considerably extended. Many new species and a few genera have been added to the flora, partly on account of more modern views concerning species, but chiefly because collecting has been greatly facilitated by numerous trails made by water surveyors and others through sections which were inaccessible and unknown to Hillebrand and the early collectors. While a great amount of systematic work has been done in recent years, local workers are placed at a certain disadvantage in being so far away from the larger herbaria where the types of early described Hawaiian plants are kept, and which it is more or less necessary to consult before serious work can be undertaken in naming plants with which we are familiar through field experience. There are large collections of plants in the herbariums of the Bishop Museum and the College of Hawaii, but on account of local difficulties in collecting and the nature of the flora itself the collections can never be complete until every single ridge and gully of the whole island group has been visited in at least two different seasons. A large number of the most interesting plants have a discontinuous distribution, occurring as small clumps or even single individuals separated from each other by miles of forest which is often of the same character, some of these species even extending to more than one island. Recent monographs give a true indication of the revision necessary in systematic work with the flowering plants of Hawaii. Hawaiian ferns are perhaps the best known group, and it is

[1] The death of Mr. Forbes occurred August 10, 1920, during the session of the Conference.

doubtful if there are many unnamed species, but interesting problems of relationships will have to be worked out especially in the genus Asplenium in which the local species seem to form closely related groups, although many of the species also found outside of Hawaii come from widely separated localities. The lowly hepatics and mosses of Hawaii have proven to be of great interest to students of plant distribution, and while fairly well known systematically our knowledge of them is by no means complete. The algae are fairly well known; systematic work on the lichens is practically complete; but of the fungi we know almost nothing. The higher forms of fungi, for some unknown reason are extremely rare in Hawaii, although in Samoa and other islands of the Pacific where the conditions are apparently the same they are abundant. Our knowledge of the Mycetozoa is limited to six species none of which are limited to Hawaii, but others will undoubtedly be found when more local workers become interested in this group. Summarizing our knowledge of the systematic botany of Hawaii I would say that *all* the genera, *most* of the rarer species, and *all* of the common species are fairly well known and are represented by specimens in the local herbaria, but that our knowledge of the range of the species, and the limits of variation even of the commoner species is very incomplete, and will require further study and collecting.

The most important factors in the local distribution of Hawaiian plants are due to volcanic eruptions. All the surface of these islands with the exception of a narrow fringe of coral rocks near the shore is of volcanic origin. The topography both of the recent and heavily eroded mountains is different from that where most ecological work is being carried on at the present time. The igneous rocks and the resulting soils are different from those in most parts of America. The physical differences of rocks are obvious, but we know little of the chemical differences, and nothing at all in so far as their influence on the indigenous vegetation is concerned. Plant invasion on new volcanic areas has occurred countless thousands of times throughout the Pacific, and only after a thorough recognition of this process can a clear insight be obtained of Hawaiian vegetation. Also the destruction of natural vegetation by volcanic eruptions has been a common occurrence, and I do not think we yet realize what a vast influence these forces have had on plant distribution throughout the Pacific. In any discussion concerning plant distribution we shoud not overlook the effect of violent eruptions in causing the migration of birds, and even the occasional dissemination of seeds to long distances. Last year a comparatively insignificant eruption from Mauna Loa caused the whole Hawaiian group to be enveloped in a blue haze for a distance of nearly 1000 miles, and to what extent this affected the weather and incidentally the season's growth for that year, for lack of sufficient data we can only surmise. Volcanic phenomena and their relation to either native vegetation or cultivated crops have received but scant attention, and all that has been written on this subject would hardly fill a moderate sized volume.

Most barren rock surfaces require ages of weathering before they will support the higher forms of plant life, but portions of the smooth pahoehoe lava flows on Mauna Loa, become vegetated with higher plants within two years, often within a year, after an eruption. Rough aa flows and cinder become covered with vegetation at a later date, The first conspicuous plants to appear on a new lava flow are a lichen, Stercocanlon, and a moss, Pilopogon, while at about the same time or soon after, certain ferns appear in the cracks of pahoehoe lava, especially a folded form of *Polypodium pellucidum,* a fern greatly resembling the widely distributed *Polypodium vulgare* but limited to Hawaii. When it occurs on open lava flows, the simple, once pinnate frond is folded together like a hinge, the pinnae at the same time being twisted upward so that the lower surface bearing the fruiting bodies points downward. Usually this fern occurs in the rain forests as an epiphyte, and the frond is flat like most ferns. Except when *Polypodium pellucidum* is replaced by *Nephrolepis exaltata* on the lower levels the next most common fern is one belonging to the genus Sadleria. There are six species of this genus in Hawaii, all but one of which are endemic, *Sadleria cyatheoides* only occurring elsewhere on the island of Sumatra. The first flowering plant to appear is a variety of the Ohia, *Metrosideros polymorpha,* which almost always starts as an epiphyte on the Polypodium or Sadleria. After these plants form a scattered association, other plants gradually invade the area, and in the course of time varying with the situation, different formations such as rain forests, dry land forests, and meadows, come into existence.

A new volcanic area in Hawaii may be called a semi-xerophitic habitat, even though the yearly rainfall may reach as high as 350 inches. The first plants to invade the new flows on Mauna Loa on Hawaii are invariably the same at all elevations, and on all sides of this mountain, in spite of the fact that the annual rainfall varies from 30 to 350 inches, and the greatest minimum temperatures from freezing point to 60 degrees. Evaporation experiments on the slope of Mauna Loa indicate that the evaporation rate on an aa flow is four times as great as in a rain forest. The open character of the habitat, the strong unobstructed winds, the black surface, strong reflected light, and quick run-off are the most obvious features affecting vegetation on a new lava flow. As the flow becomes covered with vegetation, these early characteristics gradually disappear, and the vegetation takes on the characters of that in the immediate vicinity, which is determined by the rainfall, elevation being an associated circumstance.

The zonal distribution of Hawaiian plant communities according to elevation has been described by a number of botanists, but no exact instrumental or careful ecologic work has yet been published, and the distribution of plants within the zones has not been carefully worked out. The lowland zone which is characterized by introduced plants has a rainfall varying from 10 to 60 inches. The lower and upper forest zones have a rainfall varying from 60 to 350 inches, and extend above the 5,000 foot level, the distinction between these two zones not being as definite as one might judge from the descriptions. The upland zone probably has a rainfall varying from 20 to 80 inches, and in its upper part, frost and even snow are not an uncommon occurrence.

The middle forest zones are of most interest to the visitor, both on account of the number of strange plants, and the unusual aspect of the forests. Practically all endemic Hawaiian plants are woody, and woody Lobeliaceae, Violaceae, Caryophyllaceae, Primulaceae, and Geraniaceae and Compositae, must always excite the wonder and interest of the plant lover, and incite inquiry as to their relationships with the herbs and woody plants of other lands. In Hawaii the botanical collector is always rewarded with a full load of flowering and fruiting specimens at any season of the year, and while there must be definite seasons for individual species they have not yet been carefully worked out. With a few notable exceptions the flowers are small and inconspicuous except when borne in large masses as is the case with the Ohia and the Koa, and they generally lack odor. Most rain forest plants start as epiphytes, and even on the edges of the forested areas one often finds common introduced weeds such as the sow-thistle, *Sonchus oleraceus,* and the sorrel, *Rumex acetosaefolia* growing as epiphytes. The original support of the larger forest trees, usually a tree fern, eventually dies, and the trees have great, irregular, stilt-like roots, or trunks, and in certain types of rain forest the explorer travels for considerable distances over great tangles of prostrate trunks and woody rhizomes, all of which are covered with epiphytic ferns, and great spongy balls of herpatics and moss. Climbing plants are represented by few species, the *Leie Freycinetia arborea* of the Pandanus or Screw-pine family being the most frequent. Endemic herbs with the exception of ferns are rare in the forests, and are mostly confined to the open bogs.

The most common endemic forest tree in Hawaii is the ohia, *Metrosideros polymorpha* and its varieties, which may be found in all habitats throughout the group. Pure stands of *Acacia koa* and Sophora of the Leguminoseae, *Osmanthus sandwicensis* of the Olive family, *Myoporum sandwicense* of the Bastard Sandalwood family, and *Dracaenia aurea* of the liliaceae occur, but most forests contain an unusually large mixture of many species, the principal families being the Rubiaceae or Coffee family, the Rutaceae or Orange family, the Araliaceae, Lobeliaceae, Gesneriaceae and Urticaceae or Nettle family. The Kukui, an Euphorbiaceous tree introduced by the Hawaiians some 1500 years ago, marks the limit of the lower rain forest, and its present distribution gives some indication of the amount of erosion which has taken place in the islands since that time, especially along the cliffs of the Waimea canyon on Kauai, and the windward sea cliffs of Molokai, where it now occurs in isolated hanging valleys. The other zones are of equal interest to the botanist and offer numerous ecological problems but are perhaps not as strikingly unusual as are the forested areas.

In concluding it is not out of place to draw attention to the rapid change which is taking place in the natural vegetation at the present time, not only because it is an interesting problem in itself but because of it, our chances for studying the primitive vegetation are rapidly decreasing. Beginning with the time when these islands first supported an enormous native population, the indigenous vegetation has undergone great changes, but it is only within comparatively recent years that wholesale destruction of the native flora has taken place. To cite only one example: on Haleakala, Maui, within the last 50 years dense forests have entirely disappeared from the whole south and east slopes of this mountain, while within 15 years nearly every large tree on the greater part of the north slope below 2,500 feet has died. This is usually due to a combination of causes, and the reason is not always the same in every case, but it is generally the indirect result of industrial and agricultural development. The introduction of domesticated and wild animals, the clearing of the land for wood or agricultural purposes, forest fires, ravages by insects, the competition of introduced plants, the building of trails, and the lowering of the water table as the result of water development have all played a part in changing the natural conditions of the endemic vegetation, which in the end must succumb to more vigorous plant species. In the course of time areas of a strictly indigenous vegetation will become smaller and smaller, and the chances for ecological work in virgin forests will have passed. The bulk of the present Hawaiian forests are of use only as conservers of the water supply, introduced trees being of much greater commercial value, and unless foresight is taken to preserve certain sections of the forest reserves for scientific purposes, it is only a question of time before there will be no more strictly virgin forest areas in Hawaii.

ORIGIN OF THE HAWAIIAN FLORA

By Forest B. H. Brown

INTRODUCTION

The problem of the origin of the Hawaiian flora may be simplified by considering the seed plants apart from the spore plants and the dicotyledons apart from the monocotyledons.

The fact that spores can readily be transported long distances by any of the various agencies of dispersal (air currents, ocean currents, migratory birds) makes the problem of the origin of the spore plants difficult and uncertain of analysis. But seeds, with few possible exceptions, are ill adapted for transportation over great distances (2000 miles) by air currents, and there is little evidence that migratory birds have been materially more effective than winds in carrying seeds to land so isolated as the Hawaiian islands. The direction from which plant dispersal has evidently occurred does not correspond to any known path of bird migration if indeed birds had acquired migratory habits at the early period in which most of the plant immigrants appear to have arrived upon the islands. This, in connection with the fact that birds after long migration arrive with the digestive tract empty and presumably with the plumage and other parts of the body free from all but the most tenaciously clinging seeds, makes it improbable that either birds or winds have been effective to any appreciable degree in the transportation of seeds over great distances of sea; only the agency of ocean currents remains as a probable factor. The problem of dispersal is therefore simplified by restricting the discussion to the seed plants. Ocean currents may have operated directly in a few instances in bearing floating seeds or fruits such as the coconut to the islands; but in that the majority of seeds sink in water, it seems likely that as a rule they were brought in drift material.

The direction of flow of the Pacific currents of the present, however, is unfavorable for the transport of drift from the region (Central America) from which most of the plants appear to have come, and, further, would result in continuous rather than rhythmic dispersal. But there is reason to believe that at the time when dispersal occurred the currents of the Pacific were essentially different from those of the present. Plant evidence is in accord with this assumption as will be shown presently.

COMPOSITION OF THE FLORA

It is a remarkable fact that no gymnosperms have ever been found in Hawaii. Their absence, however, may be due solely to the fact that these plants have not succeeded in crossing the ocean, a supposition that is borne out by a number of evidences. For example, green cones sink in the sea water; the seed coats of most species are readily permeable to water; young seedlings are easily killed by adverse conditions of light and moisture. Moreover the high endemism of North American conifers in comparison to the Angiospermus makes it clear that these plants have shown little tendency to cross ocean barriers in any direction.

Gymnosperms being absent, the Hawaiian seed plants therefore comprise approximately one hundred and twenty monocotyledons and seven hundred and eighty dicotyledons, about nine hundred in all. The monocotyledons are in large part herbaceous plants not suitable for fossil preservations and are without the development of secondary wood which would make possible any systematic classification of anatomical character comparable to what has been accomplished in the dicotyledons. Furthermore, the grasses and many other monocotyledons have small seeds easily concealed in whatever the native might carry in long voyages from one island group to another and hence would be accidentally introduced. The monocotyledons, therefore, furnish meager and uncertain information bearing upon their geological history.

The Hawaiian dicotyledons, on the other hand, are largely (78 per cent) woody plants, especially the endemic species of the endemic genera of which 95 per cent are shrubby or arborescent; to this class belong nearly all of the trees of the indigenous forests. In this class of plants the various elements of the wood have attained a highly complex differentiation and clearly defined evolutionary tendencies are exhibited in each of the numerous specialized branches. Not infrequently the systematic position of a dicotyledonous species, genus, tribe, family, or order is morely clearly indicated in the anatomy of the woody stem than in the floral characters. Anatomy therefore serves to check the evidence or to bridge over gaps in the evidence based upon external characters. Furthermore, to the extent that anatomical details are preserved in fossil wood, such characters are of value in establishing the relation of existing floras to fossil floras.

The dicotyledons, therefore, furnish evidence not only in the external morphology but in the anatomy of the stem and in the fossil record which bear upon their geological history, and the abundance of fossils of woody dicotyledons makes it possible to extend the investigation into the fossil record. The woody dicotyledonous plants therefore make favorable material with which to investigate the origin of the Hawaiian flora, and by confining the present discussion to these plants, many elements of uncertainty are excluded.

PROBABLE AGENCY OF PLANT DISPERSAL

The dicotyledonous flora as a whole numbers about seven hundred and eighty species but in all probability these have arisen from about one hundred and twenty-five ancestral immigrants. In the relationship which these descendants sustain to one another it is clear that these immigrants constitute a remarkably heterogeneous group, not less than seventy-four families being represented or an average of less than two immigrants per family. This is quite the contrary to what one finds in a flora resulting from an overland migration, but rather such as one would expect if brought from long distances as waifs and arriving one by one over considerable periods of time. There is nothing apparent in the flowers, fruits, seeds and other characters of these plants as a whole to indicate the operation of any selective agency of dispersal. On the contrary, the same high degree of heterogeneity prevails in the character of the fruits and seeds as in the relationship; the composition of the group appears to have been determined purely by the laws of chance and all evidences strongly favor the conclusion that plant immigrants must have been brought to the islands by some physical agency such as ocean currents. By any other agency many of the fruits or seeds would be impossible of transportation. Only a small portion, it is true, have buoyant seeds or fruits but there are none which could not have been brought by floating conifer logs or similar drift. And (1) with the predominance of conifers on the continent, culminating in the Triassic-Jurassic time (2) with the submergence of the region (Central America) from which the bulk of the Hawaiian flora appears to have originated and (3) with the changing of ocean currents when the Atlantic and Pacific were united through wide submerged areas of Central America, resulting probably in a more decided westward trend of the Pacific currents in the equatorial belt, it is clear that conditions in the past must have been more favorable than at present for the dispersal of American plants westward to the Pacific islands. And in that submergence of the Central American region has occurred rhythmically, it follows that the dispersal of American plants westward over the Pacific would occur at intervals, i. e. in dispersal waves; it is of great interest to find that the plant evidence bears out this supposition with particular clearness; not less than two dispersal periods (or waves of dispersal) may be recognized, or three waves inclusive of species introduced by human agency.

THREE WAVES OF DISPERSAL

So far as evidence goes there is little to indicate that the first plants to become established upon the islands arrived early in the history of the Angiosperms. Throughout the present flora, representatives of highly specialized families (metachlamydeae) such as the compositae, campanulaceae and labiatae make up a conspicuous element and are particularly characteristic of the group of plants which appears to have been the first to arrive. Nevertheless, it is not unlikely that the first arrivals antedate the first known fossil Angiosperms inasmuch as the fossil history of these plants does not begin until the dicotyledonous families are well differentiated.

That the periods during which immigration occurred were of long duration is shown by the great differences of age apparent in the several descendant lives. Also, there is a break in the floral composition and in the degree of endemism and other characters indicative of age, which separates the flora into distinct groups, or sub-floras, and makes it clear that immigration has not been continuous but has been interrupted at intervals. At least two periods or waves of immigration can be distinguished, or three, inclusive of the group of plants introduced by man, as follows:

1. The group of plants arising from the first period of dispersal is characterized by the large number of Compositae, Campanulaceae, Labiatae, Rubiaceae and Rutaceae which it contains. Affinities are largely with plants of Isthmian America, and all appear to have originated directly or indirectly from this region. Many of the tribes to which the Hawaiian island representatves belong, are, except for the Hawaiian representatives endemic to

America, but the endemic units belong to a tribe (Prasioideae) distributed from southeastern Asia westward through the Mediterranean region, its only extra-continental extension in the Hawaiian islands. But the Hawaiian genera are most closely related to a genus confined to the west Mediterranean region and extending into the Canary islands. As will be shown presently, geological conditions existing in early Cretaceous time or earlier would have favored dispersal from this region to the Hawaiian islands by way of Central America. The following table is instructive:

PLANTS OF THE FIRST WAVE OF DISPERSAL

Family	No. of ancestral immigrants	Probable origin	No. of descendants
1. Urticaceae	2	American	3
2. Amarantaceae	2	"	5
3. Caryophyllaceae	1	"	18
4. Saxifragaceae	1	"	2
5. Rutaceae	2	"	28
6. Malvaceae	1	"	5
7. Violaceae	1	"	3
8. Begoniaceae	1	"	1
9. Araliaceae	2	"	18
10. Loganiaceae	1	"	9
11. Apocynaceae	1	"	1
12. Labiatae	1	Indirectly American	36
13. Solanaceae	1	American	4
14. Rubiaceae	4	"	40
15. Campanulaceae	3	"	93
16. Compositae	7	"	56
Total, 16 families	31 immigrants	descendants	322

2. The group originating from the second dispersal wave is next in age and is evidently of considerably more recent origin than the first. Evolution has in no case progressed as far as the creation either of endemic genera or of endemic sub-tribes, and not more than three species, on an average, have arisen from a single ancestral immigrant. In many cases the closest existing relatives occur in the region of the East Indies or Australia, but such affinities appear to be of a collateral character and remote from the center of origin. The second wave, like the first, seems to have come, in large part at least, by way of the Central American region, and during about Lower Eocene time. It is a remarkable fact that the ten largest families found in the Lower Eocene flora of the lower Mississippi valley (Lauraceae, Caesepiniaceae, Urticaceae, Papilionaceae,) Rhamnaceae, Sapindaceae, Myrtaceae, Mimosaceae, Anacordaceae,) are all abundantly rep-

resented in that portion of the existing Hawaiian flora which has apparently originated from the second dispersal wave. It is of great significance, in this connection, that a cusp-pointed phyllode of the same size and obovate outline as the Hawaiian *Acacia koa* var. *lanaiensis* has been found in the American Lower Eocene. Even the uninervate character of the fossil is indicated in the phyllodes of young seedlings and juvenile foliage of the Hawaiian representative; not only the ancestral stock of the Hawaiian phyllodinous acacias appear to have come in this period from the American continent but inasmuch as a fossil stem with coco-like structure has been found among the fossil plants of the Canal Zone, it is probable that the coconut arrived in this wave of dispersal of American plants. This portion of the Hawaiian flora may properly be regarded as a relic of the American Lower Eocene. The first wave of migration must therefore greatly antedate this time.

3. A number of plants (breadfruit, candle nut and others) have, in all probability been introduced by primitive man. For sake of comparison these plants may be considered as a third group.

The plants originating from the first dispersal wave are almost exclusively confined to the interior uplands of the islands, occurring mainly at high elevations in the mountains. This is a characteristic feature of the group as a whole and is reasonably explained on the supposition that the ancestral immigrants were also interior upland plants, the continental angiosperms not yet having invaded the lowland or littoral regions where conditions were favorable for fossil preservation. If so, the tendency which plants of the first dispersal wave exhibit to inhabit the interior uplands is a relic character of the ancient angiosperms and antedates the fossil record.

Age is also indicated by the amount of evolution which has taken place on the islands. The existing representatives of the first immigration number between three hundred twenty-two and three hundred fifty species, but these appear to have arisen from thirty-one ancestral immigrants. All of the genera are endemic, and certain of these endemic genera constitute a closely connected series similar to those of a sub-tribe. In other words, not only endemic genera but endemic sub-tribes have been evolved on the islands, starting in each case from a single ancestral immigrant. The sub-tribes particularly are indicative of age and number six or seven as follows: (1) Schiedea-Alisinidendrion in the Caryophyllaceae; (2) triplasandra-tetraplasandra-Pterotropia-Reynoldsia in the Ciraliaceae; (3) Stenogyne-Haplostachys-Phyllostegia in the Labiatae; (4) Clermontia-Rollandia-Delissea-Cyanea in the Campanulaceae; (5) Cirgyroxiphium-Wilkesia and (6) Dubantia-Raillardia in the Compositae; and possibly (7) Hibiscadelphus-Kokia in the Malvaceae.

As an index of age, the extremely low generic coefficient of the endemic genera is particularly significant. On a mountainous topography, such as that of the Hawaiian islands the number of plant species is large in proportion to the number of genera. On more level topography, on the other hand, such as characterizes a large part of the continental areas, the number of species per genera is relatively small. On the Hawaiian islands there have been evolved genera with lower generic coefficient ($\frac{\text{genera}}{\text{species}} \times 100$) than their continental relatives, and in so far as change has probably taken place by slow degrees, it follows that, as long as change takes place, the coefficients of floral groups upon the same topography should vary inversely, though not in proportion, with the age of the group. Accordingly, it is quite as one would expect to find that the sub-flora originating from the first dispersal wave should have the lowest generic coefficient (13) and the sub-floras arising from progressively younger waves of dispersal should have progressively larger generic coefficients. The coefficients of the sub-floras originating from the first (oldest), second, and third (youngest) waves are respectively 13, 36, 47. (See fig. 1.)

The relative age of the three dispersal waves is also indicated in the anatomy of the wood. In dicotyledons of the first dispersal, the vessels of the wood have an average diameter of .12 mm.; dicotyledons belonging to the second wave, on the other hand have vessels of .14 mm. in diameter; those of the third wave (the introduced plants) have vessels of .22 mm. in diameter; or, arranged in sequence according to time, the diameters are .12 mm.; 14 mm.; 22 mm.; respectively. Plants which have been longest on the islands have (without exception so far as I am aware) vessels of extraordinarily small calibre, in several species being no larger than the fibres and almost indistinguishable from them, in cross-section.

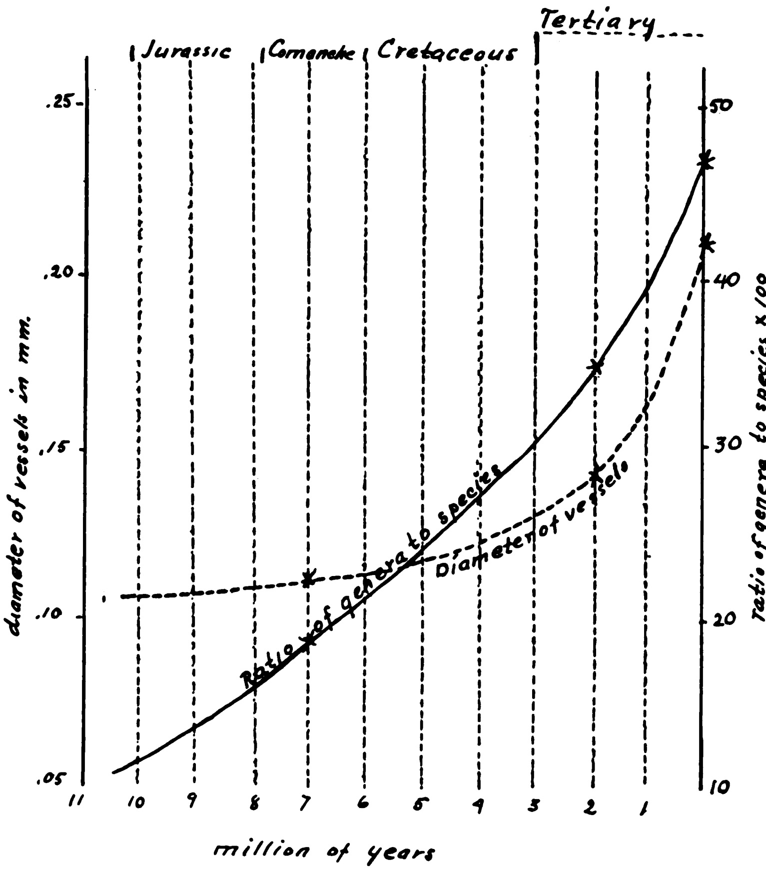

FIGURE 1. Curves showing progressive decrease of vessel diameter and generic coefficient with age in Hawaiian woody plants.

Reduction in size of vessels seems to have been an evolutionary tendency common to each of the descendant series arising from continental immigrants with vessels probably of relatively large calibre; and in so far as change has taken place gradually it serves as an index of age. Upon the supposition that reduction in size of vessels has been an evolutionary tendency many peculiarities in the Hawaiian flora are reasonably explained: (1) certain specialized endemics such as *Acacia koaia* have smaller vessels than their more generalized close relatives (*Acacia koa*); (2) large vessels are characteristic of continental fossil floras from which the Hawaiian representatives appear to have been derived; (3) peculiarities of the Hawaiian climate (low light intensity), uniform moderate temperature, high relative humidity) favor slow transpiration probably with the consequent reduction in the caliber of the vessels; (4) the average diameter of vessels in Hawaiian plants varies so long as change occurs, inversely though not in proportion, to the age of the flora; introduced continental species and continental island species like the breadfruit (native of Java) have vessels of far greater diameter than those of the endemics.

Hence Hawaiian dicotyledons have (1) smaller vessels and (2) a lower generic coefficient than their continental relatives and both of these characters appear, within limits, to vary inversely with the age of the flora. When the values obtained are plotted in relation to their chronological abscissae (fig. 1) curves are obtained in each case, and these curves are in essential agreement, the lowest values being characteristic of the oldest plants, and progressively higher values of the progressively younger groups. Neither of the curves appear to have flattened. From the inclination and degree of curvature of the graphs thus obtained it is apparently indicated that these evolutionary changes are still in progress, particularly the decrease of generic coefficient.

EVIDENCE BEARING ON AGE AND ORIGIN OF THE HAWAIIAN SUB-FLORAS

The Hawaiian dicotyledons excluding those brought by man, appear to have come mainly from or by way of the Central American region. The affinities of the second wave with American Lower Eocene seem particularly clear, and this, together with the fact that the tribes to which the genera belong have their center of origin in the same Central American region as the Lower Eocene fossils are found is apparently indicative of the time and source of the second immigration of plants to the islands.

The first wave of immigration, as already explained, must have occurred at a considerably earlier period than the second; otherwise it would not be possible to account for the relatively great difference in age of these sub-floras which is apparently in every character where comparison is possible, and in that geological conditions, during Jurassic-Comanchic time, as will be discussed presently, were favorable for dispersal of American plants over the Pacific, it is not improbable that the first immigrants may have arrived at this period.

A large proportion of the Hawaiian species which appear to have originated from the second period of immigration, have their closest existing relatives in the region of the East Indies or Australia, and this has been generally accepted as evidence of the Austral-Malaysian origin of the Hawaiian flora. The true affinities, however, appear to be with the Lower Eocene flora of the region of Isthmian America extending from the latitude of the Lower Mississippi Valley to the Amazon region of South America. From this region the Hawaiian representatives, on the one hand, and their close Indo-Malaysian relatives, on the other, seem to have had a common origin. With the subsidence of wide areas of Central America in Eocene-Oligocene time, the equatorial currents of the Atlantic must have continued westward over Central America into the Pacific, probably changing the direction and rate of flow of the Pacific currents in a way favorable for the dissemination of Central American plants to the Hawaiian islands and to the East Indies or even the shore of Australia, Asia, or the islands of the Indian Ocean. The distribution of the Begoniaceae and of Trevesia among the Compositae, and of numerous other plants bear out this supposition in detail. The Hawaiian sub-flora originating from this period of dispersal may therefore be regarded as a relic of Central American Lower Eocene flora and to have been dispersed under conditions existing at that time.

The most ancient position of the Hawaiian flora, however, is of considerably greater age than the sub-flora assumed to have arisen from dissemination in Lower Eocene time and must therefore have reached the islands at a correspondingly early period. According to Professor Schuchert, the Central American region was open again in Jurassic time, and, continued through Comanchic to Cretacic time. The affinities of this sub-flora and its relatively great age as indicated in every character, are quite in harmony with the supposition that the ancestral immigrants must have reached the islands at this time, and under the geological conditions of these periods. Under such conditions, it is easy to understand how a single ancestral immigrant from the Mediterranean-Canary island branch of the Prasioideae could have reached the Hawaiian islands by way of Central America;

land connections between Africa and South America would have facilitated dispersal from this region.

If, as the evidence indicates, the first immigration of Hawaiian angiosperms occurred at this early time, then such highly specialized families as the Compositae and Campanulaceae must then have been in existence. But with the center of origin of these families in northern South America, close to the region of trans-Pacific dispersal it is evident that such plants would find their way to the Hawaiian islands early in their history; probably therein lies the explanation why an extraordinarily large number of immigrants—10 in number—should belong to these two families. (See table on previous page.).

Chances of dispersal were probably more favorable during the early period. The Gymnosperms were then predominant; the wood is of low specific gravity and floats for long periods; the stems reach large diameter and are favorable for the lodgement of seeds. Hence it follows that even though the angiosperms were subordinate in the vegetation and confined to the interior uplands, it is quite as one would expect that many would be carried over.

At the time of the second dispersal, on the other hand, the Angiosperms were predominate on the continent, or at least they had invaded the lowlands and littoral regions. But inasmuch as the woody stems in most cases, sink in water or soon become water logged, there must have been little drift which would remain floating any great length of time; hence a correspondingly small opportunity for seed and other life being carried in drift. The great predominance of angiosperms, however, would, to a certain extent, compensate the lack of chance.

SUMMARY

The Hawaiian dicotyledons appear to have originated in large part from Isthmian America.

During their geological history, two periods of dispersal are distinguishable, the first occurring at some time during the Jurassic-Comanchic-Cretacic submergence of the Central American region; the second, during the Eocene-Oligocene submergence.

Ocean currents bearing seed-containing drift appear to have been the chief agency of dispersal; and in so far as gymnosperms, the wood of which is extremely buoyant, were predominant in Jurassic-Comanchic time, American seeds and other life must have been more generally dispersed over the Pacific during the first inundation of Central America.

The Hawaiian sub-flora originating from the inundation of Central America in Jurassic-Comanchic time is probably one of the most ancient existing Angiosperm floras and indicates the correspondingly great age of the Hawaiian islands.

THE ORIGIN OF THE HAWAIIAN FLORA AND FAUNA

By F. Muir

The question of the origin of the fauna and flora of the Hawaiian islands is of very great importance on account of its bearing upon many questions relating to the Pacific. The first great question that confronts us is as to the status of the archipelago; is it entirely oceanic or has it been joined to a continental area? A correct answer to this question would clear up many problems in the far south as well as in other parts. If it be oceanic, we should look for a cosmopolitan fauna and flora drawn from various quarters of the Pacific; should we decide that it is continental, then we should expect to find a more homogeneous fauna and flora drawn chiefly from one of the continental areas bordering on the Pacific and closely allied to it.

On this point there is a difference of opinion and the evidence is conflicting; so all we can do at present is to submit the evidence and views of the different workers and see where they will lead. Personally, I can speak only from the point of view of an entomologist, but the evidence presented by the study of insects convinces me that the islands are oceanic.

A review of the insects of the Hawaiian islands and their nearest allies shows that they are drawn from all sides of the Pacific, except the north and northeast. In some cases the species of a single genus have two distinct origins. The hymenopterons genus Odynerus is an example of this. Dr. Perkins, who is an authority upon this group and who has devoted considerable attention to the Hawaiian species, has shown that they form two groups, one of which has close relationship to Oriental or Japanese forms. If we examine the different families represented in the islands, a dual or plural origin is often recognizable. The family Delphacidae of the Homoptera can be cited as an example. Here we have two groups; one consisting of species at present placed in the world-wide genus Kelisia, and the other consisting of some eight genera which until lately, were considered to be found only in the Hawaiian islands. In the Kelisia there is one species (*K. paludum* Kirk) which is also found in Fiji, Australia, Malay Islands, Ceylon and Philippine Islands. The endemic genera are divided into two groups which I consider have little connection with one another. The ancestors of one group arrived in the islands very much earlier than the ancestors of the others. In the older group there is one genus (Nesosydne) which is now known to have representatives in the Galapagos islands and in St. Helena. Such examples could be multiplied but a list of names would be of little interest on this occasion. To those who are interested in this question I refer to the Introduction of "Fauna Hawaiiensis," where the "waif and stray" nature of our insects is well shown.

The first thing to attract the attention of an entomologist starting on the study of the Hawaiian insects is not the insects which compose the fauna, but the insects which are missing from it, and it is this great, outstanding feature that must be accounted for rather than the presence of certain insects in the islands. As an example I will cite the case of the Lamellicorn beetles, the great group to which the May and June beetles belong. This group is known from all over the world, but is represented in the islands by only a single genus belonging to the Lucanidae or stag beetles. Now the larvae of Lucanidae live in wood, both sound and rotten, and could therefore be transported over sea, whereas the larvae of all the other Lamellicornia live in soil and could not be so carried. These insects are too heavy to be carried by air currents and are poor flyers. Another example is the "Tiger Beetles." The larvae of these live in holes in the ground and feed on living insects, which happen to walk by their home. Such larvae could not survive long journeys on floating islands, and as they are poor flyers and heavy, could not fly or be borne by air currents. Examples could be multiplied from each order, but I must refer the curious to the "Introduction" already mentioned.

In a broad way an analysis of our insects shows that those insects capable of flying, or being borne by air or water currents, are represented, but those not capable of being so borne are not.

Now if we erect a land bridge (and our insects would require several) to any one continental area, we have the enormous task of accounting for the absence of such large groups of insects. It is quite thinkable that during the long ages the islands have been in existence, combinations of circumstances could have brought the ancestors of our insects to these shores, but to me it is unthinkable that a land bridge, or several, could have existed and such large and predominant groups of insects could have been kept out.

The geographical distribution of some of our insects is very strange. The genus Proterhinus has some one hundred and fifty species in these islands, and only one species is known outside, this one being found in Samoa. Did we derive ours from Samoa, or Samoa their's from us? The nearest relatives of this genus are in New Zealand, New Caledonia and the Canary islands in the Atlantic. I have already mentioned the case of Nesosydne (or Ilburnia, as we must now call it) being in Galapagos islands and St. Helena, but until the islands in the southern Pacific are more fully explored, it is of little use speculating as to the original home of many of our insects.

The means by which our insects originally came to Hawaii are difficult to state with any certainty. We are looking to other sections of this Conference to throw light upon this matter. We want to know more about the air and water currents of today and also what they were in the past. This latter will depend greatly upon the findings of the geologists and paleo-geographers. At present our "drift" is mostly from the northeast, but our insects show little affinity to those of Northwest America. Insects arriving from that locality would not find familiar trees or plants and would have great difficulty in establishing themselves. In the case of phytophagous insects, it is not only necessary that the insect be transported to our shores, but also that suitable plants should be established for them to feed upon.

One of the chief objections brought up against the flotsam and jetsam method of stocking these islands, is that many of the insects could not normally live on drift wood or similar bodies in the water. This is quite correct. If they could easily live on drift we should have a much richer insect fauna. But it is only by a combination of circumstances happening once in long periods of time that insects arrived, and that is why we have such a poor insect fauna compared with continental areas.

Our insect fauna is rich in moths, especially the microlepidoptera, or small moths. This group has great power of flight. Once when traveling between Hongkong and Java, when about two hundred miles from the coast of Cochin China, I noticed a great number of little moths flying about the ship. Some of them were very small, delicate insects with delicate fringe round their wings (plume moths as they are called) and I was surprised to find them in perfect condition. I suspected they were breeding on some vegetable substance on board. But I soon noticed that these insects were in great numbers all round the ship and all passing in one direction, from the northwest to the southeast, in the direction of the prevailing wind. Although the water was rough, many settled on the surface and rose again in perfect condition. We were going at right angles to the current of migration and it took about three hours to pass through them. Many of these must have eventually reached the coast of Borneo after a flight of some six hundred miles. Insects carried up into the upper strata of the air could be carried long distances before they would come to earth again. There are only two butterflies native to the Hawaiian islands. One (*Vanessa tammeamea*) is related to *Anosia phescippus,* whose wide distribution over the Pacific in the wake of its food plant (various species of Asclepias) has been recorded by J. J. Walker. He shows good reason to believe that this has been a natural migration. How many adventurous individuals went off into the Pacific before the white man had carried their food plants there, and therefore could not establish themselves, it is interesting to imagine. The second butterfly is a little "blue" (*Lycena blackburni*) which is of interest as it is the only representative of the group which has no glands on the back of the larvae. But then we have no tree ants to attend to the larvae and eat the secretion from the glands.

Although these remarks do not show the origin of the Hawaiian insects so far as phylogeny is concerned, they briefly state some of the facts which have convinced entomologists that the islands are purely oceanic, and have been stocked by waifs and strays from various parts of the Pacific. Only a much greater knowledge of the insects of other islands in the Pacific, especially of the south and southeast, will enable us to state with reasonable assurance from what part of the Pacific they came, and so enable us to follow their phylogeny, at least vaguely.

DISCUSSION

MR. MAYOR: Referring to the migration of insects on air currents, there is a good work by Dr. Ball of the Carnegie Institution written when he was stationed on Rebecca Shoal Light, forty miles from the Florida Coast. It is entirely surrounded by salt water. There is no land. When a wind blew from Cuba, ninety-two miles away, it brought a swarm of land mosquitoes. And not only mosquitoes but small gnats and flies, so that it is certain that an insect may be carried ninety-two miles over the sea.

THE DISPERSAL AND AFFINITIES OF POLYNESIAN LAND SNAIL FAUNAS

By Henry A. Pilsbry

The mollusk faunas of the Pacific islands, marine as well as land, are related to the Eastern world, not to America. In the land and fresh-water faunas with which we are now concerned, no trace of American influence has been detected.

Travelling eastward from the Moluccas and New Guinea, which have faunas of continental type, we find similar faunas in the Bismark archipelago and the Solomon islands—large Helicidae such as Papuina and Choritis, large Zonitidae, Placostylus, the carnivorous Rhytididae, various slugs, the operculate Cyclostome snails, and others characterize these rich faunas, which malacologists, at least, will scarcely hesitate to consider of continental type. Further out, we come to the New Hebrides and Fiji groups. Here the Helicidae and many others have dropped out, but we still find large Zonitidae and Placostylus together with Rhytididae, the slug Veronicella, various operculate snails, large salt-marsh snails such as Pythia, and the fresh-water Mealnia and Ampullacera, also Batissa, a genus of large oriental bivalves. The presence of these groups, and especially the large, often ponderous Placostylus, led Hedley to view the Fijis, lying halfway between Australia and the Society islands, as the eastern limit of an ancient land which he called the Melanesian Plateau. The hypothesis that this area was once continental has been widely accepted. The evidence for it from other sources is now considerable.

Continuing eastward, we come into the island world of central Polynesia; the Cook, Austral, Society, Paumotu and Marquesas groups: scattered over about 1,700 miles east and west, nearly as large north and south. Throughout the high islands of this great area the land mollusk fauna is remarkably homogeneous. There can hardly be said to be more regional differentiation than there is in the Hawaiian group. The same or closely related genera extend throughout. For the greater part, these genera are also represented in the islands of the Melanesian Plateau, or are related to the latter. In these faunas Partula and Trochomorpha—like snails, carinate Zonitids, are the largest. These, together with small Zonitidae, Endodontidae, Tornatellinidae, Pupillidae, Succineidae, Realiidae, Georissa and Truncatellidae, chiefly compose the fauna. The fresh water Melania, Bullinus and the Cyrenidae drop out, as well as the large salt-marsh snails, Pythia and Cassidula. This may be partly due to the restricted fresh water stations. The minute Diplommatinids, almost universal eastward, are lacking.

A certain number of the small snails of the shore zone, such as Opeas, Tornatellina, Assiminea, and the Limax from Rarotonga and Tahiti, have doubtless been generally spread by native or later commerce.

There are certain special groups, such as Libera in the Cook and Society islands, Taheitia, Lamellorum; but all appear to be derivatives of more widely spread genera. Partula has been differentiated into recognizable subgenera in different island groups. *Partula hyalina,* of Tahiti, has also been found in the Cook and Austral groups. It is the only large land snail known to occur in more than one group.

How are we to account for this homogeneous fauna of minute high islands scattered over an area about as large as the United States east of the Mississippi? Was it by distribution over continuous land? Or was it by the occasional agencies of oversea drift, carriage by birds or by wind, bringing the snails to islands which have been built up singly and separately out of the abyss?

An answer to these questions at present can only be provisional. It is a matter of individual opinion, based largely upon our views upon geologic questions. If we believe with Schuchert, Iddings and others that there has been enormous subsidence in the Pacific, then we may reasonably entertain the idea of former land of continental dimensions or perhaps of a series of arcs, now and again connected, in the southern and western Pacific, if the faunal evidence favors that view. If, on the other hand, we start with the assumption that the distribution of land and water has always been as ill-balanced as it is today, that the present oceans beyond the continental platforms are roughly permanent, then the faunal evidence one way or the other becomes irrelevant.

It must be recognized that however the fauna was distributed, it would be so far homogeneous as to contain only families or genera represented in the land of its departure. I have elsewhere noted the fact that the fauna of central Polynesia contains primitive types common to the Fijis and to other islands westward. Also that the higher types of the Melanesian plateau are lacking. Dr. W. D. Matthew has called attention to the fact that the older a given group is, the longer time there has been for the chances of over-sea dispersal. While this is perfectly true, it does not account for the absence of dispersal in the later Tertiary, during the existence of Helicidae, Bulimulidae, Diplommatinidae and other high land snails in Fij and westward.

The argument for distribution of animals by natural rafts has never been more convincingly stated than by Mathew in his paper, "Climate and Evolution." Much of his argument, however, is not applicable to the Pacific islands. Here we have no large rivers like the Orinoco or Amazon to give forth natural rafts. If a single tree is washed into the sea it must be very exceptional. That such a tree would float 400 or 500 miles and make a good landing carrying snails still alive; that it would land in a place where the snails, Partula for example, would find congenial conditions, must be rare if it ever happens. The chances estimated by Mathew seem far too favorable. But in the present case we have to populate about 50 small islands scattered over two million square miles, with a varied population of shore and forest snails, partly arboreal, partly terrestrial, nearly uniform generically throughout, and characterized by the exclusion of modern groups of snails.

Every practical snail hunter knows how fastidious many forest snails are in the matter of station. Snails of the shore zone, such as the Auriculidae and Truncatellidae might readily find suitable conditions on a new shore; but forest snails such as Zonitidae, Endodontidae, Partulidae would not. A mammal bird or reptile once cast ashore, can make its way to a suitable station. No practical conchologist would expect an Endodonta, Amastra or Achatinella to do so. Unless we imagine a natural raft stocked like Noah's ark for each island, we must suppose a long series of happy accidents for each individual island.

Minute snails or the eggs of larger ones are doubtless carried by hurricanes for considerable distances; but where the distances are several hundred miles, it is doubtful whether such means have been effective. In the Hawaiian islands, it is clear that within the duration of existing species, there is no evidence of such adventitious distribution. The ranges of the species and their relationships to species adjoining are remarkably consistent. This appears to be true also of the Partulas of the Society Islands.

Partula, one of the most widely spread Polynesian snails, is viviparous like the Achatinellas. The carinate groups of Endodontidae oviposit in the umbilicus of the shell. If carried by winds or birds, the entire animal would have to be taken. The forest ground-snails for the most part bury their eggs in moist soil or decaying vegetable debris. The chance of such an egg, carried aloft by the wind, falling in a spot favorable for its development appears remote. While natural rafts have doubtless played a part in the dispersal of mollusks as well as of other animals, and winds have carried snails over the sea, it appears to me that these hypotheses are seriously strained when applied to Polynesia. There are too many of the same genera on widely remote islands.

It appears to me that another hypothesis accounts for the facts in a more credible manner, and at least deserves further investigation. According to this hypothesis, the mid-Pacific groups from the Cook Islands to the Marquesas are viewed as remnants of a fragmented continental mass, possibly two-thirds as large as Australia, and this land was connected with the Melanesian Plateau before the latter was occupied by the higher groups of mollusks. This Polynesian land persisted as a large island or series of island arcs after the connection westward was severed, and finally broke up in the last half of the Tertiary.

Such an hypothesis accounts for the homogeneous fauna over widely scattered islands, and the absence of modern families and genera.

In the Hawaiian islands we have a fauna showing many analogies with that of other parts of Polynesia. The dominant families are more or less highly specialized land snails of a low group, the Orthurethra. As elsewhere in Polynesia, modern groups of snails are absent. There is a rich fauna of Endodontidae and small Zonitidae, an extraordinary development of Pupillidae, Tornatellinidae and Succineidae, with endemic genera. There are no land operculates except Helicinidae. Achatinellidae and Amastridae replace the Partulidae of the southern islands. Melania, Lymnaeidae, and the special genus Erinna represent the fresh water mollusca.

There is clearly nothing in this to suggest direct connection between Hawaii and the Polynesian islands farther south. Of the two faunas, that of Hawaii is surely more antique. The common elements of the two appear traceable to derivation of both faunas from rather similar ancient continental sources.

DISCUSSION

MR. SAFFORD: Is it not a fact that none of the mammals of Australia or New Guinea are found in these Islands?

MR. PILSBRY: Yes, that is true.

MR. MAYOR: One factor that we often neglect to consider is that very few scientists have lived in the place they are studying. The natives of these islands are great navigators and did not hesitate to go on voyages of several weeks' duration, and, when they did, they took with them taro and bananas and a great supply of food wrapped in banana leaves. Now these are the plants where the Partula is most often found. There is no mystery in connection with the wide distribution of this species. I have seen it all over Tahiti, but we don't find it at Moorea because the natives going there do not supply themselves with food. The distance is short and they know they will find plenty of food there. Again we do find it in the Australs considerably separated from the other islands. The native custom is to take food enough for about three weeks in their canoes. They go ashore on some island when this food supply is exhausted. That would explain the fact that the Partula is found practically everywhere. It is evidently the result of migration from the Malay Archipelago through various islands to Rotuma and from there to Samoa, to the Cook Islands, Tahiti and New Zealand. The islanders were very venturesome sailors, and as we know they took voyages of long duration to the Hawaiian islands from the Society Islands and Tahiti.

Moreover the time required for the evolution of the Partula is not great. New species can be produced very quickly. Crosses between two species will produce a new species not seen before. Of course I will admit that a place like Fiji may have been connected with New Caledonia and New Zealand. But it seems improbable that a large continent could exist in the midst of the Pacific and have no mammals but only lizards and snakes which could easily have been carried across the sea on logs or brought by the natives for religious purposes.

MR. PILSBRY: I am very much gratified to hear this explanation of the distribution. I had already, although I had no special knowledge of conditions on those groups, made the supposition that the shore shells in Hawaii had been distributed by natives on native voyages. As to the rapid growth of species, I think there could be two opinions. Now the Society Islands Partula all belong to a single section. We separate them from closely related species and it is a matter of hair splitting whether they are species. It is a matter of opinion. The mutations which appear are the same as those in the Hawaiian islands. Their color mutations are of little value. Every species goes through a kaleidoscopic series of changes in a short time. But on the different groups of Polynesia we find the Partula somewhat more differentiated. We divide them into sections. The Marquesas Islands, Society Islands and Samoa each have their own genus. They go back a long way. Now in places where we know something about the history of the land, in North America and northern Europe we find that practically all the modern species reach back into the last geological period, and in America we know that quite a number of modern species in Florida are found in the Pliocene period. While color mutation goes on rapidly, real structural change takes place slowly. In the genus Cerion a remarkable change has been brought about by hybridization, but changes are small. Some people admit only one species, some a dozen, so that they cannot be the explanation of the differentiation of the species that has gone on between the islands of the Pacific.

MR. BARTSCH: From what Dr. Pilsbry said about Cerion one might be led to believe that shell characters only had been considered. If this were true, then we would be today exactly where we were when we began our breeding experiments in 1912.

It was the close resemblance of the shell which was responsible for my referring in the early reports to forms used in our experiments, simply as the King's Road and the White House type of *Cerion glans,* these names being derived from the localities from which our stock was obtained on Andros Island, Bahamas.

The fact that they would not hybridize prompted an anatomical examination, which showed that these two forms were so different in their anatomical structure that it is not at all surprising that no crossing had been effected. I am sure Dr. Pilsbry would not only have considered them distinct species but would have placed them in separate groups on account of these divergent characters and yet I am of the opinion, judging from some of our breeding experiments that they are of rather recent origin. I am inclined to believe that the entire *Cerion glans* group was evolved by hybridization in Pleistocene time when the Bahama Islands formed a connected land mass. At this time the group was enabled to spread around the entire land area. Later when the melting of the glacial ice caps returned water to the sea an interrupted distribution ensued which finally ended in the formation of the many colonies we have today, each occupying an extremely local area. The members of each of these colonies appear to possess certain characters peculiar to that colony, produced by internal and external adjustments which have resulted in the final fixation of stable characters.

Our crossing of the Bahama *Cerion viaregis* with the Floridian *Cerion incanum,* two very unrelated forms, has produced no end of forms, many with entirely different characters than either parent stock possessed. All this fluxing has been produced within two generations and if fixation can be equally speedily affected then it seems that the question of a long time element for the production of new forms is not at all necessary. In fact our experiments would rather argue for saltation than for an infinite time element.

HAWAIIAN FAUNA AND FLORA

By William Alanson Bryan

I have just returned from a rather extensive journey along the Pacific Coast of Central and South America and to Easter and Juan Fernandez Islands and have not yet had time to put my observations into final form. This presentation should therefore be regarded as preliminary.

The origin of the fauna and flora of the Hawaiian islands is involved in the larger question, the origin of the life in the Pacific islands. The available data are not yet sufficient to permit a clear and satisfactory solution. As Dr. Pilsbry says, it is impossible to think that the land mollusca inhabitating the group arrived here by chance, or that they have been carried by the wind, or attached to birds' feet or have floated here over two thousand miles of open ocean. And having once arrived here it is impossible for them to have attained present distribution through the islands by any means except that of crawling on their own stomachs from one end of the group to the other. Such observations call for the existence of former land connections which have since sunk beneath the sea, leaving the groups of islands as we know them today. Moreover there is abundant physiographic evidence, as I have elsewhere pointed out, that bears out such a theory of submergence in the group.

Dr. Muir and I have discussed the migration of insects at various times and I agree with him fully that at least a large part of the insect fauna of the Hawaiian group might possibly have arrived here from time to time wind-borne or water-borne. However, I personally regard the insects as of little value in a study of the origin and former connection of our land faunas. Only a day or two ago Mr. Swezey informed me that 26 species of insects had been reported by our entomologists established in the islands within the past few months. How they got here is not known. But such an illustration is enough to show that insects have many means of reaching these isolated islands and for that reason are of little value in an attempt to answer the question involved in the origin of the fauna as a whole.

I have listened with more than usual interest to the discussion here on the origin of our plant life, and it seems to leave in my mind as I believe it does in yours, the feeling that it is necessary for us to have some additional investigations in and about the Pacific in order to account for the origin and dispersal of the plants.

When you turn to consider the existing marine fauna of our Hawaiian waters you will find that all of the zoologists who have worked on it are inclined to think that our marine animals are closely related to, in fact a part of the Indo-Pacific region rather than derived from the American faunas. This too in spite of the fact that the winds and the currents as they exist today set from America and not from the Malay Straits.

Turning to the land again we have in Hawaii a family of birds (Drepanidae) that have no very close relations with any other existing family. Dr. Gadow who has studied their anatomical characters is inclined to think that they are distantly connected with the Tostropidae of Central America. They are however very different in their habits and are not closely allied with them. Moreover this Hawaiian family is broken up into a number of widely diverging genera and numerous island-bound species; so much so that the Zostrops may have had their origin from our fauna rather than our fauna having been derived from Central American sources. Our genus of Chasiemphis on the other hand has its relatives in the old world; Australia for example may have supplied this species to the Hawaiian islands.

It would seem that during the long period of time that the islands of the Hawaiian group have stood so close together—within sight of each other—the birds above all animals, would be able to move freely from one island to another and thus keep its stock uniform. But we find that this peculiar family is broken into genera and the genera into island-species inhabiting only one restricted region or valley. From the breaking up of this group we have in one genus (Oriomistis) a red species in the middle of the group, a greenish one on Kauai, a yellow-green one on Maui and a brownish one on Hawaii and so on through the several genera.

My opinion is that we may have to look further back than the Cretaceous period to find the origin of at least part of the Hawaiian fauna and flora because of the slow processes of evolution. If we attempt to trace out relationships in all fields we are going to find, as Dr. Brown points out with the flowering plants, that there is a wide difference in the relationship of the different groups, often extending across and throughout the Pacific, which indicates to me that there must have been very different conditions prevailing in this ocean in ancient times, with land areas and ocean currents far different from those existing at present.

Rather than regard our Hawaiian fauna and flora as growing up on the islands as an accidental accumulation on a highly isolated volcanic group of barren islands I prefer to believe that these islands have had some land connections, or bridges, and all my study and observation confirm me in that opinion.

These animals and plants must have come from somewhere, and I feel that when we get the relationships and connections worked out we shall find that they have had some definite connections with older continental areas. My feeling is that with Cretaceous coal on the island of Mocha off the coast of Chile, coal in Australia, coal in New Zealand and coal on the little isolated island of Rapa in the middle of the South Pacific we are going to find that more of our plants and animals have originated in the then warm regions of the Antarctic when these regions were doubtless more closely connected than some are now inclined to believe.

I have just returned from Juan Fernandez Islands and Easter Island. The anthropological and biological interest afforded by remote Easter Island almost overwhelms one. This island is but 13 miles long by 7 miles wide and is made up of the remains of three large craters, one in each angle of its triangular outline of the island. On the slopes of these are thirty ash cones of varying sizes. Easter Island appears to have been at a standstill as far as elevation or depression is concerned ever since it rose above the surface of the sea. The long crater slopes have vertical sea cliffs a thousand feet in height, indicating the vast time the island has stood as it is now.

The land animals are exceedingly few, the bulk being insects, a group which unfortunately is of little value in tracing origin or relationships. Most of the species both plant and animal have arrived at the island since it was visited by Europeans. On this island I found no land shells with the exception of one species which appears to be very closely attached to the plant which the primitive Polynesians carried there, according to their legends, for the purpose of making tapa. Of the total list of about 134 species of plants one half have been recently introduced while a number originally found growing on the island, were introduced by the natives themselves even as here in Hawaii. Of the entire list of native plants scarcely one is sufficiently differentiated from near relatives growing elsewhere to make it worthy of a specific name. They all seem to belong to widely varying forms capable of being carried either by wind or by water; yet the island has stood as it is for countless ages as shown by its sea cliffs As it stands it is a fine example of an isolated oceanic volcanic island that has gathered its fauna and flora from accidental arrivals and thus differs greatly from Hawaii. Its land life is as much South American as it is Polynesian.

On the other hand, curiously enough, all the marine animays I was able to collect or observe about the shores of the island have definite affinities with Polynesian and even with Hawaiian fauna. This too in spite of the fact that the currents and winds are from the South American shore much as ours here in Hawaii are from the North American coast. This was not a great surprise to me even though the nearest Polynesian island of any size is more than 1500 miles to the westward, and migration from there would be against the currents and winds. It was what I expected and the reason for expecting it I shall attempt to explain in another connection at a later time.

I went next to the Juan Fernandez Islands where different conditions were met with. The group is composed of two islands. I first visited the outlying one (Mas Afuera). It is ninety miles from Mas Aterra and is six miles in length by three in width and attains an elevation of about 6000 feet. On its eastern side are more than twenty valleys, cut down until their valley floors rise at a grade of ten percent so that at the valley heads you look up 4000 feet at the valley walls. Many of these valleys are so narrow that the sun scarcely ever reaches the bottom.

I found land shells on that volcanic island which more or less closely resemble those found here and are doubtless of Polynesian origin. I found also a well developed flora closely related to that of the larger island (Masa-tierra) which extended in almost every case from the shore to the very summit. In Hawaii we usually get quite different plants at different elevations. It was a singular and significant thing to note the wide range of plants which inhabit that island.

The other island, generally referred to as Juan Fernandez, undoubtedly the last remnant of a submerged volcano, is thirteen miles long, three and one half miles in the widest part, and attains an elevation of 3000 feet. On this island are 60 endemic species of plants many of them very similar to those in Hawaii. I almost lost myself in the mountains under the impression that I was in the Hawaiian woods. That is, I found the animals and plants and their associations and the general conditions of climate very similar to that found here under similar conditions.

The object of my long journey was to test out a theory. As some of you know my wife and I were interested in the study of Hawaiian mollusks. Prior to her death we had discussed the origin of our shell fauna and had come to the conclusion that if the land shells of Juan Fernandez were at all related to those of Hawaii the fresh water shells, should there be any, would tell even more of that relationship, for reasons that I need not enlarge upon here. Knowing that the Juan Fernandez land shells had at least a superficial resemblance to those found here, I thought that it might be worth while making alone the long journey we had planned making together, in order to study the matter carefully on the ground.

Curiously enough I found no fresh water fauna or flora peculiar to that island, although there are a few permenent streams. Still more peculiar especially in comparison with Easter Island is the fact that the animals about its shores are all of South American origin, with the possible exception of the large lobster for which both islands of the Juan Fernandez group are famous, but which does not live on the Chilean coast only 390 miles away.

When one goes as far as I did to find a thing and does not find it he naturally seeks an explanation. It seems to me, from the many different types of indirect as well as direct evidence of submergence that I found there, that there has been profound submergence in that group sufficient enough to cut these two islands apart and isolate their plants and animals. Be it remembered in this connection that these islands were never inhabited by a primitive people and that their winds and currents pass between them and not from one to the other. Personally I am just as satisfied that the whole of Juan Fernandez archipelago went down in a sudden cataclysm as though I had stood by and seen it go. In no other way can you account for its curious mixtures of old land faunas and floras; its marine faunas and its absence of fresh water life. But we want more data. For example, the fishermen tell me they fish over the swirl of water which they believe to be caused by a submerged ridge between the two islands. Moreover they report bottom off shore six to ten miles in several directions in from sixty to ninety fathoms of water.

When I found there a species of Gunnera differing from another species on an island only ninety miles distant and both apparently in the process of still further evolution with the prospect of a submarine ridge connecting the two islands I put it down as pretty good evidence of submergence. When I know that Gunnera also occurs in the Hawaiian islands 6000 miles away I consider it also as an indication of submergence rather than accidental introduction, and so on through a list of connected or related observations both here and there.

When we get to the bottom of this whole matter and the data is finally in, I feel that we shall find there has been a widespread and general submergence in this whole vast region.

SOME PROBLEMS IN HAWAIIAN ENTOMOLOGY

By F. Muir

The chief object of this Conference is to bring together scientists interested in problems of the Pacific with the object of cooperation and mutual assistance. Scientists from the earliest times have formed a brotherhood and entomologists all the world over have banded together for the advancement of their own particular studies.

The Pacific is a huge laboratory where nature has carried on huge experiments in migration, segregation and species formation for enormous periods of time. To understand fully the various processes which have brought about the present entomological conditions in the Pacific it is absolutely necessary to know the conclusions arrived at by workers in other branches of natural science, and to trp to coordinate all our knowledge to form one harmonious plan. This ideal may never be attained but we have to work towards that end.

Entomology, both scientific and economic, is further advanced in Hawaii than in any other islands in the Pacific. It dates back to 1793 when Fabricius, in volume II of his celebrated work "Entomologia Systematica" described two Hawaiian Hymenoptera, *Odyneurus radula* and *Ichneumon fuscata*, collected by Capt. Cook in 1778. Subsequently other early circumnavigators called at the Hawaiian islands and collected a few insects. But we had no adequate idea of the unique fauna until 1876 when the Rev. Thomas Blackburn came to the islands. He resided in Hawaii until 1882 and during that time collected in all the main islands but chiefly around Honolulu. Alone and in conjunction with Dr. David Sharp he described many new species and genera, and other specialists described some of his material. This work roused the interest of naturalists of Great Britain and in 1890 the British Association for the Advancement of Science appointed a Committee "to report on the present state of our knowledge of the Sandwich Islands, and to take steps to investigate ascertained deficiencies in the fauna, with power to cooperate with the Committee appointed for the purpose by the Royal Society, and to avail themselves of such assistance as may be offered by the Hawaiian Government or the Trustees of the Museum at Honolulu." Dr. David Sharp was appointed secretary and

Dr. R. C. L. Perkins was chosen as field explorer. At a later date the Bernice P. Bishop Museum cooperated in the work, and many specialists worked on the material collected. The results of the labors of these men are embodied in the three large volumes of the "Fauna Hawaiiensis." Apart from this work the Proceedings of the Hawaiian Entomological Society contains most of the information published on the insect fauna.

All this work was purely systematic, consisting of collecting and classifying the insects of the archipelago. The economic aspect was never considered. But no activity of the Bishop Museum has been of greater economic value to the territory than its coöperation in the preparation of "Fauna Hawaiiensis" for this work forms the basis of our knowledge of the peculiar conditions of Hawaiian insect fauna, the recognition of which has guided us in the economic work which has been of such great value to our chief industry. Unfortunately it has become popular in some quarters, even among zoologists, to belittle systematic work and to look upon it as holding an inferior position. Either through lack of knowledge or understanding the detractors of systematics are unable to see that it is the one branch of science which cannot be dispensed with since without it one is unable to speak or write on any branch of entomology with intelligence.

In the introduction to the "Fauna Hawaiiensis" Dr. Perkins has reviewed the insect fauna in a masterly manner and, with a commendable caution, has drawn certain leading conclusions regarding several of the main biological problems. For details I must refer inquirers to that work. The first problem with which we are faced in order to acquire a correct understanding of the origin of our insect fauna is the status of the archipelago. Is it purely oceanic or is it continental? The answer to this question will influence all our ideas. In the one case we shall conceive of our fauna as having arisen from a very few immigrants, the endemic families, genera and species having all arisen locally; in the other case we shall think of our fauna as being the remnant of a large and richer continental area.

The question cannot be settled by zoologists alone, nor even by biologists alone; all the evidence must be taken into consideration which geology, hydrography, geography, paleogeography and paleontology can bring to its solution.

The evidence of entomology is overwhelmingly in favor of the oceanic theory. The most striking thing about the Hawaiian fauna is the absence of whole groups and the orders present are represented by only a few families which could have come by flight or by air or ocean currents. To give but a few examples: the whole group of the Lamellicorn beetles is represented by a single genus composed of a few allied species, of Lucanidae, and these are confined to the island of Kauai. The larvae of this family live in rotten or sound wood and could be carried in drifts. The great group of Scarabeidae, whose larvae live in soil and therefore are not likely to be carried in drift, and all of the Phytophaga, whose larvae feed on living leaves and therefore could not come on drift, are not represented at all. These beetles have small power of flight and are too heavy to be carried by wind. The Cincindelidae are also absent. Owing to their specialized habits their larvae could never arrive in drift and the adults could not fly or be wind-borne for long distances. To me one of the most interesting features of this Conference is the amount of evidence that has been brought forward bearing upon this subject; and the outstanding feature of the evidence is the strong support it gives to the oceanic theory. So strong, indeed, is that evidence that I shall consider it as conclusive until such time as the holders of the continental theory can bring forward stronger evidence in support of their theory. That there are cases hard to explain without land connections is possible, but the difficulty of explaining why so much is not here, if we postulate a land connection, is infinitely greater.

The argument for continuous land areas draws its chief support from geographical distribution and the supposed impossibility of certain forms passing over large ocean areas. Upon the last point I must insist on our vast ignorance. The data as to what is carried on floating islands and drift is very small and future expeditions should make careful examination of all such material met with. The amount of insect life washed down with "drift" during floods is enormous and is well known to the birds as well as to collectors. In Australia I have watched the birds patrol the river during floods and take toll from every passing log. It is not every insect washed out to sea that reaches a destination; but only one or a small colony, perhaps, out of the millions set adrift during long ages, survives. For this reason experiments to see if certain beetles could live in sea water are of little value.

The argument from the geographical distribution of genera is based upon the idea that the species of a genus are always of monophylatic origin. That this is so in the vast number of cases is no doubt correct, but I raise the point as to its universality. I will give two examples drawn from Hawaiian Homoptera which appear to break the rule.

Elsewhere[1] I have stated my reasons for considering the authochthonous genera of Hawaiian Delphacidae as having two distinct origins. The ancestors of these two groups arrived separately, one considerably before the other. Both have one character in common, viz., two distinct longitudinal carinae upon the face. Each has given rise to parallel genera having only a single carina on the face. I believe that the genus Nesosydne Kirk arose from Aloha Kirk within the islands. While working over the Delphacidae in the British Museum I found two specimens from St. Helena described by White under the genus Ilburnia which are congeneric with Nesosydne, so I had to sink the latter; there were also two species described by Walker under Delphax from the Galapagos islands which, although not so entirely typical, have to be placed in the same genus. In spite of this disconnected geographical distribution I still hold that the Hawaiian species Nesosydne, or rather Ilburnia, arose locally from Aloha and have only an indirect connection with the species in Galapagos and St. Helena through a widely distributed ancestor closely allied to Aloha if not identical with it.

The second example is taken from the Chermidae (Psyllidae) or Jumping Plant Lice. The genus Kuwayama Crawford differs chiefly from Trioza Foerster by the absence of genal cones. Crawford[2] considers that the three Hawaiian species of Kuwayama have no direct phylogenetic connection with the species of the same genus in other parts of the world, but arose locally from a local Trioza, possibly *T. ohiacola.*

Although such cases may not be very numerous, yet I believe they will be found to be numerous enough to be taken into consideration when discussing geographical distribution and land areas.

Another strange case of goegraphical distribution among the Hawaiian Delphacidae is that of *Kelisia paludum* Kirk. This

[1] Pro. Hawaiian Ent. Soc. III, 3, p. 168, 1916.
[2] Loc. cit. III, p. 445, 1918.

insect was originally described from the islands and considered to be endemic, but during my travels in the Pacific I have taken it in Fiji, Australia, Java, and the Philippine islands and have specimens from Ceylon and India. A study of this insect in its various habitats may show that it has been disseminated by man's agency, along with several plants, and perhaps insects, from the Indo-Malayan region.

When we inquire as to the manner in which the insects arrived in Hawaii we must turn for information to the meteorologist and hydrographer, for the currents of air and water were the chief agents. It is not enough to know how these agents are acting at the present time; one must have some reasonable idea as to how they acted in the past. And here we have to turn to the geologist and paleogeographer. The main currents of air and water are the outcome of physical agents which have acted from the time when the earth took upon itself its present form, but they have been modified by the relative position of land and water. When the land barrier between North and South America was broken down the tropical ocean currents must have been greatly altered. If the coast of northwest South America or west Central America was extended to the northwest, as is postulated by some geologists, then the present currents along the coast of America must have been greatly altered and directed towards the Hawaiian islands. The raising of the Polynesian plateau would also change the present currents considerably. Any or all of these modifications might have made it much easier for insects and plants to have reached the islands.

Dr. Forest Brown in his interesting paper on the "Origin of the Hawaiian Flora" stated that 30 seeds arriving at the rate of one in a million years would account for most of the endemic plants. It would require a slightly higher number of insects to account for the insect fauna. He also stated that the genera in which there were many endemic species, and which are therefore probably the most ancient, have small seeds. Broadly speaking we could parallel this in the case of the insects, with a few exceptions.

In the field of evolution the islands offer some interesting problems; for here a great number of species, many genera and some families have been evolved under conditions more simple (and therefore more likely to be within the understanding of the human mind) than we can hope to find in any other part of the world. There are no reasons to suppose that biological conditions in the islands were ever any more complex than at present; in fact it is likely to have been otherwise.

A study of many of these species indicates that natural selection has played little or no part in the origin of the endemic insects. Many of these are mainly phallic species in which the body (or chrootic) characters have differentiated very little but the male genitalia have differentiated very distinctly and considerably. Elsewhere[3] I have put forward some evidence to support the suggestion that the external male genitalia are the first portion of the insect to reflect any alteration of the germplasm. In other cases (i. e. *Ilburnia cyathodis* and its varieties),[4] we have considerable chrootic differences which might even be considered of generic value with practically no difference in the genitalia. I cannot conceive of these phallic differences being of any selectional value, but having once risen they may be of value as a form of isolation.

Gulick has shown the value of isolation as a factor of differentiation of land shells. The study of the insects leads to similar conclusions. But if hybridization, or the mixing of the chromosomes, at each generation is the only or chief cause of variation, then should not any restriction of crossing by any form of isolation limit variation? If so then large continuous areas with little or nothing to impede migration should be favorable to variation and areas unfavorable to migration, such as mountains and islands, should be the reverse. But this is contrary to all experience.

This is not the place to dwell upon the economic entomology of Hawaii except in so far as it reflects upon wider scientific questions. All of our insect pests are introduced and our chief method of combating them is by the introduction of natural enemies. Along these lines we have been strikingly successful, owing to our unique biological conditions and our knowledge of them. Without the systematic work previously mentioned we could only have worked in the dark; we should not have known whether a pest was a native of the islands or an introduction.

During the last twenty years a great deal has been written on the death factors of insects but mostly along two lines. First a long list of captures has been recorded and experiments on feeding animals with insects have been made. These have been

[3] Loc. cit. III. p. 210, 1916.
[4] Loc. cit. IV, 1, p. 91, 1919.

of great value and have shown us that certain insects are attacked by certain enemies, but they have given us but little insight into the effect such predatory insects might have so far as natural selection is concerned. The second line of investigation has been on injurious insects, mostly where they are very numerous, and therefore free from any great struggle for existence.

In our search for enemies to control our insect pests we have had to study the pest over wide areas where it is held in check by natural agencies, sort out various death factors and experiment with them in the Hawaiian islands. The sugar cane leaf hopper (*Perkinsiella saccharicida*), and its allies have now been studied in Fiji, Australia, New Guinea, the Malay islands of Larat, Ceram, Borneo and Java, the Malay Peninsula, China, the Philippine islands, Formosa and Japan. These studies have taken several years and the observations have been made by several men. The result is to demonstrate that the death factors acting upon these insects are similar in all these regions and that it is the eggs and the young that are destroyed up to as high as 90 to 95 per cent, leaving only 8 to 3 per cent of the adults to fall in the struggle for existence. By introducing some of these factors into our islands and getting similar results to those we find in their native habitat we have demonstrated that these are true death factors. Such experiments carried out on such an extensive scale have to be considered when we discuss the action of natural selection on specific characters. From this point of view our economic work is of great value to biology, for our experiments have been carried on on a larger scale than anywhere else.

The above is but a little of the evidence contributed by Hawaiian entomology towards the solution of some of the problems presented by island life in the Pacific. Unfortunately the vast majority of the Pacific islands at present can produce little entomological evidence toward the solution of these problems as the fundamental work of collecting and identification has not been done.

When one considers how rapidly the natural conditions of so many of the Pacific islands are being swept away by the requirements of modern civilization, one cannot advocate too strongly the immediate prosecution of this work. The manner in which the entomological work in the Hawaiian islands has been done presents a good example of how it should be done elsewhere. Investigation carried on upon purely scientific lines has resulted naturally in immense economic advantages. To try to reverse the method would, I believe, be less satisfactory.

SOME ASPECTS OF HAWAIIAN ENTOMOLOGY

By O. H. Swezey

In presenting to the Conference the importance of entomology in the Hawaiian islands and outlining some of its more salient features, let me say at the start that coming as you have to this so-called "Paradise of the Pacific," those of you who are interested in insects will soon find that this is no "Paradise" for the insect collector. The visitor who has seen or read of the large and showy insects and gorgeous butterflies that have been taken in some groups of tropical islands of the South Pacific, knowing that Hawaii is situated in the tropics, and therefore expecting to find much the same display of insect life here, will be sadly disappointed when he goes into our valleys and mountain forests in search of showy desirable captures.

On the lowlands and cultivated districts, there is apparently a great sufficiency of insect life. The gardeners and agriculturists complain that there are more insert pests here than anywhere else in the world. There certainly are plenty, both in kind and in the number of certain kinds that may be present per plant or tree. There are scarcely more, however, than are usually found in cultivated regions. With very few exceptions, these pests, together with many insects of no economic importance occurring on the lowlands, do not belong to the native insect life, but are immigrants from other parts of the world which have arrived here by some natural means or through the channels of commerce. A goodly number have been purposely introduced of recent years by reason of their being parasites or predatory on those which are pests.

Thus there are two distinct classes of insects as regards their origin and their scientific interest. The scale insects, plant-lice, and other garden and crop pests; the flies, ants, roaches and other domestic insects about our houses, are chiefly immigrants which have arrived here since the coming of the white race to the islands. On the other hand are the really native insects which have developed here through long periods of time, and which are much more numerous in species than the immigrant insects, though much fewer in number per species, and are rarely seen by any except the enthusiastic entomologist who by surmounting many difficulties, and by diligent search in the mountain forests is enabled to find them in small numbers. To be sure there are a certain few native insects to be found on the lowlands which have not yet been supplanted by the immigrant species; but it takes one of experience and familiarity with the native fauna to distinguish between these and the ones which are immigrants.

On account of these two classes of insects (native and immigrant) we have two phases to entomological work: economic entomology dealing with the insect pests and their control, and the study of the native insect fauna which has been found of great interest in many lines. The work of the economic entomologist has been very successful along the line of studying immigrant insect pests in their homelands, and introducing to Hawaii such parasites or other natural enemies as were found efficient there in keeping the pests in check. This kind of work dates back to 1893-1900 when Mr. Albert Koebele, working alone for the Board of Agriculture introduced many valuable ladybeetles and other beneficial insects from Australia and elsewhere. Later on this kind of work was taken up more extensively by the Territorial Board of Agriculture and Forestry and by the Experiment Station of the Hawaiian Sugar Planter's Association, until at the present time no less than a dozen trained men are engaged in one phase or another of economic entomology.

Some of the successful accomplishments of this group of workers in the line of introducing natural enemies for insect pests have been the introduction of a dozen or more ladybeetles and numerous hymenopterous parasites to prey on plant-lice, mealybugs and scale insects; army-worm parasites, leafroller parasites, egg-parasites, and other parasites on the sugar cane leafhoper; several parasites on the Mediterranean fruitfly and the melonfly; the New Guinea Tachinid parasite of the sugar cane beetle borer; the Philippine Scolia parasite on white grubs; and others of minor importance. A recounting of the travels and experiences of the entomologists when in search of these parasites is a long interesting story by itself but cannot be included here. None of these parasites has exterminated the pest, but in most cases the pests are sufficiently controlled by them so that other means of control are not practiced.

Not much interest was displayed in the native insect fauna until the Rev. Thomas Blackburn, who was connected with the Cathederal in Honolulu during the years 1876-1882, collected the native insects quite extensively in the mountains about Honolulu and sent them to England for determination. Mr. Blackburn's pioneer work revealed the highly interesting endemism of the Hawaiian insect fauna, and eventually led to the systematic exploration by R. C. L. Perkins, and the publication of "Fauna Hawaiiensis." This exploration was begun in 1892 and continued for about ten years, and constitutes the most complete entomological exploration of any group of oceanic islands that has yet been undertaken in the Pacific Ocean. As the result of this exploration, 3245 species of insects were listed in the "Fauna Hawaiiensis," 2740, or 84 per cent of the species were considered endemic. These were largely new species whose descriptions appear in the "Fauna." The book is a series of monographs comprising 2391 pages and 81 plates, many of them colored. The greater part of it deals with insects, altho the other classes of land animals are also included—chiefly the Mollusca, spiders and birds.

This work on the insects brought out the main characteristics of the native insect fauna, as well as indicating which families of the different orders are present and what prominence the different ones have in these islands. A brief review of these will serve to indicate to you what is to be found in the way of native insects in our native forests. It will not assure your collecting many of them, however, if you should wish to spend a day collecting in the more accessible mountain forests. One reason for this is that many species are attached to particular trees or plants and unless searched for on their particular hosts will not be found; and it often happens that this tree or plant does not occur in the particular place where one is collecting. The fact that many of the trees are quite limited in their distribution, is a factor of importance in determining the distribution of many of the insects of Hawaii.

Then, too, many of the species occur only on a single island. This feature is most pronounced on the island of Kauai separated from Oahu by a channel about 70 miles in width. Almost its entire insect fauna is peculiar to the island.

The island of Hawaii is much the same, though not to so great an extent. The group of islands,—Maui, Molokai and Lanai,—are separated by channels of about 10 miles and have many species of insects in common, though each has quite a good many that are peculiar to itself, and they also have some that occur on Hawaii and Oahu respectively. Oahu thus has some species in common with the Maui-Molokai-Lanai group and also some in common with Kauai. There are a few which occur on all of the islands.

As an illustration of island distribution of related species, the banana leaf-rollers may be used. These are caterpillars of the genus Nacoleia (*Omiodes*). Six species are at present known to feed on the wild banana plants and probably there are more yet to be discovered. Four of these species are on the wild bananas on various parts of Hawaii, one on Maui, and the sixth species on Oahu and Kauai. In the same way there are lepidopterous leaf-miners on ohia lehua, *Pipturus,* and on many other trees which have different species of their respective genera on the different islands. Many similar examples could be given of the development of different species on the same host tree but on different islands.

Furthermore, many of the known species of Hawaiian insects are exceedingly rare, the description in the "Fauna Hawaiiensis" being based on a single specimen and no others having been collected since. For example: of the 440 species of Microlepidoptera, 25 per cent were described on a single specimen, and 41 per cent on not more than 2 specimens. Much the same situation prevails in other orders, showing that for about half of the species the chances are very small for a collector to obtain specimens.

On the other hand, some species are often found in unusual abundance: for example, a bark beetle (*Proterhinus angularis*) which may be collected by hundreds beneath the bark of dead Straussia trees; a large weevil (*Nesotocus giffardi*) considered rare, whose larvae I once found in hundreds beneath the bark of a recently fallen Cheirodendron tree; a leafhopper (*Ilburnia gunnerae*) found in great abundance on the leaves of the strange plant, *Gunnera petaloidea;* a Prionid beetle (*Parandra puncticeps*) otherwise rather rare, whose larvae were once found in large numbers in dead wood of *Acacia koa;* and of other trees. Such cases occur where the collector was so fortunate as to arrive on the scene at the opportune moment, when these dead trees were in just the right condition to be inhabited by the insects mentioned.

The foregoing is sufficient explanation of why an insect collector unacquainted with the islands will meet with disappointment on his first trip into the mountains, where instead of finding the tropical forest teeming with insect life, he will have to search well to secure much insect material.

The following review of the orders shows which families predominate in the Hawaiian fauna, and which important ones are entirely lacking.

The Hymenoptera are represented by 17 families, or about 18 per cent of the known families. There are 498 species, nearly half of which are Aculeates, and more than half are Parasitica. There are 53 [1] native bees of the family Prosopidae. The native wasps belong to three families: Crabronidae with 18 species; Pemphredonidae with 10 species; Eumenidae with 104 species which chiefly belong to the genus Odynerus. Many species of the latter occur on the lowlands. They all store caterpillars in their nests in the cavities of lava rocks, borer holes in trees, burrows in the ground and in other situations. They serve a very useful purpose in the reduction of leaf-roller caterpillars, some of which are of economic importance.

There is but a single ant that is considered endemic. The other 20 species present in the lowlands are all immigrants, and a few of them are quite annoying about our houses, though we are not yet troubled with the notorious Argentine ant.

Of the parasitic Hymenoptera, Bethylidae is a prominent family with nearly 200 species, most of which are in the genus Sierola.[2] There are a few species of Proctotrypidae. There are 53 Cynipids, but none are gall-makers; they all belong to the Figitidae which are parasitic. Some of the families of the Chalcidoidea have a few species, the greater number falling in the family Encyrtidae of which the genus Eupelmus has 54 species. The Ichneumonidae are chiefly Ophionines with but 31 species.

[1] The figures here given are based on the "Fauna Hawaiiensis." A few species in some of the orders have been added since.

[2] Fullaway, New species of Sierola. Occ. Papers. B. P. B. Mus., vol. VII, No. 7, 1920.

The Braconidae has one native species, but there are a good number of introduced species, both immigrant and those purposely introduced.

Coleoptera is much the largest order with 43 families, or about half the total number represented and 1288 species. Dr. Perkins considers, however, that the real Hawaiian fauna of beetles represents only 17 of these families; the other 26 families being foreign, and represented by only 71 species, or less than 3 species per family. The important families are: Carabidae with 204 endemic species; Staphylinidae 95; Histeridae 34; Nitidulidae 136; Elateridae 76; Anobiidae 134; Cioidae 39; Proterhinidae 136; (this family is peculiar to the Hawaiian islands and all the species are in the genus Proterhinus. One species, however, is known from Samoa, and it may be that more will eventually turn up outside of Hawaii. They are small bark and dead wood beetles related to the Aglycyderidae); Curculionidae 132 species; Cerambycidae 52; Coccinellidae with 2 or 3 doubtful species; Lucanidae with one endemic genus of 7 species, occurring only in a limited area on the high plateau of Kauai. The following important families are absent: Cicindelidae, Buprestidae, Chrysomelidae, Scarabeidae and Bruchidae. The greater number of the endemic beetles are small and obscure. The Carabids are of fair size, but usually not much met with except by searching in special places. The native Cerambycidae are the ones of greatest attraction, and are of respectable size. They are considered prizes when captured; for as there are but a few species of them on each island and as each is associated with particular trees and attacks them at a certain stage of injury, or decay, they are not often met with in ordinary collecting.

Of the Lepidoptera 764 species were listed, nearly equally divided between the Macrolepidoptera and the Microlepidoptera. Of these, 92 per cent were considered endemic. Moths predominate, there being but two native species of butterflies. One is the Kamehameha butterfly (*Vanessa tameamea*) related to the red admiral in the states. The other is one of the "blues" (*Lycaena blackburni*). Both species occur on all the islands and are usually to be seen on a day's collecting trip in the mountains. They rarely come to the sea level. Eight other species of butterflies are to be seen on the lowlands, chiefly common American or cosmopolitan species. The

Sphingidae are worthy of mention with four native forms of Celerio which show relationship to an American species; and one species of Tinostoma whose relationship is not known, and of which but a single specimen has been secured. There are comparatively few families of the moths, the chief among them are: Caradrinidae with 34 species; Hydriomenidae 17; Selidosemidae 39; Pyraustidae 72; Gelechiidae 41; Hyponomeutidae 270; Carposinidae 33; Tortricidae 45; Tineidae 15. Of the 117 genera represented, 37 are endemic and 12 of them belong to the Hyponomeutidae. The most prominent of these genera is Hyposmocoma with 177 species, or 25 per cent of all the endemic Lepidoptera. These are small moths with great variation of color patterns, which run in groups of 6 to 10 species of great similarity. Their larvae are in cases, usually covered with bits of lichen or moss. They occur among mosses and lichens on tree trunks, ferns, rock surfaces, and in hollow twigs, dead branches, etc. This group is worthy of a great deal more study. It is likely that many more species will be found, a considerable number of those now known being described on single specimens.

Neuroptera in the broad sense has 116 species. The most important features of this group are the lacewingflies (Hemerobiidae) with 51 native species, and the damsel flies (Agrion) with 26. Two species of antlion are known. Such families as Trichoptera, Perlidae, Ephemeridae, Mantispidae and Panorpidae are entirely absent.

Diptera has 135 endemic species occurring in but 10 families; Mycetophilidae, Chironomidae, Limnobiidae, Dolichopodidae, Pipunculidae, Sarcophagidae, Anthomyidae, Trypetidae, Drosophilidae and Asteidae. Such important families as Culicidae, Tabanidae, Syrphidae, Asilidae, Muscidae, Dexiidae and Tachinidae are conspicuously absent from the endemic fauna, though in the Culicidae we have three foreign mosquitoes which are sufficient to make up for any lack of native species. The extraordinary development of the Drosophilidae is the most striking feature of the dipterous fauna, there being about 50 species known, and probably many more will yet be found. Most endemic Diptera are small and obscure, the crane flies and the Sarcophagidae being the most conspicuous in size.

Hemiptera has 238 endemic species (which number has been considerably increased since the publication of "Fauna Hawaiiensis") divided nearly equally between the Heteroptera with 110 species and the Homoptera with 128. These figures will be greatly increased by further work in these groups. Most prominent families of the Heteroptera are Miridae, Nabidae and Myodochidae. Six other families have but a few species. In the Homoptera the important families are Delphacidae, Cixiidae, Tettigoniidae and Psyllidae. These are mostly leafhoppers and treehoppers, being largely tree inhabitants instead of living in grass or herbage, and are in the main attached to particular trees. Of late years they have received a good deal of attention and study by most of the local entomologists. The scale insects and plant-lice have many immigrant forms present in the islands, but there are a few mealybugs which appear to be native.

Orthoptera has very few endemic species. Of the 83 species known only about half are endemic. There are no stick insects or mantids except two introduced species of the latter; no true grasshoppers except two foreign ones; of the several roaches and earwigs, there is possibly one of each which is native; the Locustidae has 9 native species, and there are 35 crickets. They are mostly small crickets of the genus Paratrigonidium, but several species are very elongate and belong to an endemic family, Prognathogryllidae. They are the most interesting part of the Hawaiian Orthoptera, being flightless, with very elongate antennae, are nocturnal in habits, concealing themselves in the daytime beneath bark, in holes in decayed wood, or in hollow stems. One must be quick to capture them when they escape on being disturbed.

A peculiar feature in some orders is the presence of certain families represented by a single species, or 2 or 3 species at the most. These are considered to be of more recent arrival than those families with many species, especially those with endemic genera having many species, which would be considered as having developed from ancestors that arrived at a much more remote time.

Flightlessness is quite prominent in some of the orders. A great many of the species of Carabidae are flightless. These all have the elytra fully developed, but have only vestigial wings. A good many in the Homoptera and Heteroptera are also flightless, as are a few species of parasitic Hymenoptera, Diptera, and Hemerobiidae of the Neuroptera.

Since the time of the collecting for and the publication of the "Fauna Hawaiiensis," there has been no one working exclusively on the native insect fauna, but all the entomologists of the several institutions here, working chiefly on lines of economic entomology, have been interested in advancing the knowledge of the native insect fauna. These entomologists have been associated in an organization known as the Hawaiian Entomological Society, which holds monthly meetings for the presentation of papers and the discussion of entomological subjects. This society has been in existence since 1905 with a membership of 20 to 30, including professional entomologists and others interested in the subject. The printed "Proceedings" of the Society has amounted to 1479 pages. It includes quite a number of descriptions of new species discovered and described by various members.

Much interest is taken by the local entomologists in the relation that the Hawaiian insect fauna may have to that of other Pacific island groups, when the latter have been as thoroughly studied, and comparisons can be made with them, and in the bearing that this may have on the solution of such problems as the origin of the Hawaiian insect fauna, also the flora, and the origin of the Hawaiian group itself—whether part of a submerged continent or of independent origin, discussion of which theories I will not enter into here.

A word as to favorable or accessible places for collecting the endemic insects. Near Honolulu, the most desirable places are the trails to Mt. Olympus and Mt. Konahuanui (peaks of 2500 and 3000 feet elevation respectively) in the Koolau Range about 5 miles back of the city. More remote regions accessible by trails are Waiahole, Kahana, Punaluu and Wahiawa of the Koolau Range, and Mt. Kaala (4000 feet elevation) in the Waianae Range. The best collecting is found at 2000 feet elevation and above. An immigrant ant (*Pheidole megacephala*) has played havoc with the native insect fauna of the lower regions, and one must get well above its line of advance. It is probable that some of the endemic species have been exterminated by this ant.

On Kauai, the region above the Waimea Canyon and the high plateau is penetrated by numerous trails. On Maui, the best collecting is on the upper slopes of Haleakala, an extinct volcano of 10,000 feet elevation; also the lower part of the windward forest which is penetrated with great irrigation ditches. The most favorable collecting place of all is on Hawaii in the region of the actve volcano, Kilauea, at an elevation of 4000 feet. Here within easy distance are varying conditions from extreme desert, to very rainy fern forests. More collecting has been done here than at any other one place in the islands, with the possible exception of the immediate vicinity of Honolulu.

SOME ASPECTS OF ECONOMIC ENTOMOLOGY IN HAWAII

By D. T. Fullaway

It is customary in dealing with Hawaiian insects to distinguish between endemic and non-endemic forms, but there is really no hard and fast line between the two; it often becomes difficult to decide whether an insect in hand should be included in one category or the other, and the worker's judgment is taxed to reach a satisfactory conclusion. It appears to me that a more proper distinction would be between early and late immigrants; but our knowledge of immigrants except in a casual way goes back only a very short time, and other criteria than collectors' records are generally used to determine the insect's status with regard to endemicity. It is patent, however, on very limited acquaintance with the fauna, that the endemic insects, or those so-called, play a very small part in the economic life of the country; that the insects of economic importance are almost entirely late immigrants, insects that have appeared on the scene while the agricultural and related industries of the country were being built up. As this development progressed, the endemic insects, dependent for the most part on the endemic vegetation, have receded with it to the more inaccessible places, and the field they have vacated the immigrants have occupied.

A business man in Honolulu was once heard to remark apropos of the advent of some new insect pest "Yes, and all that haven't got here yet are on the way." This was meant to be facetious but it states an actual fact and one of great importance to us. If the insects we have to deal with are practically all immigrants and more are coming all the time, it would appear that our most important and most pressing problem is to find the means to ward them off.

If we had not the great barrier of ocean which surrounds us it might be important to study the means of insect migration more than we have done and develop counter measures; but while some species present here can be accounted for by supposing they have used the natural means of transportation such as flight, drift, etc., it is almost certain that the bulk of our economic species have come on the ships which enter our ports in the pursuit of commerce, and to prevent the entrance of these invaders we have our horticultural quarantine. It seems to me, however, we do not generally realize the commanding importance of this work,—our first line of defence against insect pests. The prosperity of the country demands that it should be tightened to the fullest extent possible by prohibitions, closer inspection and, if necessary, the maintenance of quarantine grounds for plants. The trend of the practice today is in this direction and has every reason behind it when it is considered to what an extent shipping has increased here, how much greater use is being made of our wharves, the development of new lines of travel since the war, etc., etc. It seems to me also that money might be profitably spent investigating the insect pests of the lands whence most of our travel comes for the purpose of preparing a defense in anticipation of their invasion.

I am particularly insistent upon this point in view of our experience with insects that have been anticipated and have eventually gained access to the islands. Their behavior is such that ordinary measures of repression and control are usually fruitless. The reasons for this can be stated in a way. A highly favorable climate and the absence of the usual restraints permit almost continuous breeding which results in an excessive multiplication of individuals. A rapid dissemination follows which can not be checked before the pest has occupied uncultivated, rocky, mountainous or otherwise inaccessible areas. The failure of artificial methods of insect control to give results here, and their general unpopularity I attribute mainly to this peculiar behavior of our immigrant insect fauna. Methods requiring incessant application of expensive measures and failing to give desired results are almost certain to be unpopular. There is no doubt that the great dependence placed on natural control of insect pests in these islands has come about through the success of this method and failure of artificial methods. Experience has shown that it is the method adapted to our needs and to our conditions. This method involves the searching out and introduction of the parasites and predators on our destructive immigrant species in the lands from which they have come. Parasitism and predation among insects is a very common phenomenon which even the layman today is acquainted with and the check which this parasitism exerts on the multiplication of insects is also well known. It should be pointed out here that the same circumstances which prevent the migration of injurious insects to our isolated islands also prevent beneficial insects from reaching us. Likewise the same causes which lead to the rapid spread and excessive multiplication of injurious introductions operate equally on the beneficial ones that prey upon them. The absence of severe competition which immigrants enjoy is also balanced by the freedom from the possibility of hyperparasitism. If the application of this method to the subjugation of an insect pest does not result in a full and complete control of the pest it at least brings its multiplication within such bounds that artificial methods can be used with some degree of satisfaction. The main defect of the method from a practical standpoint is its limited application.

WHAT HORTICULTURAL PLANT QUARANTINE HAS DONE AND CAN DO FOR HAWAII

By Edward M. Ehrhorn

In the early eighties of the 19th century the State of California accomplished a great work—the establishment of a Horticultural Plant Quarantine. At that time the fruit industry of California was growing in bounds and two serious pests, the San Jose scale and the Fluted or Cottony Cushion scale appeared in such enormous numbers as to threaten the deciduous fruit as well as the citrus industry. Both of these insects were of foreign origin. The Commissioners of Horticulture and the fruit growers realized then that to prevent other similar pests from being introduced on foreign plant shipments something must be done and done quickly. Stringent laws were therefore enacted which made possible the control and supervision of all horticultural importations. And it was well that California did pass these laws for the records of the Horticultural Board show that many dangerous pests were found on shipments of plants from all parts of the world which would no doubt have become established in the State but for their strict examination and destruction at the port of entry.

Since 1904 the Territory of Hawaii has followed the good example of its coast neighbor and through stringent laws has prevented many dangerous insect pests and plant diseases from gaining a foothold in these islands.

Most of the injurious insect pests now found in Hawaii affecting the various field and garden crops and other plants as well as stored products are of foreign origin. Barring a few cosmopolitan species, these pests have been introduced from countries surrounding or situated in the Pacific Ocean. The same may be said of the mainland of the United States; there, however, we also find pests from countries bordering on the Atlantic Ocean.

The Commissioners of Agriculture and Forestry in Hawaii, fully realizing the importance of absolute control and knowing of the existence of dangerous pests such as fruit flies and cane insects prohibited the importation of all fruits and sugar cane from the East or West Indies, Asia, Australasia, Oceanica, Malaysia, Mexico, Central and South America.

When we consider the enormous army of destructive pests scattered all through the lands of the Pacific Ocean only waiting a chance to gain admission here, Hawaii may well be considered fortunate in having so few insect pests attacking its most important crop—sugar cane. From a record of the United States Department of Agriculture "A Manual of Dangerous Insects Likely to be Introduced in the United States Through Importations" we find that sugar cane insects alone not at present known here in these islands run into hundreds of species. Of the well-known pests, there are 10 species recorded from Java, India, Formosa, and adjacent territory, represented by Red Spiders, Froghoppers, Tenebrionids, Scarabeids, Buprestids, Chrysomelids, Pyralids, and Tortricids. Among other important sugar cane pests of record, not thoroughly studied as to their spread, habits and destructiveness, we find 50 pests belonging to the Lepidoptera, 25 to Coleoptera, 50 to Jassids and Fulgorids, 21 to Coccidae, 21 other Homoptera, 27 Locustidae and 7 Gryllidae.

Our second important product—the pineapple—is attacked by only two scale insects which might be considered troublesome, especially if clean culture methods are overlooked. This is indeed very fortunate if we glance over the long list of pests that remain outside of our country. In the Pacific lands there are a number of serious pests of the pineapple among which a fruit fly, *Dacus xanthodes* of Fiji would prove very destructive if it were ever introduced.

I could go on indefinitely, taking up the citrus, mango, avocado, coconut, fig, forest trees generally, garden crops and forage crops, and from records at hand show that each one has many injurious pests which have not gained entry here.

We are again fortunate since the quarantine rules of the Federal Horticultural Board of the United States Department of Agriculture have been enforced, for under these regulations very few plants can be imported into the United States and its territories.

Since the organization of the Federal Horticultural Board much time and study has been devoted to acquire better knowledge of the dangerous pests of agriculture in the countries where these pests are known to exist and it has been possible at first hand to study and report their bearing on the future success of plant quarantine. In Hawaii the Board of Agriculture and Forestry and the Hawaiian Sugar Planters' Association have sent entomologists and plant pathologists to the various countries in the Pacific in search of enemies of our most destructive pests, and these men have not only accomplished that which they sought to accomplish, but have had a great opportunity to study a few of those pests which it is absolutely necessary to keep out of Hawaii. However, we need more such work; we have just touched the border. The more we know about the pests injurious to our crops the better off we shall be, and we should continue research on this problem and should endeavor to establish the most cordial coöperation with our fellow-workers of the countries of the Pacific.

MISCELLANEOUS PAPERS ON BOTANY

CULTIVATED PLANTS OF POLYNESIA AND THEIR VERNACULAR NAMES, AN INDEX TO THE ORIGIN AND MIGRATION OF THE POLYNESIANS

By William E. Safford

Erroneous theories relating to the physical geography of the Pacific Ocean and the origin of the Polynesians have been perpetuated by recent popular writers. Some of these assert that the Pacific islands are the vestiges of an ancient continent which sank beneath the waves leaving only the peaks of the highest mountains above the surface. The natives of these islands have been divided into several ethnological groups, one of which, the true Polynesians, includes the Hawaiians, the Maoris of New Zealand, the Samoans, Tongans, Rarotongans, Marquesans, and Easter Islanders, the last named inhabitating a small volcanic islet at the southeast extremity of Polynesia, situated in longitude east of the meridian of Salt Lake City. Among the absurd theories above referred to is one which holds that the Polynesians are of Caucasian origin; another hints that Easter Island was formerly inhabited by some mysterious race distinct from the Polynesians and suggests a Melanesian strain in the natives; while one writer asserts a connection between the inhabitants of the Peruvian Andes and the authors of the curious inscribed wooden tablets found on the islands, which he pretends to decipher.

In attempting to trace the origin of the Polynesians one of the most certain guides is the study of their economic plants together with the vernacular names applied to them in the various island groups. Some of these plants are important food staples; others are used for making intoxicating drinks; others for cordage or textile purposes or as a source of dyes or pigments. The range of some species is restricted to the more tropical islands while others occur throughout Polynesia. I shall first speak of the species which have found their way across Polynesia to Easter Island, which from an ethnological point of view is perhaps the most interesting island of the Pacific Ocean. Among the plants introduced into this island in prehistoric times, are a number whose vernacular names are identical with the same or similar species in Hawaii. Many of them may be traced to the Malay Archipelago, the cradle of the Polynesian race. Following is a list of the most important economic plants of the Easter Islanders together with their botanical names: *taro* (*Colocasia antiquorum*), called *kalo* by the Hawaiians, in whose language the *t* of southern Polynesia becomes *k*, the *r* becomes *l*, and the primitive *k* is indicated only by a break between vowels; *kape*, or *kapi* (*Alocasia indica*), the giant acrid taro called *'ape*, or *'api*, by the Hawaiians; *toa* (*Saccharum officinarum*), sugar cane, called *ko* by the Hawaiians; *meika* (*Musa paradisiaca*), the banana, called *mai'a* by the Hawaiians; *ti* (*Cordyline terminalis*), the well-known *ki* of the Hawaiians, who make from its root an intoxicating drink; *hara* (*Pandanus tectorius*), the *hala* or *lauhala* of the Hawaiians; *pia* (*Tacca pinnatifida*), the Polynesian arrow-root, which is called by the same name in Hawaii; *uhi* (*Dioscorea alata*), a yam whose vernacular name is identical with the Samoan *ufi*, the New Zealand *uwi*, the Madagascan *obi* and the Malayan *ubi*, applied to the same and kindred species, as well as with the Hawaiian *uhi* which is applied to the yam-like root of a species of Smilax; *hue* (*Cucurbita lagenaria*) a gourd, the fruit of which, called *ipu*, is utilized for water-bottles or food-containers, also called *hue* and *ipu* by the Hawaiians; *maute* (*Broussonetia papyrifera*), the paper mulberry of which the Polynesians make their tapa cloth, called *aute* by the Tahitians and New Zealanders and *wauke*, or *oauke* by the Hawaiians. The very name applied to Easter Island itself, *Te Pito o te Henua*, is etymologically identical with the Hawaiian *Ka Piko o ka Honua;* and just as in Hawaii land is called *honua* or *'aina*, so in Easter Island it is *henua* or *kainga;* the Hawaiian *uka* and *kai* in *mauka* (landward) and makai (seaward) are identical with the Easter Island *uta* and *tai*. The Hawaiian *'a'ole* (no) becomes *kakore;* and *lani* (heaven) becomes *rangi; aloha* (love) becomes *aroha* and *'oe* (you) becomes *koe*.

I ask indulgence for this digression. I could not refrain from pointing out the relationship between the Easter Islanders and the Hawaiians. The very close resemblance between their languages is remarkable in view of the enormous distance which separates them. I could go farther, in presenting to you their remarkably parallel calendars or system of dividing the lunar month, the identity of their divinities, their systems of taboo, etc., but I will refrain. I must, however, say here that there is no indication either on Easter Island or in Hawaii that the present inhabitants were preceded by people of a race distinct from the Polynesians. Easter Island is so far removed from the equator that certain staples of the more tropical islands of the Pacific will not grow there. The most important of these are the coconut and the breadfruit, both of which are Asiatic plants which accompanied the Polynesians in their migrations, and have been established in all climates which will permit them to live. Another important Polynesian plant conspicuous for its absence in Easter Island and New Zealand is the narcotic *kava* or *'awa* (*Piper methysticum*), the roots of which are used for preparing an intoxicating drink.

The coconut (*Cocos nucifera*) now so widely spread in the tropics, is called *niu* throughout Polynesia, a name easily identified with *niug* or *nivog* of Guam and the Philippine Islands, and with *nior* or *niyor* of certain islands of the Malay Archipelago. Precolumbian writers, including Marco Polo, referred to this fruit as the *nux indica* and called attention to it as an important source of oil. There is no evidence that it reached America before the Discovery. Its buoyant husks render its transportation by ocean currents possible yet in most cases it has undoubtedly been spread through human agency.

Bananas and the seedless breadfruit were carried from island to island in the form of sprouts or suckers, and sugarcane in cuttings. The identity of the Hawaiian names of these plants with those of southern Polynesia is most significant. They are all found in Guam and the Philippines, and must have come from the Malay Archipelago. On the other hand the paper-mulberry is probably of Japanese origin; the tapa made from its inner bark is in reality a coarse paper. The *ti* plant and the *'awa,* or *kava* pepper, were in all probability encountered by the Polynesians after they had entered the Pacific. The Maoris of New Zealand have certain legends conected with the *ti.*

Several of the most conspicuous trees of Hawaii now growing spontaneously were undoubtedly introduced in prehistoric times. Among them are the *kukui,* or candle-nut (*Aleurites moluccana*) which covers the mountains back of Honolulu like pale green tapestry; the *kou* (*Cordia subcordata*) from which the ancient Hawaiians made some of their most beautiful poi-containers; the *ohia* (*Eugenia malaccensis*), the fruit of which is edible; the milo (*Thespesia populnea*), also the source of a beautiful wood from which "calabashes" were formerly made; the *kamani*, or *kamanu* (*Calophyllum inophyllum*), which yields an aromatic gum; and the *hau* (*Hibiscus tiliaceus*), the source of an important bast fibre. All of these trees occur in Asia, some of them are now of world-wide distribution. The origin of the kukui is indicated by its specific name *moluccana.* The name "kukui" is derived from the fact that its oily nuts are "*kukuied,*" or strung together, to form candles; in Samoa it is called the *lama,* or torch tree. The Hawaiian name *kou* is identical with the Samoan *tou,* applied to the same species of Cordia; the name *milo* is widely spread; in Easter Island it is applied to a leguminous shrub in the form of *toro-miro;* and similarly *hau,* the name of *Hibiscus tiliaceus* is applied to a distinct species of the mallow family from the bark of which a textile fibre is prepared. The variations in this name are most interesting; in Samoa it becomes *fau,* and is applied also to certain Urticaceous plants yielding fibre; in Guam it becomes *pago;* and in the Philippines *bago,* or *balibago.* The handsome glossy-leaved *kamanu,* called *tamanu* in southern Polynesia, is identified with the "Alexandrine laurel" of India.

From the evidence here offered it is certain that the principal economic plants of the Polynesians are from Asia, whence they accompanied the Polynesians on their migrations. Corroborating this evidence by that of comparative philology, which shows that nearly all the primitive words, or names of natural objects in the Polynesian dialects can be traced to the Malayan archipelago, we can share with confidence the belief of the Rev. George Pratt, who devoted forty years to the study of the Polynesians and their language. According to this distinguished scholar the Polynesians must have migrated before the primitive Malay language had become corrupted by the inundation of the Arabic and by the introduction of Sanscrit words from India. Just as the Arabic became softened by Malay influence so, he suggests, the Malay language may have been hardened by Arabic influence, changing such words as the primitive *langi* (sky) to the modern Malayan *langit;* ika (fish) to *ikan; ua* (rain) to *ujan; ala* (road), to *jalan; afii* (fire) to *api.* Whether or not the Polynesian dialects were derived from the Proto-Malayan, it is quite certain that these languages had a common origin, and it is very probable that the ancestors of the Polynesians were closely related to those of the brown people now inhabiting the Moluccas and Celebes, whom they resemble in both physical appearance and in language.

NEW ZEALAND'S CALL TO THE BOTANIST

By Charles Chilton

New Zealand lies in the South Pacific Ocean, separated from Australia by the deep Tasman Sea about 1200 miles wide. The two large islands, north and south, extend from about lat. 35°S to 46°6'S, the main axis of land being about 1000 miles in length.

In addition to the two large islands, and those that are immediately adjacent to them, there are numerous other outlying islands included in the biogeographical region of New Zealand as defined by Hutton in the Index Faunae Novae-Zealandiae. These include the Kermadec Islands to the north, the Chatham Islands to the east and the Antipodes, Bounty, Lord Auckland and Campbell Islands to the southeast. Macquarie Island still further south is included in the area defined by Hutton and is certainly more nearly related biologically to New Zealand than to any other large area of land, though its fauna and flora have a decidedly Antarctic aspect; and politically it is under the control of Tasmania. The Cook Islands and the Samoan Islands that previously belonged to Germany are now under the jurisdiction of New Zealand and their possession emphasizes New Zealand's connection with the Pacific and with the scientific problems connected with that ocean.

The coast line of New Zealand is greatly indented and irregular and in consequence is of great length compared with the enclosed land area. Within comparatively short distances it shows great variety of rocky cliffs, sandy beaches, wooded shores, tidal bays and mud flats. The land surface extends from sea level to mountains reaching to a height of 12,000 feet and includes extensive plains, some presenting features of deserts, others rich well-watered lands, swamps, rivers and large fresh water lakes. Consequently the vegetation varies exceedingly and shows greater diversity than can be met with in any other portion of the globe of similar area. Much of the surface and of its vegetation has been greatly altered by civilization and cultivation, but on the mountains and in the great valleys, especially on the west coast of the South Island, the native forest remains almost untouched and the indigenous flora unchanged and never likely to be entirely destroyed.

Outlying islands near the coast have been set aside as animal and plant sanctuaries. They have been separately selected so as to be suitable for as many different kinds of animals and plants as possible. These sanctuaries are Little Barrier Island, off the coast of Auckland, Kapiti Island near Cook Strait, and Resolution Island off the southwest of Otago. In addition to these there are large national parks around some of the mountains and along the courses of some of the rivers, where an attempt is also being made to preserve the indigenous flora. The rainfall as a whole is abundant, but shows great variety in different parts. For example in the Canterbury Plains near Christchurch it is about 25 inches per annum only, while at Otira, on the western slopes of the Southern Alps, only 80 miles away in a direct line, it may be 190 inches. So varied are the conditions for plant growth that Dr. Cockayne in endeavoring to divide the area botanically had to establish no less than fifteen botanical regions.

The flowering plants and ferns have already been pretty carefully surveyed and dealt with from a systematic point of view, and most of the species are probably already known, though some additional ones doubtless remain to be discovered and the relationships of those already named require much further investigation. In the lower plants, like the algae and fungi, the field is much more unexplored. The relationship of the New Zealand plants to those on the islands to the south of New Zealand and on other subantarctic islands has been dealt with somewhat fully by various investigators, but it will be necessary to know much more accurately their distribution on these islands and their affinity to the former plant covering of the Antarctic Continent, before final conclusions can be arrived at. Similarly as regards the plants that may be supposed to have reached New Zealand from the north a wide field of inquiry lies open and the relationship of the New Zealand species to those on Lord Howe Island, Norfolk Island, New Caledonia and New Guinea offer a fruitful field for further investigation. Particularly would a careful comparison of the special features of the New Zealand flora with those of the Hawaiian islands, which, like New Zealand, have long been separated from any large area of land, be likely to afford interesting and valuable results as to the method by which such isolated areas have become covered with plants.

A good foundation for a knowledge of the ecology of New Zealand plants has already been laid by several writers, but the clothing of the shingle slips, river beds and shingle fans in the subalpine regions and denuded areas in the volcanic regions presents botanical problems that can perhaps be studied with greater economy of effort and labor in New Zealand than in any other country. The Canterbury College Mountain Biological Station at Cass, situated at a height of 2000 feet above sea level, offers special facilities for work on some of these problems.

Many interesting results may be expected from a careful examination of the species that have been introduced and of the reasons that have enabled some to spread widely while others remain restricted in area. The contest between the introduced species and those indigenous to New Zealand should give opportunities for observations and conclusions likely to be of wide application in questions concerning the distribution of plants. The wide extent of country and the varied character of the climate permits of the production of many plants of economic value, but as yet very little has been done in the way of experiment to ascertain what products could be profitably grown between the wheat, oats and other crops of the agricultural farm.

Particularly is it necessary without delay to ascertain whether the native forests of New Zealand can be treated so as to yield a continuous supply of timber and how far it will be necessary to supplement them by the introduction of timber trees from other countries.

Past experience elsewhere has conclusively shown that these problems can be profitably solved only by acquiring a wide and sound scientific knowledge of the plants dealt with and of the conditions under which they grow, though investigations of the kind may apear at the time to have no bearing on economic problems.

The following list contains a few of the chief works dealing with New Zealand botany. From them references to others can be readily obtained.

Transactions of New Zealand Institute, vols. 1 to 52, 1868-1920.
Hooker, J. D., Flora Novae Zealandiae, 1853-55.
Hooker, J. D., Handbook of New Zealand Flora, 1864.
New Zealand Journal of Science, 1882-1885, 1891.
Kirk, T., Forest Flora, 1889.
Kirk, T., Students' Flora of New Zealand, 1889.

Cheeseman, E., Manual of New Zealand Flora, 1906.
Laing and Blackwell, Plants of New Zealand, 1906.
Subantarctic Islands of New Zealand, vols. 1 and 2, with bibliography, 1919.
Cockayne, L., New Zealand Plants and Their Story (new edition), 1919.

COMMENT BY MR. SAFFORD

New Zealand's call to the botanist is indeed alluring not only to the systematist and the student of phytogeography but to all those interested in the origin and uses of cultivated plants. During our recent excursions in the mountains of this island, the members of the Section of Botany have been impressed by the comments made by New Zealand delegates on certain similarities between the flora of Hawaii and that of New Zealand, in some cases the similarity extending to the vernacular names of plants of the same genus or plants more or less resembling each other. Thus on encountering the climbing screw-pine (*Freycinetia arnotti*) and hearing its local name *ieie*, they would exclaim: "Why, we too have a Freycinetia and we call it *kiekie!*" On seeing the natives gathering the fragrant myrtle-like *maile* (Alyxia) for making *leis*, or garlands, they recognized its name as being identical with their own *maire*, which in New Zealand is applied to certain plants with glossy myrtle-like leaves. In the same way the name awa, applied to the narcotic *Piper methysticum* by the Hawaiians, becomes kawa-kawa in New Zealand, where it is used to designate an allied plant, *Piper excelsum*. This, though not narcotic, is pleasantly aromatic and stimulating and is used as an anodyne for toothache. The name *ti*, applied to *Cordyline terminalis* is in New Zealand used for many species of the same genus, including this one, so dearly beloved by the Hawaiians. In ancient times it was an important food plant of the Maoris, and may still be found in their abandoned plantations. Another food plant used by both the Maoris and the Hawaiians and bearing the same name is *taro*, the starchy root of which is here the source of poi. The large gourd, *Cucurbita lagenaria*, is called *hue* in both New Zealand and Hawaii, and the food receptacles and drinking cups made from its shells are called *ipu*. *Uhi*, the name for yam (N. Z. *uwhi*) is applied to the potato and to the edible starchy root-stock of a fern (*Marattia fraxinea*). The genus Pandanus does not occur in New Zealand, but the Maori name *whara*, applied to floor-mats, is easily identified with the Hawaiian *hala* and the Samoan *fala*, from which mats are braided. The *hau (Hibiscus tiliaceus)* and the *milo (Thepesia populnea)* are also absent from New Zealand, but their names in the form of *whau* and *miro*, are applied by the Maoris to other plants resembling them either in the form of their leaves or in the texture of their wood. The paper-mulberry, called *wauke* by the Hawaiians and *aute* by the Maoris, was used by their common ancestors as a source of bark for tapa-making. This plant is no longer used in New Zealand, and is there almost extinct. All of these plants originated in the Eastern Hemisphere; but *Hibiscus tiliaceus*, an important source of cordage and *Cucurbita lagenaria* furnishing "calabashes" to primitive people, had found their way to America in precolumbian times. The only American plant of economic importance which reached the Polynesians before the days of Captain Cook was the sweet-potato, called *kumara* in New Zealand and *uala* in Hawaii. It is interesting to note that taro, ti, and the paper-mulberry were also cultivated by the Easter Islanders who called them by the same vernacular names; and the natives of the last-named island, *Te Pito o te Henua* (*Ka Piko o ka Honua*), also cultivated the sweet-potato and called it *kumara*. It is quite probable that this species first established itself in the Pacific on certain islands of southwestern Polynesia. We know that it had not reached Guam nor the Philippines before the voyage of Magellan. To both the Mariannes and the Philippines the sweet-potato was brought by the Spaniards from Mexico with its Aztec name *camotl,* or *camote.*

Apart from the botanical interest which the cultivated plants of New Zealand and the various island groups of Polynesia may have, their vernacular names demonstrate, in a most striking manner, the homogeneity of the Polynesians and point to Malaysia as the cradle of their race.

THE FIELD LABEL IN BOTANY

By Elmer D. Merrill

If we critically examine any herbarium we invariably find that the herbarium sheets present almost no data other than those currently recorded, the scientific name, collector, locality, and data of collection. Special notes, local names, economic uses, etc., are either not recorded by collectors or if recorded are contained in notebooks and as a general rule such data is not transferred to the herbarium sheets. As a result most herbaria are not fulfilling their proper functions and are almost never consulted by other than systematic botanists on account of the dearth of data other than that valuable to systematists.

Current methods of field work and current methods of recording data regarding individual collections must be modified if the large older herbaria and the new herbaria now being built up are to be made more generally useful. It is believed that this end can be gained by adopting a simple method of field labels on which economic data may be recorded in the field, these field labels to be attached to the mounted sheets so that all the original data are at once available to those consulting the collections. This method has been developed in the Philippines with the most admirable results so that the large herbarium of the Bureau of Science is now not only an index to the systematic aspects of the Philippine flora but also to the economic aspects as well. The collections are consulted not only by systematic botanists but also by foresters, individuals interested in economic botany, philologists, and others because the data such individuals desire are all available in the herbarium.

The field label idea has been developed not only for the use of the trained collector, but also with a view to the needs of the untrained individual, indicating in a simple manner the data that should be recorded with each individual collection. Through its use it has been possible to assemble a vast amount of economic data, such data as is in general not available in the herbaria of the classical type. The form given herewith (fig. 1) is that adopted for the current botanical work of the Bureau of Science and may be modified to meet the local needs or for any specific purpose. The original label is placed with the specimen when it is arranged in the press for drying, remains with the specimen during all stages of preparation, and is finally attached to the upper left hand corner of the mounted herbarium sheet.

FLORA OF THE PHILIPPINE ISLANDS.
HERBARIUM, BUREAU OF SCIENCE.

Common name .... ***Dialect*** ....

Field No. .... ***Herbarium No.*** ....

Collector ....

Island or Province ....

Locality ....

Habitat ....

....

Altitude above the sea .... ***meters.***

Tree; shrub; bush; vine; herb ....

Height of plant .... ***M.***

Diameter, breast high .... ***Cm.***

Flower ....
(Odor, color, etc.)

....

Fruit ....
(Kind, odor, color, etc.)

Special notes ....

....

Economic uses ....

....

2—569

Date ....

FIGURE 1. Field label used in the herbarium of the Philippine Bureau of Science. Reproduced full size.

Through its use it has been possible for the Philippine Bureau of Science to utilize the services of scores of individuals, often untrained natives, both in and out of the government service, in compiling valuable economic and ethno-botanic data. Forms have been freely distributed to amateur botanists, foresters, rangers, missionaries, teachers, ethnologists, geologists and others, and the results obtained have really been marvelous. By supplying small collecting outfits and field labels we have been able to secure from non-botanical expeditions very extensive and valuable collections which otherwise would not have been made, not because the non-botanical individuals were not interested in securing botanical material but because they had no knowledge of how to prepare specimens, a very simple process, or how to record notes.

This brief paper is presented chiefly for emphasizing the great value and eminent utility of field labels in current field work in botany and to impress on the members of non-botanical expeditions the great desirability of their coöperation in collecting botanical material in the more isolated and little-known parts of the world. With very slight additional equipment any expedition into Polynesia will be in a position to secure exceedingly valuable botanical material and with the use of simple field labels record the data desirable from the standpoint not only of systematic botanists but also the biologists, the entomologists, the philologists, the foresters interested in purely economic phases of botany.

SOME RECENT INVESTIGATIONS ON THE FLORA AND PHYTOGEOGRAPHY OF JAPAN AND ADJOINING REGIONS

By K. Shibata

The following paper is not offered as a thesis, but is intended to present a brief survey of recent phyto-geographical and floristic works by Japanese botanists together with a discussion of their salient features bearing upon problems connected with Pacific regions.

As is well known, Japan is a very much extended country in latitude as well as in altitude, and has consequently a wide range of variation in climatic, soil, and other conditions. The extraordinary richness in plant life thus brought about has long been the object of eager studies by many foreign and home botanists, among whom might be mentioned in this place Kaempfer, Thumberg, Miquel, Siebold, Maximowicz, Frantiet, Yatabe, Matsumura, Miyabe, Makino and others. The decided progress in the floristic exploration of our land made in these decades is borne out by the fact that Matsumura was able to enumerate more than 7000 species of vascular plants, belonging to 194 families, in his "Japanese Names of Plants," published a few years ago. Though our knowledge of lower forms of plants occurring in Japan is far from complete, we may still add to the above numbers some one thousand species of marine and fresh water algae (excluding diatoms) and three thousand five hundred species of fungi and bacteria. Thus the total number of plant-forms hitherto known from Japan considerably exceeds 10,000.

As the floristic investigations of our territories, Korea and Formosa, have been pursued in recent years with remarkable success, an up-to-date statistical representation of results attained might be of some interest. At my request, Dr. T. Nakai, the government botanist of Korea, has summarized his studies in the following table. (The figures in parentheses indicate the number of endemic forms):

	Number of			
	Fam.	Gn.	Sp.	Var.
Pteridophytes	12	42	206 (17)	15 (4)
Gymnosperms	2	10	21 (4)	
Monocotyledones	20	175 (1)	633 (62)	100 (45)
Archichlamydeae	82	373 (3)	1301 (218)	240 (100)
Metachlamydeae	35	214 (2)	698 (127)	81 (147)
Total	151	814 (6)	2859 (428)	436 (296)

Previous to the work done by Nakai, some 1400 species belonging to 130 families and 550 genera were known from Korea through the investigations of Palibin, Komarow and others. The most noteworthy plant found by Nakai is *Hanabusaya asiatica nov. gen. et nov. sp.*, a perennial herb with beautiful blue-violet flower, belonging to the family Campanulaceae. Among the arboreous elements, composing one-fourth of Korean flora, a new salicaceous genus, Chosenia (Chosen being the Japanese designation of Korea) was made known by the same author, quite recently.

Concerning the Formosan flora, a statement similar to the above can be made. In 1896 A. Henry enumerated about 1400 species in his "List of Plants from Formosa." Since the acquisition of the island, in 1897, Japanese botanists began to pay attention to the flora of Formosa and made several collecting trips thereto. In 1904 Dr. B. Hayata started, under the government's auspices, a vigorous botanical survey of the island, assisted by many able collectors. He publishes results of his investigations, since 1911, in annual volumes entitled "Icones Plantarum Formosanarum" and with the ninth volume of this work, just issued, the number of flowering plants and vascular cryptogams can be summed up as follows: 169 families, 1185 genera and 3608 species, among which some 1200 are new to science. Some of the families containing the largest numbers of species are:

Polypodiaceae	442	species	belonging to	50	genera
Gramineae	213	"	"	" 79	"
Leguminosae	184	"	"	" 62	"
Compositae	143	"	"	" 57	"
Cyperaceae	126	"	"	" 20	"
Urticaceae	108	"	"	" 30	"
Euphorbiaceae	86	"	"	" 31	"

The most remarkable plant found by Hayata is a new coniferous tree, named *Taiwania cryptomerioides,* which grows in the Middle Formosa mountain range at an altitude above 7000 meters, and attains great dimensions, exceeding not rarely a height of 30 meters and a diameter of 2 to 3 meters. Other interesting new genera are: Arisanorchis, Parasitipomoea, Polliniopsis, Dolichovigna, Pseudosmilax. The discovery of a new species of Archangiopteris, an old marattiaceous fern, and also of Mitrastemon, a curious parasite belonging to Rafflesiaceae, deserves special mention.

The phytogeographic studies, or the determinations of floral regions, along with the pursuit of their inter-relationship, involve a more vexed problem than mere enumeration of existing plant-forms. The distribution of plants in certain regions is influenced not only by climatic but also by historic factors. Taking all the available data in account, we may divide Japan in four floral regions, namely:

1. Arctic Region, consisting of Sakhalin, Kurile Islands and northern half of Hokkaido (excepting certain coastal districts).

2. Temperate Region, extending from south of the above toward Northern Honshu to about 38 degrees N. L.

3. Subtropical Region, comprising the part of Honshu lying south of 35 degrees N. L., Shikoku, Kiushiu and southern islands reaching to Okinawa. The middle part of Honshiu lying between 35 degrees and 38 degrees N. L. is of an intermediate character, being either temperate or sub-tropical according to the distance from sea-coast and to the elevation.

4. Tropical Region, consisting of the lowland of Formosa with adjoining islands and Bonin Islands.

The above mentioned regions are most conveniently characterized by arboreous elements, of which there are estimated to be about 600 species in Formosa and 740 in Japan proper.

1. In the Arctic Region are found *Picea ajanensis, P. Glehni, Abies veitchii, Abies sachalinensis, A. mariesii, Pinus pumila* and *Larix dahuricatin saghalien,* together with deciduous trees, such as Salix-, Betula-, Alnus-species and small shrubs belonging to such genera as Vaccinium, Ledum, Phyllodoce. The herbs belonging to Senecio, Cacalia, Petasites, Angelica, and other genera which show often a vigorous vegetative growth, are also characteristic of this region.

2. In the Temperate Region deciduous trees such as Fagus, Quercus, Ulmus, Juglans, Salix, Populus, Prunus, Acer, Fraxinus, and the conifers, Pseudutsuga, Thujopsis, Thuja, Chamaecyparis and Crytomeria are common.

3. The Subtropic Region is characterized by conifers, Podocarpus and Pinus Thunbergii, and by many evergreen trees, belonging to Quercus, Pasania, Cinnamomum, Ilex, Eurya, Sym-

plocos, Camellia, Evonymus, Pittosporum, and other genera. Many plants, for example, *Abies firma, Tsuga sieboldi, Pinus* densiflora, Carpinus, Zelkowa and Cornus are found in both regions, forming somewhat transition elements.

4. The south end of Formosa, reaching to about 22 degrees north latitude. A really tropical vegetation thrives in this region, having several Ficus-species, *Bischoffia japonica, Calophyllum inophyllum, Garcinia multiflora, Terminalia catappa,* Eugenia-, Palaquium-, Hibiscus-, Acacia- species, palms, mangroves and many others as representatives. Bananas, pineapple, sugar canes, coffee, rubber trees, teak and other useful plants can be grown. The small islets of the Bonin group, showing tropical features in their vegetation, seem to contain several endemic plants, which deserve careful study from the modern point of view of the evolution of plants. The ethnologically interesting island Botel-tobago, lying east of the south end of Formosa, was botanically explored by Kawakami and others and some 430 species of flowering plants and 70 species of fern-allies are recorded from there.

As to the vertical distribution of vascular plants, distinction of zones analogous to the above stated horizontal regions can be made. At Mt. Morrison, Middle Formosa, the subtropic forest-zone lies between 500-1800 M. altitude, and consists of ever-green trees of such genera as Cinnamomum, Quercus, Castanopsis, Machilus, Trochodendron. The zone higher up to 3000 M. is occupied by the temperate forest, which contains luxuriantly growing conifers, such as *Chamaecyparis formosensis, Picea morrisonicola, Tsuga formosana,* intermingled with Fagus, Juglans, and other genera. The area above the 3000 M. limit belongs to the so-called sub-arctic zone with *Abies kawakamii* as the characteristic element. In Shikoku and Honshiu subarctic coniferous trees, such as *Abies veitchii* and *A. Mariesii* grow at an altitude above 2000-1000 M.

The distribution of bamboo plants in different floral regions is of special interest. The large bamboos, Dendrocalamus and Bambusa, are found in the tropical region of Formosa, whereas Phyllostachys- and Arundinaria-species thrive in the subtropical region. Many species of smaller bamboo plants belonging to the endemic genus Sasa grow luxuriantly in the temperate region of northern Japan, contributing greatly to the characteristic physiognomy of mountain vegetation.

The floristic elements of Korea taken as a whole are most akin, according to Nakai, to that of Japan proper, more than seventy per cent of the former being common to both lands. The distribution of arboreous flora, especially of *Pinus koraiensis, Pinus pumila,* and the like, indicates clearly once existing land connection between the continent and Japan, the part of Korea lying north of 39 degrees north latitude, forming a floral district together with montane Manchuria and Ussurie, whereas the vegetation of southern Korea has a more pronounced Japanese character.

As to the comparatively recent formation of the Japan Sea evidence can also be brought forward from the distribution of marine algae. Among 17 endemic genera of sea-weeds in Japanese waters, one and only one monotypic genus *(Coccophora langsdorfii)* is, according to K. Okamura, restricted in its distribution to the Japan Sea, whereas 11 genera are peculiar to the Pacific coast, the remaining 6 being common to both regions. In this respect the discovery made shortly before by Nakai of some endemic arboreous plants in Dagelet Island off the east coast of Korea, is of special interest, as they indicate somewhat the nature of the vegetation of a forest-covered land, once connecting Japan and Korea.

The intrusion of some tropical or subtropical elements, such as *Cersidiphyllum japonicum,* Phellodendron, Rhus, Lespedeza, Lindera and Ardisia, far north in the temperate region can be taken as a peculiar feature of the Japanese flora and partly explained as the influence of the warm oceanic current bathing the greater part of the coast of Japan. On the other hand, historic factors can not be overlooked in the consideration. Fossil remains closely related to the above mentioned species were found in the Tertiary beds of northern Asia, indicating a prevailing warm climate at that period. From Sakhalin even the discovery of Tertiary fossils belonging to Ginkgo, Sequoia and Cycad is recorded. In the glacial period, set at about the end of the Tertiary epoch, some of these tropical plants might have migrated, or been driven, southward to the present habitats. Evidences of glaciation have been found recently by Yamasaki and others, though not referable to any definite geological period, in the mountains of central Japan. The effect of refrigeration might then not have been so severe as to eliminate altogether these floristic elements. Or, it is also possible, that they regained the northern posts after the subsidence of ice.

Recently the origin of the Japanese alpine flora was made the subject of careful study by Koizumi. Among some 400 species studied, about forty per cent are of endemic or autochthonic nature and forty-five per cent belong to heterochthonic, boreal, or circumpolar elements, which the author considers to have migrated southward in the Pleistocenic glacial period by way of the Bering-Okhotsk land mass, taking one of the routes: Kamtschatka-Kuriles-Yezo or Kohotsk-Sakhalin-Yezo. H. Takeda, who made a careful study of some 300 species of vascular plants collected in Sikotan, the southermost island of the Kurile group, expressed the view, that the migration of boreal elements in Yezo and Honshiu took place more likely through the Kuriles than through Sakhalin. In fact all geological and paleontological evidence tends to indicate that from the end of the Tertiary epoch until the Pleistocene an extensive land mass developing in the Bering Sea region connected northeastern Asia, including Japan with Alaska, thus affording a common birthplace for the floristic elements inhabiting these regions and that portion of the North American continent lying west of the Mackenzie River basin. However, the well known argument of Asa Gray, that the flora of Japan is so intimately related to that of the eastern coast of America, that sixty per cent of plants from the former are to be found also in the latter region, may hardly be maintained, owing to the inaccuracy in specific identifications made in his time. The arcto-pleistocene or glacial elements must easily have gained footing on the mountains of northern Japan, the grounds having been often through active volcanic action, laid bare and thus made suitable for the invasion of these plants. But also in middle and southern Japan, even in Yakushima, lying south of Kiusiu, a sporadic occurrence of alpine plants belonging to the circumpolar and Bering elements is to be found on the summit of mountains which lie at present considerably below timber line. Such might be taken as relics of an extensive arctic flora flourishing under the colder glacial climate once prevailing in these regions. The adjoining regions of the Asiatic continent have been recently explored by several Japanese botanists. While professor in the University of Peking, Y. Yabe made a careful floristic investigation of the Province of Chili and the northeastern part of Shansi. He describes in a paper, now in press, some 970 species of vascular plants, among which 58 are new to science or to the region, showing as a whole the floristic characters related either to Himalayan or Ural-Altai regions.

In this short communication I can not enter into details of work done by Japanese botanists on the lower cryptogams. Marine algae have been most thoroughly investigated by K. Okamura and K. Yendo. Much has been done also on fungi by M. Shirai, K. Miyabe and their associates. Lichens are studied by M. Miyoshi and mosses by S. Okamura and others. Many contributions to the general problems of botany can also not be discussed in this place.

LAS PLANTAS MEDICINALES UTILIZADAS POR LOS FILIPINOS

By Leon M. Guerreo

(Abstract rendered into English by William E. Safford)

In his introductory remarks Dr. Guerrero stated that he did not pretend to treat the subject exhaustively, but that he wished to call attention to the great value of many of the plants and plant-products of the Philippine Islands as medicines, which attracted the attention of early explorers, botanists, and physicians. A great number of these plants are already known; many more remain to be identified. In this connection Dr. Guerrero called attention to the valuable service rendered by Elmer D. Merrill, Director of the Philippine Bureau of Science. Dr. Merrill has brought to light many new species and he still continues this important work, at the same time correcting errors of previous writers and establishing the synonymy of botanical names of plants independently described by several botanists.

Information relating to the application of plants reputed to have medicinal virtues has been obtained from native herbalists and dealers in drugs, whose ideas have, in many cases, been more or less colored by the superstitions of the primitive inhabitants of these islands. In order to assist the laymen in the identification of these plants the vernacular or common names have been added. In some cases confusion has resulted from the application of the same name to several species and in others by the application of several names to a single species. Errors arising from these causes demonstrate the necessity of having one recognized valid botanical name for each species. This name, in the Latin language, will be the same in all countries no matter what the spoken language may be. Dr. Guerrero called attention to the necessity of great caution in accepting the statements of enthusiasts regarding remarkable virtues supposed to be inherent in particular plants, and also to the wisdom of comparing plants reputed to be valuable for medicine with closely allied plants of other countries. He also called attention to the fact that many native plants had been erroneously regarded as identical with plants of other countries to which they bore more or less resemblance; so that certain lists of Philippine plants contain the names of species which do not occur in those islands. In addition to native plants used in curing diseases Dr. Guerrero referred to others used as poisons, narcotics, or love potions.

After giving a list of the principal writers on systematic and economic botany of the Philippine Islands, the paper closed with a "Lista de las plantas medicinales de reconocida importancia y mas populares utilizadas por los Filipinos." This paper will be published by the Philippine Bureau of Science. It is interesting to note that a great many of the plants included in Dr. Guerrero's list occur in Hawaii, some of them introduced through human agency in prehistoric times, others in recent years.

WORK IN ALGAE AT THE PUGET SOUND BIOLOGICAL STATION

By T. C. Frye

The region is rich in species; about 75 are common, exclusive of unicellular forms. Some of the larger ones among the Phaeophyceae, notably Nereocystis and Costaria, are very abundant, and comprise the major portion of the vegetation along the shore. The abundance of Nereocystis and its economic importance have led us to work with it more than with any other forms.

Taxonomically we have done very little. Some work was undertaken in both green and red algae, but awaits the completion of work on Northwestern algae by Setchell and Gardner. This sumer work on the identification of our diatoms was begun.

Perhaps half a dozen or more morphological papers have been completed, mostly on the brown and the green algae. These are usually short, intended to clear up a definite species or a definite point and completed in one to three months. Long problems cannot well be undertaken because most of the workers are at the station for the summer only.

In ecology we have undertaken the mapping of the algae along the shores of some of the nearest islands, and indicating the associations. Most of the work in ecology, however, has been experimental, with a view to determining some of the factors which govern the distribution vertically and horizontally along the shore. We have shown that desiccation is a factor, possibly the chief one, in the distribution of algae vertically above the low tide line, and that light and acidity are factors in the distribution of Fucus, and some other species.

Economically, the station was worked on the production of food from kelp. Among these products are fertilizer, pickles, candied citron substitute, and algin. The cost of drying prevents the use of kelp on a large scale as a fertilizer at present, although there is one factory on Puget Sound. Candied citron substitute and pickles have never been attempted on a commercial scale.

In experimental morphology work was completed on many algae, determining the region of growth, the effect of retarded growth, the result of mutilation, and the rejuvenation of parts.

In physiology the composition of the seaweeds, notably Nereocystis has been studied. The abundance of Nereocystis, its rapid growth, and the uniformity of temperature in sea-water, makes the region highly suitable for physiological work in which uniform temperature is required.

In this short resume credit cannot be given to the individual worker, but most of the work at the station will be found in Publications of the Puget Sound Biological Station, of which the second volume is now nearly complete.

THE STUDY OF PACIFIC OCEAN ALGAE

By Josephine E. Tilden

(Abstract Prepared by the Chairman of the Section of Botany)

A systematic study of the marine and freshwater species of the algae of Pacific countries would be a work of great importance. Too much stress can not be placed on taxonomic work as a foundation.

Information should be gathered relating to the geographical distribution of the Pacific Ocean species of algae.

During the recent war the Government made an investigation into the fertilizer resources of the United States. As a result, the great kelp beds of the North Pacific Ocean may in the future be used to supply the potash needed in commercial fertilizers.

In Japan, China, and many Pacific islands, seaweeds form an important article in the diet of the common people. As more is learned about the chemical composition and food value of these plants, their use may extend to other countries.

A list of names used by the natives of Pacific countries for different kinds of algae, accompanied by descriptions of native uses of these plants and by records of myths and stories in which their use was indicated, would be of the highest value to the anthropologist.

The geological aspect of algae—as calcareous pebbles or concretions in freshwater lakes and streams; as calcareous and silicious formations laid down in the vicinity of hot springs and geysers; as deep sea deposits—affords problems requiring deep study. In recent years another subject for geological investigation is indicated—that relating to the part played by various species of lime-secreting green and red seaweeds in the building of the so-called "coral" reefs.

Observations should be made by the vulcanologist as well as by the algologist on the very simple forms of plant life—the blue-green algae—which occur in steam cracks and in the hot water of dripping cliffs in the vicinity of volcanoes.

The algae constitute the primitive food of fishes. The secondary food supply of fishes is made up of crustacea in the ocean, wherever conditions are suitable for their growth. The least physical or chemical change in these conditions may cause them to disappear, and in turn, the animal forms dependent upon them.

Taking all of the above facts into consideration, there is indicated a pressing need for an immediate and critical investigation of freshwater and marine plant life.

The following methods of work are recommended:

A. A series of "source books," which shall contain, under one cover, so to speak, all the algological data, based on Pacific material, published up to the present time. Material for this is at hand. With sufficient facilities and assistance, the books could be published within a year's time. The scope of such "source-books" may be understood by reference to the volume: "Myxophyceae." Minnesota Algae, vol. I.

B. A systematic survey of the entire Pacific Ocean should next be begun, with the series of source-books as a foundation. Two expeditions would need to be fitted out, and two years' time should be allowed for the completion of the work.

The field of observation of the first expedition should include the North American, South American and Asiatic shores, from Cape Horn to Alaska and from Bering Sea to the Malay Peninsula.

The second expedition could take advantage of the regular Pacific steamship lines, with the use in certain localities of trading boats, fishing boats, lighthouse tenders and pilot stations. This expedition would explore the island groups of the Pacific Ocean, New Zealand, and the eastern shores of Australia.

C. The leaders of these two expeditions, with certain members of both expeditions, should do the preliminary work of Easter Island, in order to have an opportunity of planning together in the field, with the object of making the recording of results uniform in detail.

D. Each expedition should include in addition to a leader and a secretary, about a dozen workers: three collectors for plants and animal plankton, bacteriology (meteorological, chemical and physical data); three collectors for marine zoology, algal contents of stomachs of animals, and other zoological data; four collectors for the largest algae, botanical, anthropological, geological data.

E. Collections to be made: algae, bacteria, marine animals, stomachs of animals, samples of sand and rock bottoms, photographs, moving pictures.

F. Data to be accumulated: temperature of water and air; salinity, acidity, currents, tides, light conditions, depth; zones of distribution; abundance; records of parasitic and epiphytic organisms; kind of rock material to which specimen is attached.

G. Specimens of plants, animals, animal stomachs, and rock samples to be sent to experts and to be finally deposited in sets, in 50 leading institutions of the world.

H. Results: Important contributions and monographs should be ready for publication within five years.

NECESSITY FOR BOTANICAL EXPLORATION IN THE PACIFIC

(Prepared by the Section of Botany for presentation to the Conference.)

It is evident that systematic botany is the basis of all other botanic work in Polynesia, as elsewhere; for to correlate all other lines of investigation it is necessary that the name and exact position of the species should be known.

Botanical exploration of Polynesia has been desultory. Some areas have been rather intensively explored, some slightly explored, and others almost wholly ignored. While certain local floras have been published on various parts of Polynesia, yet no single island group has been so extensively explored that we may claim its flora to be "known." Exact information as to what has thus far been accomplished in the field of botany of the islands of the Pacific should be presented. The bibliography of the subject has already been worked up by the U. S. Department of Agriculture and exists in the form of a card catalogue in the library of the Bureau of Plant Industry.

In published floras, even where the species of the higher groups are comparatively well known, as in that of Hawaii, an enormous amount of work still remains to be done on the lower groups, including the algae, fungi, lichens and mosses. For a proper interpretation and correlation of the Polynesian flora, botanical exploration must be general. Regions slightly known from a botanical standpoint must be thoroughly explored, and at the same time regions already visited by early scientific expeditions must be revisited and intensive exploration initiated. The recent additions to the flora of Hawaii, supposed to have been thoroughly known, show the necessity of such work. Moreover it is of the greatest importance that comprehensive collections be made in historical areas in Polynesia, so that the systematist may have at his disposal topotype material. In the larger islands botanical exploration must be continuous over several months or a year, especially in those regions where there are pronounced wet and dry seasons. In the case of some species anthesis is continuous, but in the majority of cases species flower and fruit at certain definite seasons. While in temperate regions the collection season is limited by climatic factors, in the tropics the collector must work in the field in all months.

Special attention should be paid to ethnobotany; for in certain regions essential data on the uses of plants and plant products by the natives must be secured while it is still available. Vernacular names of plants are of special importance in throwing light on the interrelationship of native tribes and as an index to their possible origin and distribution. An example of this is shown in the names of such important economic plants as the sugar-cane, the coconut, the breadfruit, the taro, and a number of fiber plants and trees which have accompanied the Polynesians in their migrations and have carried with them their vernacular names, by means of which they may be traced back to their early home in the Malayan region. The method of preparing plant products should also be carefully noted, such as the preparation of poi from the taro root, the preparation of a drink from the root of *Piper methysticum,* the manufacture of bark-cloth from the inner bark of the paper mulberry, and the braiding of mats from pandanum leaves. Such notes help the ethnologist to group tribes having similar customs and similar arts.

New methods must be adopted in current field work. It should no longer be permissible that collectors be content to prepare their botanical material accompanied only by strictly botanical notes. He should secure all possible available data regarding local names uses, and if possible products of the plants collected, such as fibers, resins, dyes, oils, medicines, and the like. All data should accompany the actual specimens. It may be recorded on a field label like that developed by Dr. Merrill in his Philippine work. (See paper in this volume.)

The collector must secure a comprehensive series of specimens representing each number of species collected. The average number of duplicates should be between 10 and 15. This material will not only show ranges of variation but the duplicates will be available for distribution and exchange. Plans should involve supplying duplicates not only to Pacific institutions but also to the larger botanical institutions of the world. Ample and valuable duplicate material available from remote regions is the best possible means of securing attention from the older institutions of Europe, especially those institutions in which the essential Polynesian types of previously described species are preserved.

FISHERIES OF THE PACIFIC

OCEAN PASTURAGE AND OCEAN FISHERIES

By W. E. Allen, Scripps Biological Institute

(Presented by invitation of the Committee on Program. Read by H. F. Moore.)

Among the more prominent of man's fundamental interests in the sea is that of food supply. For primitive man that was the sole and essential interest. For civilized man that interest is more or less completely overshadowed by interest in transportation, but it is still permissible to say that production of marine foods is of vital importance and that the degree of its prominence in our thought merely varies with the directness of our dependence upon such foods. Very properly then, we who are here resident upon these favored shores of the broad Pacific, should closely scrutinize all phases of the great problems involved in maintenance or extension of the food resources at our gates.

It is a universal tendency of human kind to be content with the obvious, to give attention to gross phenomena, to ignore primal causes and to hope to evade final results. Choice fish, fresh, iced, dried, smoked, pickled and canned, has been easily accessible to most of us. We visit the ocean shore and see great numbers of fish. We view great fleets of fishing boats, the very existence of which indicates a sufficient supply of fish to assure their upkeep. We read in the newspapers about the large catches, in magazines about the fisher folk and their ways, and in various books about the romance and the tragedy and the commercial and political power bound up in fisheries operations. With such varied and cumulative evidence before us, it is not strange that most of us think of fisheries problems as concerning nothing but fish. My part in this program is to call attention to the fact that these problems go deeper than that, and that their solutions demand excursions into fields vastly remote and unfamiliar to most of our people. For the sake of brevity, I must confine myself mainly to that one of these fields which affords the rock bottom upon which to build for any adequate understanding of marine life.

I refer to the field of knowledge of the phytoplankton, that vast assemblage of plants invisibly small, which alone is capable of manufacturing from raw materials in the open seas those complex substances which can be used for the sustenance of higher forms of life. Because it, like the green herbage of our pasture lands, manufactures these necessary materials, and because, also, it, like the land pasturage, directly or indirectly furnishes foods for all animals associated with it, we sometimes call it the pasturage of the sea.

Our own personal dependence upon land pasturage is fairly obvious though indirect. Green grasses and legumes manufacture from soil waters and gases of the air starches, sugars, oils and proteids which can be eaten by cattle, sheep, swine, or fowls, and worked over into still other sugars, oils and proteids peculiar to their own bodies. We in turn eat the flesh of these animals or the milk or eggs produced by some of them, and then work them over into our own substance. In some cases we make direct use of the plant materials without the intervention of the other animals. It is fairly plain to most of us that neither we nor the domestic animals can manufacture our own flesh and blood from such simple materials as soil water and atmospheric gases.

Our dependence upon ocean pasturage is much less obvious, partly because few of the oceanic animals which we use feed directly upon this pasturage, and partly because the individual plants composing it are so small as to escape our notice. It is also possible to be misled by the notion of certain investigators that marine animals (even including fishes) may derive a considerable proportion of their nutriment by direct absorption of certain materials dissolved in sea water.

It is, however, becoming more and more evident as knowledge increases, that the relationship of living things to each other are strikingly similar in sea and on land. Probably all of us make more or less use of salmon for food because salmon flesh is easily and quickly convertible into human flesh. mackerel and herring. Mackerel live on still smaller fish or squid and small fish. Squid in turn have used fish such as mackerel and herring. Mackerel live on still smaller fish or when such food is scarce, they may use small crustaceans or may even come directly to use of the ocean pasturage itself. At any rate, the small crustaceans feed directly upon this pasturage. It is also true that a good many predacious fishes use the plants for food while in very young stages of development. The pasturage in turn maintains itself by using the energy of sunlight for manufacture of food stuffs. When we think in terms of salmon it seems a long way to the original food factories located in the tiny bodies of the marine plankton plants. When we think in terms of mackerel or sardines or mussels or oysters, it is only a brief span from tiny factory to ultimate consumer. In either case, we may be sure that marine foods which we eat are just as truly derived from plants as is the case with any land food.

Now it may seem strange that plants of the open sea should be able to supply the requisite quantities of food for so many animals if their size is so small. A very common kind of these plants in Southern California waters (*Nitzschia seriata*) is about 1/4000 of an inch in length. But small size is compensated by vast numbers and wide distribution. When the particular plant which I have just mentioned is present in very moderate quantities, there may be about 300,000 individuals to each quart of sea water, or about twenty to each drop of water. But sometimes individuals of this kind may be so numerous as to give a brownish color to the water in which case there may be some millions in each quart of water and some hundreds in each drop of water. We have a record of areas of brownish water of this character some fifty miles in extent and probably some fathoms in depth. Surely the amount of plant material which occurs beneath such an area compares very favorably with the plant material found upon a similar area of pasture land. If this marine plant happens to furnish a nutritious food for sardines or for the minute animals which they may eat, such an area is probably more productive of fish flesh for human consumption than is a similar area of ordinary range land productive of the flesh of range cattle.

A moment ago I mentioned the fact that some investigators had got the idea that many marine animals thrive over long periods of time by simply absorbing nutriments which were thought to occur dissolved in sea water. There were two principal reasons for this view, one the fact that so many marine animals are caught which have no traces of food in their digestive tracts, the other the supposition that large quantities of nutrient substances had been found dissolved in sea water. Careful investigation has shown that for animals no usable quantities of such materials exist in the dissolved condition, but no full explanation has yet been found for the frequency with which the digestive tract of animals are found empty. I have noticed the puzzling fact that the tiny animals which directly feed upon the phytoplankton (or ocean pasturage) are seldom, if ever, found in greatest abundance at the time that the pasturage seems to be most abundant. So we find that there are a number of reasons why we may easily overlook the importance of the pasturage of the sea.

I hope that I have now indicated sufficient ground for the assumption that without conservative plant life in the sea there can be no animal life in the sea, that is to say, no fish and no fisheries. If the pasturage be scant, the animals will be impoverished both in flesh and in numbers, this being no less true of our fishes merely because most of them eat other animals. If the pasturage be abundant the animals may increase both in flesh and in numbers. These effects will be almost immediately seen in the case of very small animals which live altogether upon plant food. They may not be observable for months or years in the case of animals so large as any of our important food fishes. Even then, the effect must be sought for. It does not appear without some careful study. Perhaps the best example of such study which has yet been made is that which concerns mackerel catches in the English Channel for British markets. This study was made by members of the scientific staff of Plymouth Laboratory in England, and while very imperfect, it does indicate influence of plankton distributed upon the size of commercial catches of mackerel, and it indicates that more or less sunshine in February and March means more or fewer mackerel for market in May. This is probably because much sunshine in February and March means much pasturage for the minute animals which form a large portion of food for mackerel in succeeding months. With plenty of food the mackerel thrive and they stay within catching distance. With scanty food they probably go elsewhere.

In the case of larger fishes, a lack of sunshine in February and March of one year may cause so poor development of pasturage that the very young fishes cannot find food and they may starve by millions. If such a fish requires three years to reach maturity we may not see the evil effect of this starvation until we note the small number of adult fish in the third year. On the contrary, if we knew nothing of causes we might be surprised at excessive abundance of marketable fish in the third year after a season of much early sunshine, heavy pasturage, vast numbers of microscopic animals and thriving little fishes.

Such a year of abundance would almost certainly cause a great increase to be made in fishing equipment for the next season which, however, might be exactly the lean season due to starvation of vast numbers of little fishes which has just been referred to. Not only would all fishing industries handling that fish suffer loss, but it might easily happen that the concentrated assault upon a sparse population would deplete it beyond recovery.

Assuredly now if pasturage is thus essential it is important for the continued success of our fisheries, their efficient maintenance, possible expansion and better development that we should know something about it.

Before an intelligent stockman selects a range, he examines its capacity for furnishing food for his cattle. The amount of his cash outlay, the size of his establishment and the number of cattle which he places, is determined by his judgment based on this examination. Closer acquaintance with the range may cause him to reduce his activities or it may enable him to make important extensions. He may find it better adapted to some types of cattle than it is to others, or that according to season, one part of the range may be more valuable than another. As compared with fisheries his judgments are easily reached and his adjustment simply and easily made. The fisherman is confronted with a much more obscure and intricate set of conditions. The ocean pasturage is nearly or quite invisible. Its examination requires expert knowledge, special equipment, and a complex series of tedious operations. At best it does not seem probable that he can get any very dependable conclusion as to the plant fertility of a given area without a good many years of expensive cooperative effort. It seems to him much more immediately satisfactory as well as more simple to just go ahead on the basis of luck. But we too are interested in the continued success of the fisherman just as we are interested in the success of the stockman and for exactly the same reasons that we try to help the stockman increase his production, we ought to do everything possible to help the fisherman to increase his production.

But some one says that it is not possible because there is no way in which man can increase the fertility of the sea or control the distribution of its inhabitants. To that we must reply that a problem is not to be rated as insoluble merely because it is intricate and difficult and that partial solutions may have very high practical values even if complete solution is impossible. What then are the best lines of attack upon this problem of the fertility of the sea and how can it best be approached?

Let me say first that it must not be supposed from what I have already said that the fisherman himself can do nothing. Mr. G. E. Bullen of the Plymouth Laboratory made quite a study of fishermen's signs as well as of the microscopic things to be found in the water where mackerel could or could not be caught to advantage. He mentions such distinctions as "stinking water," "yellow water," "blue water," and "green water," and notes the fact that the more intelligent fishermen were quite successful in predicting success or failure of hauls under certain marked conditions. Some of us are sufficiently experienced to be able to verify that sort of thing from our own observations. If we could induce even a few fishermen to keep fairly dependable records along such lines as this, they would not only have some immediately practical value but a real usefulness in supplementing more specific scientific study through their gross indications of various conditions of distribution of living things.

But, of course, even if such cooperation by fishermen could be secured, the main bulk of the work of investigation must always be of a highly specialized character. On account of the relative inaccessibility of the sea it must also always be very expensive and difficult.

Practically the only available method for study of ocean pasturage (phytoplankton) is by taking samples of the plants from the points where found to some laboratory where they may be examined. After gaining acquaintance with the different kinds of plants in a region, it is necessary to accumulate records of where, when, and under what particular conditions they occur or live and thrive. In order to do this it is necessary to estimate the numbers found in each catch. Such an estimate must be based on actual count of a certain fraction of the catch by use of the microscope. In order to have much value the catch should be made from a measured quantity of water. Estimates obtained by such methods may be properly tabulated, classified and carefully recorded in connection with statements of every known condition which might possibly affect the organisms and determine their presence in a particular locality in any observed quantity. When accurate records have been accumulated over a period of time sufficiently long, sometimes years, sometimes decades, or even centuries, it may be possible to state with very considerable confidence the amount and kind of pasturage which may be found in a certain place under certain conditions. If these conditions of existence can be accurately identified for such simple basic organisms as the phytoplankton, that identification will serve as a basis from which to work out similar identifications for more complex organisms. Meanwhile there is always the chance that a clue may be found to a short cut to some of this valuable information.

As a matter of fact it seems highly probable that certain features may be brought out rapidly. The little which I have already said concerning fishermen's signs suggests a possibility. For example, there is a statement by Mr. Bullen to the effect that "yellow water" points to good catches of mackerel, while "stinking water" indicates light catches or none. This led him to determine the contents of the different kinds of water with the result that "yellow water" was found to contain enormous quantities of two certain kinds of copepods, while "stinking water" contained certain kinds of microscopic plants. We have found on our own shores that many fish as well as other animals are found dead on the beaches when there is excessive abundance of such microscopic plants as *Gonyaulax polyedra.* With such points of information from which to start we may soon find that excessive production of certain kinds of plants in a given area will mean poor catches of fish there for considerable periods of time, possibly for one or more seasons. It is analogous to a situation which might occur on land if loco weed should be excessively abundant for a season in a given area.

After all, however, the main thing which is to be expected from careful study of ocean pasturage is a more exact knowledge of the ways in which oceanic conditions of life produce their effects. An exact knowledge of the good or bad effects of slight changes of the amount of salt in the water give valuable clues to the ways in which such changes affect other organisms. And so with temperature, light, density, and various other conditions. It is almost impossible to make direct study of these things in the case of animals, especially fishes, because they can move about too much, they are too large and too hard to catch, and it is impossible to examine such vast numbers of them. We can not be sure that a given condition in which we find them is either normal or abnormal.

In conclusion let me emphasize the fact that the problem of the relationship of ocean pasturage to ocean fisheries is a very important and fundamental one. Because of its difficulty it requires all sorts of cooperation as well as expert work. Only the other day Mr. Dill, Chemist for the Canners' Association at San Pedro, came into my laboratory room with a lot of questions as to when copepod and other plankton were most abundant, and as to how it was distributed. He explained briefly some of his observations on fat content of sardines and mackerel, and we soon found that we were both eager to get at explanations of a lot of the same phenomena, and I think both of us could see that ways might be worked out in which we could be mutually helpful in hunting for these explanations.

As I see it, we need a great many workers of several kinds, a great many standard points of collection and the utmost possible degree of standardization and simplification of method. Observations ought to be made continuously with great frequency in the standard localities and by means of standardized series in other localities. There ought to be thorough standardization of methods of handling materials and of recording results. Our own Institution has already made a start in this direction, and we wish to do our part in establishing such procedure on our whole coast.

DISCUSSION

MR. MAYOR: Sea animals are generally well fed. The food supply is abundant. Of course in the tropics we do find less animal and plant life than in the colder regions. The plant life in Samoa was so meagre that you would say there was none at all. But that is because it is submerged and rests on the bottom. The animals do not die of starvation. Take the coral for instance: I have never seen any starving corals. Whenever there is a great rain, thousands and thousands of corals are killed. Once in Samoa after a rain the corals were covered with mud. They couldn't get food. They did look starved when I uncovered them. It is some accident or catastrophe that is fatal to fish, not the absence of food supply in the ocean.

MR. MOORE: I agree with Dr. Mayor that adult fish do not often die of actual starvation. But there is a great difference in the condition of fishes in regard to fat content at different times, and this is due in part to the relative abundance of food. The important factor is the presence or absence of plankton.

Fish will not remain where there is a scarcity of food. On the southern coast of New England a few years ago there was an enormous quantity of plankton. The fishermen made a heavy catch of mackerel. The following year there were practically no mackerel. It was found that there was an extraordinary scarcity of plankton. We do not believe that under such conditions the adult fish are starved to death, but they do go elsewhere to seek food and the fishermen can not find them. It is not improbable, however, that a paucity of plankton may result in the starvation of the pelagic larvae of fishes, whose more feeble powers of locomotion do not permit them to go far in search of food. We do know that there are years in which something happens that is adverse to the production of an adequate number of young fish. This is notably the case with the herring and it frequently happens that for several years the catch is practically limited to fish hatched in one year, with few or none of the year classes of the several seasons immediately preceding or following. This may be due to unfavorable temperature or salinity conditions but these conditions may act indirectly through the food supply as well as directly on the fish eggs and larvae themselves. We may not be able to correct a deficiency in plankton, but if we knew that it existed during a given season in a given part of the sea, we might at least use the knowledge in advising the fishermen not to waste their time in futile effort but to go where fish food and consequently the fish might be found.

MR. BARTSCH: Some years ago I listened to a most instructive discourse by Dr. Johan Hjort on this topic. He pointed out that the herring catch in Norway could be foretold by about four years by the temperature conditions of the currents as they approach the coast of Norway, because upon the temperature of these currents depends the growth of the plankton on the spawning grounds of the herring. The young herring fry in turn depends upon the plankton. If the temperature then, is too low to produce adequate food, the output of herring will be low for the year, etc., etc.

Fridtjof Nansen has worked out wonderfully the interrelationship of ocean currents and their effect upon the climate of Norway so that by a study of currents they will be able to tell the fishermen that it will be more profitable for them to go cutting wood four years hence than to fish for herring.

AN ECONOMIC SURVEY OF THE SEA

By J. Russell Smith, Columbia University

(This paper is the preliminary and unrevised report of the Committee on an Economic Survey of the Sea appointed by the Division of Geology and Geography of the National Research Council. The committee consists of J. Russell Smith, Chairman, Isaiah Bowman and Walter S. Tower, Presented by invitation of the Chairman of the Conference.)

What new services can marine organisms render to humanity?

Sir John Murray, the oceanographer, has said that the productivity of the sea is equal to the productivity of the land. If this be true, and there is small reason to doubt it, here is perhaps the greatest unused resource within the reach of man. It is commonly estimated that less than five per cent of man's food comes from the sea, and in countries like the United States the figure is lower than that. At the same time we obtain a very small amount of industrial raw material other than food from the sea. This low figure of utilization in comparison with the high figure of productivity shows unrealized opportunities that can only be measured financially in billions of dollars. This may serve as an economic measure of the need for the application of science to the sea.

Knowledge of the sea is of interest to geographers in exactly the same way as is knowledge of the land. Geographers are interested in the results of soil surveys, geological surveys, and atmospheric surveys, as well as hydrographic surveys.

The promotion of work looking toward the utilization of the sea is a proper sphere of activity for the National Research Council because the Council deals with geography. It may be pointed out that we have a fish commission operated by the United States government. It is also true that there is a Geological Survey similarly operated. Yet no one questions the propriety of attention to geology by the Research Council.

To place the life of the sea more fully at the service of man we need systematic scientific surveys, experimentation with products, and education to promote utilization of products.

Indefinite amounts of work in each of these three fields will result if a body of men give serious and continued attention to the problem of increasing the service that the sea can render to man.

The question cannot be dismissed by saying that this requires oceanographers, therefore leave it to them. For example, in discussing the possible utilization of plankton, Professor Henry B. Bigelow, one of our leading oceanographers, says, "A far more profitable field, I should think, would be to urge upon the public the use of the perfectly good fishes which they now refuse, e. g. the goose fish, the various sculpins, etc." (Private letter Feb. 14, 1920.) Whereupn Professor Bigelow then very properly hastened away to sea to continue his researches concerning plankton, a field in which he has very greatly increased human knowledge. A well-known marine zoologist described the situation by saying that scientists working with the sea have often reported great masses of various species, both animals and plants, that promise great use to man if systematic experimentation can be applied. But as this zoologist remarked, the scientists report these facts and then drop the matter. This is quite natural, for why should a man studying plankton stop and give attention to the scallops of which he accidently discovers beds of great richness covering hundreds of square miles? They are aside from *his* field. They are not aside from the field of work here presented.

The problems of economic utilization of the sea if conceived in anything like its full scope becomes primarily one of promotion. First, find what work needs to be done. Then, find some existing organization whose proper work is to undertake it. Lastly, point out and prosecute the remaining untouched or unsolved problems.

Consider for example, a specific problem. Take the case of some pelagic mollusk or crustacean which we know is found from time to time in hordes of such extent that vast quantities could be taken by vessels properly equipped. Two types of questions at once arise.

First, how may these animals be obtained in commercial quantities? To obtain them regularly requires exact knowledge as to where and when they may be found and how they may be caught and handled. This means that we need to know what controls the food supply, assemblage and movements of the plagic hordes. This may require careful, systematic, and long continued surveys of large areas of the sea by specially equipped vessels, which may at the same time gather information of use and interest in many other ways.

Second, how may these mollusks or crustaceans be used?

1. For human food. This may require work by (1) educational institutions interested in domestic science, or in physiological chemistry and nutrition. (2) by special foundations interested in health problems, or in improving the condition of the poor. (3) by food manufacturers, restaurateurs, fishing and other industrial corporations. Any of the above might be persuaded to make experiments or investigations because their interest was attracted to the possibilities of this field of work. Lastly, investigation of the human food aspect of the question would probably result in knowledge of which the proper utilization would require much definite educational work such as is indicated by Professor Bigelow's statement that he thinks it "a profitable field to urge upon the public the use of the perfectly good food fishes which they now refuse." This is in itself a real task because of the senseless conservatism of man with regard to new foods. This phase of the work of benefitting man is distinctly educational not to say propagandic.

2. Animal food. If our mollusk or crustacean promises greater use for animal food than for human food, it is of particular interest to swine growers and poultry growers, and as a problem in either of these fields it might properly and easily be undertaken by any one of several of the many experiment stations now organized in the United States and working in many fields of experimentation, with varying interests according to local conditions and the interests of the staff. It is a problem in promotion to get these stations at work on these problems which in all propriety belong in their field.

3. Fertilizers. If our mollusk or crustacean promises to be of greater use as a fertilizer than as food, this again might appeal as an object of pioneer work to many experiment stations, to fishing corporations or fertilizer manufacturers.

It need scarcely be mentioned here that an indefinite number of problems somewhat like the above actually does await solution.

At this point it should be emphasized that the great problems now facing the American public in its food supply is not new foods for people but new foods for domestic animals. People change their food habits with great slowness, but prices indicate that we are in an acute situation with regard to protein foods for our great protein supports, poultry and swine. If by experimentation the sea can be made to give a cheaper substitute for cotton seed meal, linseed meal, ground meatscrap, tankage, or dried fish, an industrial outlet is at once provided for a product worth tens, and shortly hundreds, of millions of dollars per year, and human food supply is at once though indirectly benefited.

It is desirable to promote scientific work in all directions, abstract, systematic science that may or may not promise utilities. The scientist knows, of course, that on the average there is no such thing as useless science and that the difference between abstract and applied science is fading away. Nevertheless, the low state of systematic surveys of the sea and our essential ignorance concerning it can be advanced as proof of the difficulty of getting support for so-called abstract rather than applied science.

There are really two ways of getting work done on the remoter problems of science. One is the direct appeal for the abstract science which will of course produce incidental utilities. This appeal is difficult to make with financial success. The other and easier appeal is to start specific industrial problems which in their development promptly create and demonstrate the necessity for abstract and systematic scientific work. It is easily possible that the best way to get certain systematic marine surveys made is to start teaching people how to use some marine product now unused.

Your committee believes that the time has come when the survey of the sea can be greatly promoted by a type of scientific promotion indicated by the above-stated hypothetical case of the problem of the pelagic mollusk or crustacean.

It is not primarily a problem in oceanography, marine zoölogy, marine botany, fishing, human nutrition, physiological chemistry, plant nutrition, swine feeding, poultry feeding, food preserving, or food introduction. It is, however, easy to see that many or all of these activities might be called into service and also many others in the solution of any one of many problems that await.

If the field is conceived in some approach to its real size, and a canvass made of the work now going on, specific problems of great promise will begin to take definite shape. It will then appear here, as it has already appeared in other fields of work, that much increase in work will be achieved by existing agencies merely because there is some central body of informed men who can serve as a clearing house. It is doubtless true that many expeditions have gone on specific and costly errands when, without proportional increase in cost, they might easily have been enlarged by the addition of members who could have carried on other investigations in some of the almost innumerable fields of marine research.

One of the definite needs of the day is a strong, permanent organization of some sort having for its work the whole field of promotion of knowledge of the sea and the utilization of its resources of any and all sorts.

THE FISHERIES OF JAPAN

By K. Kishinouye

The fishing industry in the Japanese Empire is no doubt the most important food source of our nation, as our people feed on rice and fish chiefly. As you well know, the empire of Japan is a group of small and thickly populated islands; and from the study of shell-heaps I found that the islands of Japan have been from ancient times the center of a very big fishing industry. The people living on our islands in prehistoric times were of course different from the Japanese of today, but they caught almost the same kinds of fish as do the fishermen of today. They caught fish along the shore and also deep water fish. It was a great surprise to me when I found skeletons of bonitos and our common tunny in large quantities in the collections from shell-mounds. At first I thought they came from fertilizer, but on close investigation I was assured that the farmers of that district had never used fertilizer. The deposit consisted of a deep layer of soil never disturbed by people, mixed with crude pottery and fishing implements made of horn and bone. Most of the fish esteemed by our people today were taken by the prehistoric people living in our islands, in much the same manner as today.

In consequence of the small amount of land to be cultivated, the people living on the small islands get animal food only from the water, for they must spare some land for the purpose if they wish to raise cattle or fowls, and naturally they go to the sea for their animal food. So our fishing industry was developed and our people are used to the animal food obtained chiefly from the sea. We also use our algae to a great extent for food and in the manufacture of glue. We use also marine invertebrates such as jelly-fish, sea-urchins, holothurians, tunicates, besides cuttle-fish and shell-fish which we collect in large quantities. Fishing in the great depths is also well developed in Japan. The Japanese fishermen catch fish sometimes at a depth of from 300 to 500 fathoms. They sometimes go off shore to a distance of 100 or more miles for the purpose of fishing.

The methods of fishing are also interesting in some respects. The fishermen used to catch fish by scaring and driving them in schools to shallow water. But recently they have discovered that this method is not a good one and they generally use the method of attracting the fish to shore or to any place convenient for the catch. The fishermen accomplish this by providing shelter or shade or food, or they attract the fish by the use of electric lights or torches. Artificial banks are also built and many other devices used.

Many interesting kinds of fish lines are in use. To catch fish in very deep water they use exactly the same methods as are used in sounding the great deeps of the ocean. A bar or spreader 3 or 4 feet long is attached to the line and from the ends of the spreader snoods with hooks are hung. Heavy weights are necessary to keep the line straight; a stone is therefore fastened to the middle of this bar. The line must be very slender and very strong. The fisherman sinks it down very quickly to the bottom. When it touches the bottom the strings are loosened and the additional weight is dropped.

Then they haul in the line two or three feet and keep it between two fingers. As the spreader is long the bite of a fish about 1 pound in weight is easily felt, especially as the fingers of the fisherman are very sensitive. When he hauls in the line somewhat the deep-sea fish comes to the surface by means of its own buoyancy because of the distended air bladder.

Now let me explain a long line for tunnies as an example of the sort of fishing implement which is used extensively in different fishing grounds for the capture of certain fishes. The long line is not used in other countries so far as I know for the capture of tunnies.

The tunnies are generally large and very swift swimmers. They go down 100 or more fathoms at once when they bite the hook so that the line ought to be very long, 1200 feet of line generally being used. The long line is buoyed to drift in the layer of water about 10 to 20 fathoms under the surface, depending on the temperature of the water. When the water is warm the line should be kept in shallow water; when the water is cold it should be sunk deeper. As there are 5 species of tunnies in our waters and some of them live in deeper layers of water, the fisherman sometimes uses snoods of different lengths to catch different species at the same time. The hook of the longest snood lies about 40 fathoms or more below the surface of the water. The buoy used at the surface has some bamboo rods tied perpendicular to it and a flag is attached. When the fish bites the hook the flag and buoy disappear instantaneously below the surface, and at that moment the fisherman catches the other buoy and then gradually hauls in the line. When the tunny runs about 100 fathoms as it sometimes does it probably strikes the bottom a little tired; then the fishermen begin to haul in the line. But when the fish becomes active again the fishermen slacken the line and let the fish go. When they haul in the line and the fish comes near the surface it is harpooned and brought into the boat. This is the usual way of catching the tunny.

The tunnies swimming near the coast are restricted to three species only. They are caught in large trap-nets, chiefly in summer.

At this point I wish to call attention to a peculiarity in the anatomy of tunnies. I shall not state it in detail as it will bore you very much. The bonitos and tunnies are quite different from other teleostomous fish in having dark red muscles deeply situated in both sides of the vertebral column. But these fishes are classified in the same family as mackerel, and others.

Tunnies and bonitos have very well developed subcutaneous blood-vessels. So far as I know this has not been shown in scientific papers. These blood-vessels are different in different species, genera and families. They are connected with venules and arterioles which form a sheet on the apaxial side of the dark-red portion of the lateral muscle.

That dark-red portion contained in one species of tunny has fourteen times as much blood as other parts of the flesh. In some species of tunnies these blood vessels pass under the third rib, in others under the fifth rib. Besides this plexus of blood vessels, we find two other form of plexuses on the dorsal surface of the liver. One form is found as a thick rod in the trellis under the vertebral column, in the yellow-finned tunny and bonito. These plexuses are probably related to some internal secretion.

In correlation with the dark-red colored muscles I have found many peculiar anatomical features, which will be discussed in a paper now being prepared on the so-called scombroid fishes.

DISCUSSION

MR. FRASER: What is being done in the schools to teach the subject of fisheries?

MR. KISHINOUYE: In the University of Tokyo we have a section of fisheries; also in the University of Hokkaido there is a Fishery Institute belonging to the department of Agriculture. There we carry on education as well as investigation. The course involves three years' study. We also have graduate courses.

MR. MAYOR: Is it your object to adopt the fishing methods of other countries, or to keep your own?

MR. KISHINOUYE: Japan wishes to keep the old methods of fishing at the same time to adopt new ones if they are suitable. We get ideas from our fishermen, but we give them new methods also. They are proud to do things as their ancestors did them.

MR. EVERMANN: I have been very much interested in the methods of deep-sea fishing described by Mr. Kishinouye. I am reminded of fishing which I once did at the red snapper banks in the Gulf of Mexico, particularly in the matter of the way the fish came to the surface because of the expansion of gases inside their bodies. We fished at a depth of from 50 to 70 fathoms with a large line and a 3½ pound sinker. The lower part of the sinker was cup-shaped, the cup being filled with a mixture of beeswax and lard in order to bring up samples of the bottom. There were two hooks used. When the fish were brought up it was almost invariably found that their stomachs had been forced into their mouths because of the expansion of gas in them, and the spewing or contents were thrown out on deck.

I made the trip to save the spewings. The contents of the stomachs thrown out proved to be exceedingly interesting. In a few days we got many small fish in all stages of digestion from the stomachs of the large ones. Sometimes they were nearly digested; sometimes they were still alive. We got 13 different species all new to science. They could not have been gotten in any other way. They were too small to be caught on a hook and line. By letting the red snapper catch them first, then catching the red snapper, we got the small fish we wanted. Dr. Kishinouye's drawings are of extreme interest. They show an extraordinarily good piece of work. The scombroid fishes have been studied only superficially without cutting up the fish, but he has gotten deep-seated anatomic structures and new generic characters unknown before. The specific characters which he gets by cross sections of the vertebrates, the location of blood-vessels, and the character of the muscles, are extremely valuable. I want to express my appreciation of the splendid work Mr. Kishinouye has done in the study of scombroids.

MR. EDMONDSON: Is there evidence of depletion?

MR. KISHINOUYE: Yes. We are inclined to believe that our important fishes are decreasing. Of course the total amount of animal food will remain constant, but in many bays and inlets certain of the food fishes are decreasing, the sardines, for example. There seems to be no decrease in those fish that have pelagic eggs.

MR. EVERMANN: Do they get scambroids near the spawning season?

MR. KISHINOUYE: Yes, large schools spawn near our coasts in July and August.

MR. FRASER: Are you using any conservation methods?

MR. KISHINOUYE: Yes, we have a closed season.

MR. MOORE: Some years ago I visited the fisheries of Japan under the guidance of Mr. Kishinouye. Since that time I have often wondered what our race will do when the land becomes overtaxed, but I am encouraged when I think of the large amount of fish Japan extracts from the sea, and how large a population exists on the small acreage available for tillage. The Japanese fishermen are resourceful and ingenious. Dr. Mayor's question as to whether the Japanese were going to continue to use their own methods suggests to me that other countries could adopt some of Japan's methods to advantage.

CONSERVATION OF FISH RESOURCES

By C. M. Fraser

In my opinion some definite recommendation as to the necessity of conservation of the fish supply should be made by this Conference. I believe it is quite possible for the human element to interfere very largely in the amount of fish. In the area in which I have done most of my work the striking example is the disappearance of the salmon in the Fraser River. For example the sockeye has become almost a negligible quantity. The Fraser river and its tributaries is the greatest spawning area suitable for spawning salmon in the world. Because the sockeye is the most valuable it has received the most attention, but other species also are going. The King salmon and Silver salmon situation is serious. These species can be caught in the open sea at the Straits of Juan de Fuca and in other places. They are caught when two or three pounds in weight which is a great loss, because if left until maturity they weigh from 9 to 15 pounds. The Chinook salmon case is worse. It may live for 5 or 6 years, but it is often caught when 2, 3 or 4 years. Yet it reaches when mature 70 or 80 pounds. The fish caught now are much smaller than they should be. They do not get a chance to mature. The halibut is of considerable age when it spawns. That makes the situation more serious for this species. With other fish the cod or so-called cod such as the ling cod, are decreasing. The same is true of the red cod and the rock cod. It has become so serious in the last year or two that all the men in the industry feel that something should be done. At a meeting of the Canadian Fisheries Association in June this matter was discussed. The attitude of the younger men in the fisheries is encouraging. They are very much in earnest in their desire to do something to save the situation.

A considerable amount of discussion has been going on for some time between Newfoundland, the United States and Canada as to means of coöperation for conservation of fish. At a meeting of the American Fisheries Society to be held in Ottawa on September 20-22 perhaps some plan may be devised to bring this about—not a large extensive plan but a general get-together on a plan of work to be done in each country. The Canadian Fisheries Association went on record as supporting any movement of that kind and voted to send a delegate to all meetings held anywhere within a reasonable distance. It is as a representative of the Canadian Fisheries Association that I am here at this meeting. It seems to me the time is more nearly ripe now than it has ever been. We have a large area of continental shelf, a great feeding ground for fish. A great deal of good could be done by a biological investigation of the waters in this area.

The main trouble here as elsewhere is the difficulty of getting men because there is not money enough to pay them. The facilities for carrying on the work are there. I think both Canada and the United States are in a condition of mind to support such recommendations as might be made. If you choose we might go on record as to the necessity of providing men and resources to begin an investigation.

It is not a national question. The fish go into the streams of Japan and Siberia. It is an international question.

[In response to Mr. Fraser's suggestion a committee was appointed to draft resolutions outlining investigations needed in the formulation of regulations for conservation of fisheries. The committee consists of C. M. Fraser, H. F. Moore, Josephine E. Tilden, T. C. Frye, Barton W. Evermann, K. Kishinouye, George F. McEwen.]

INADEQUACY OF STATISTICS OF FISHERIES

By H. F. Moore

One more matter I wish to present: The question of statistics is highly important in determining methods of conservation. As matters stand now we are without adequate data of that kind. We know in a general way that we catch a certain fish in a given section, but we do not know how it has been taken. The Bureau of Fisheries makes a territorial survey which may cover the country by sections once in five years. In that way it not only gives the total catch by geographical areas, but also the catch by the various kinds of apparatus, which furnishes us in some measure a yard stick by which we can measure the activity or intensity of the fisheries. But that is done only once in five years. We have no way of telling whether the fifth year was a normal or an abnormal year. So while the statistics are reasonably good, they are valuable for industrial rather than scientific use and are not suitable for the biologist who is taking up the study of the effects of the fisheries on the abundance and distribution of the fishes caught.

It seems to me that it might be advisable in connection with the proposed resolutions to include something that will cover that point. I have attempted to use statistics and have been embarrassed by the lack of specific data. This is an important matter to state governments which under the American form of government are charged with the duty of administering and conserving the fisheries by regulatory measures. They are confronted with a situation of more or less doubt as to the actual state and tendency of the fisheries. They can't afford to throw men out of employment and deprive men of food without good reason; but on the other hand they cannot permit the fisheries to run the risk of imperiling the future food supply. We owe it to the men engaged in fisheries administration and regulation that they should be given the means of gauging the quality of their acts and the merits of their regulations.

THE NECESSITY OF CONSERVATION OF FISH RESOURCES

By Barton W. Evermann

What I intended to say and perhaps shall say will pertain more particularly to problems of the fisheries which need investigations in relation to need of conservation of certain forms of life of the commercial fishes. I refer to the marine mammals.

The largest animals that live in the sea perhaps are the ones least known. Some time ago I looked up the literature on the mammals of the North Pacific. We have in the neighborhood of 44 species of marine mammals in the North Pacific so far as I could learn. Those are the whales and other cetaceans, the seals and carnivores. There are something like 9 baleen whales, 5 sperm whales and 14 porpoises, killers, and dolphins, or 26 species of cetaceans in all, and among them are the largest animals in the world. Very little is known about them—what the species are, what their distribution is or how abundant they are. A little while ago a whaling station was established on the California coast. Even the whalers did not know what species of whale they expected to get but they would make the most optimistic statements as to the commercial possibilities of the whaling industry, stories colored somewhat doubtless for the purpose of selling stock. The company built its plant and went into the business. They have exceeded the expectations of everybody except the promoters. They have for several months been taking on an average one whale a day off the California coast near enough to their station north of Santa Cruz to bring the catch in to the station the same day or early in the morning of the day following. The species caught is usually the humpback.

It is always an event in an ocean voyage to see a whale, even to those who have crossed the ocean many times. They are not so numerous but that the seeing of one is an event to be remembered. On the California coast in the last four months they have taken out 120 whales within 100 or fewer miles of the same place. This represents a serious inroad on that species of marine animal. The states have no regulations because whales are very seldom found inside the 3-mile limit; nor would federal regulation be of any use for the same reason. It is a question for international consideration rather than governmental regulation by individual governments. It is perfectly apparent that little or nothing can be done except through international agreement.

Of the 44 or 50 species of marine mammals in the north Pacific there are only two or three that have received much attention. The Alaska fur seal has been written about perhaps more than any other animal in the world. Yet there remains a very large amount of information which we lack about the Alaska seal; and of the Japan seal and other species we know even less. We have studied them to some extent on their breeding grounds and the Japanese doubtless know about the northern migration and possibly a little about the return southward migration. We know something about the Alaska fur seal from the time it strikes the California coast early in February until it reaches Behring Sea in May and June. But as to where it goes when it leaves the Aleutian Islands in late October and November or where it is until it comes up at San Diego in late January or February, we know practically nothing. We do not know whether the three species of fur seals mingle at all, and until we do know whether they mingle we lack a very important factor in their life history. If we find that they do not mix, if they remain entirely distinct the sponsors of the opinion that there are three different species will receive strong support.

The fur seal is now being protected by the international treaty signed by Great Britain, Japan, Russia, Canada and the United States, in which it was agreed to prohibit pelagic sealing. But unfortunately the treaty permits the killing of the seals by the aborigines of Alaska, British Columbia, and the Asiatic coast. That is a very unwise provision, for the natives kill the females, which ought to be protected.

The northern sea otter is protected by the same treaty and it is reported that they are coming back in considerable numbers. But another species of sea otter found on the California coast is almost at the vanishing point. I am afraid the treaty came too late to save it. But it may recover. The fur seals on Guadaloupe Island apparently became extinct several years ago. There is not a good specimen of its skin in any museum in the world. The same is true of the sea cow. The last one was killed probably in 1868. So Steller's sea cow has gone to join the dodo and the great auk. These are merely a few examples of large marine mammals which have disappeared. I see no reason to believe that certain marine fishes are not in the same danger. The statement that has been made that man can not do anything to decrease or increase the supply of fish in the sea may well be questioned. It may be true of such fish as the herring, but the large marine fishes like the tuna will go like the elephant seal, the polar bear, the walrus, and Steller's sea cow. They are easily gotten at and easily exterminated. I would like to urge that the countries bordering the Pacific get together and make an international treaty for more adequate protection of these animals in imminent danger.

As to the fishes, I want to speak briefly regarding those of this particular region. I have been interested in the origin of the Hawaiian Fauna discussed by others. Just a few figures concerning Hawaiian fishes. First, it is interesting to know that the first fish ever collected near the Hawaiian Islands was obtained by Solander and Banks of Captain Cook's expedition. It was a beautiful Chaetodon now very well known. The specimen found its way into the Museum of Banks where it was described in 1782 by Broussonet as *Chaetodon longirostris*. When I read of this fact I felt a greater respect for the Cook expedition.

There were other expeditions following that of Cook in which other collections—about 30 or 40 specimens—were made. Dr. Gunther of the British Museum got a collection which he began to study but never completed. But it was the first great work on the fishes of Polynesia—and a very important work.

Considerably later Dr. Oliver P. Jenkins then of Depauw University, later Professor of Physiology in Stanford University conceived the idea of coming here and collecting fishes. In 1889 he organized an expedition and spent the summer here and made the first large and really valuable collection ever made about the Hawaiian Islands. He lists about 250 species, many of which were new and which he describes.

Then the Bureau of Fisheries in 1901 undertook the study of the fish fauna of the Hawaiian Islands, and made very large collections. The next year the Bureau sent the "*Albatross*" to study the deep sea fishes. The result of the work of 1901 was 440 species of shore fishes collected about these islands. Practically all of them were reef or shallow water species. There were fresh water fish found in all the streams in Polynesia.

Of these 440 odd species 232 are peculiar to the Hawaiian Islands; and that is important. One hundred and forty-three are common to Hawaii and Polynesia (by Polynesia I mean Samoa, Fiji, Tahiti, etc.) and there are only 53 species common to Hawaii and Japan; 34 are common to the Hawaiian Islands and the coast of Mexico, Central America and Panama. Thirty four is a small number and does not mean any relation whatever between the Hawaiian Islands and American Continent. These species of fishes are widespread and are found wherever there are suitable tropical waters. There appears to be no relation between the fish of Hawaii and Japan or between the coast of America or Alaska and Hawaii. There is a slight relation between these islands and the Galapagos—but it is so small that we could almost ignore it.

Each of the islands to the south and southwest of us has served as a center of influence from which the fish have spread. Supposing the fish to have spread from India, then each island would serve as a center of influence. The big break would be between the Hawaiian Islands and Samoa because the distance between those two is greater than between any two others in Polynesia. As a rule, I am disposed to think that shore fishes do not spread very readily or very widely. The fish which spread very rapidly and widely are the pelagic fish, which may be found anywhere where the temperature is suitable. Most of the fish of Polynesia are shore fish that stay close about home. They may be found in the same place, near a wreck perhaps, from year to year, and the offspring will remain in the same place as the parents. We should keep this in mind when discussing the question of the spread of fish by means of swimming or currents.

DISCUSSION

MR. BARTSCH: Are not the fish with pelagic eggs found very widely distributed?

MR. MOORE: Yes, some of them with long larval periods, for example the eels, the leptocephali of which are carried thousands of miles.

MR. MAYOR: The color of the fish in water is protective. The lighter colored belly of the fish makes him almost invisible under water. The same thing happens in an experiment I saw tried with a potato. It was visible from a long distance across the field when placed on top of the earth. But when the lower half was painted white it was lost to view almost immediately.

MR. MOORE: A very large number of those fish referred to by Dr. Mayor will be found to have pelagic eggs, but they have as a rule a comparatively short period of incubation so they do not have time to be carried far. Also the food of the adult and of the young is found at or near the bottom. When they have to descend any considerable distance to find bottom they find unsuitable and insufficient food and die.

MR. BARTSCH: An interesting point about deep sea fish is that they sometimes come to the surface at night to feed. I remember in the Philippines we caught fish at the surface at night that ordinarily are found at a great depth. In the day time we would often bring them up dead, but we picked them up at the surface at night active and frisky.

MR. EVERMANN: The fish that can do that are built on just the opposite plan from submarine vessels. The latter would be built strong and solid, the fish are very loose-jointed.

MR. FRASER: Dr. Evermann did not make the question of conservation of mammals serious enough. For a long time there were two whaling companies in British Columbia, last year a single one. They had been operating for many years. Years ago there were many humpback whales, but in two or three years there will not be one.

MR. EVERMANN: A point to consider is that we must have the life history of the marine mammals in order to know what to recommend for their conservation. The thing needed is an investigation in order to get a clear understanding of what must be done, if anything, to conserve and save the large marine mammals. We do not know enough about them. We can get some information about the whale from the stations but that never has been done so far as I know.

MR. CHILTON: In New Zealand the seals became so scarce as to make them unprofitable commercially. Consequently they were left alone and now they are coming back. Now they are protected. The same thing may happen with the whales.

MR. BARTSCH: Is it not a fact that they are using every bit of the whale?

MR. EVERMANN: Yes. The meat was sold for food during the war. Since the war the oil is extracted from the flesh, all the glycerine is gotten out, then the flesh, bones, viscera, and blood are made into fertilizer.

MR. FRASER: It is only on condition that everything is used that the business may be carried on.

MR. BRYAN: There is a great deal of whaling carried on by Norwegian whalers on the South American coast near Chili. It occurred to me that if the Government of Chili would deny the right of landing to try out and to operate the whaling stations, they could control the number of whales taken. If the Norway whalers were not allowed concessions on the South American coast they would have to make a long run home. The Atlantic countries might not fall in very readily with an agreement made between the Pacific governments for the conservation of its marine life.

MR. MOORE: The Norwegian whaling in South America is the result of such a law as you suggest. In Norway it drove the whalers away from their own country to the southern seas.

MR. EVERMANN: That same law was in a measure successful on the Alaska coast. But floating rendering works were established so that they caught the whales at sea and rendered them on board as in the old days.

MR. KISHINOUYE: In Japan the government restricts the number of whaling vessels to about 30 and no more vessels are allowed to catch whales.

BIOLOGICAL STATIONS AND SIMILAR INSTITUTIONS IN THE PACIFIC REGION

[NOTE: Expected contributions from J. Allan Thomson, Director of Dominion Museum, Wellington, New Zealand, and from K. Kishinouye, Professor of Fisheries, Tokyo Imperial University, Japan, had not been received at the date of publication.]

THE PHILIPPINE BUREAU OF SCIENCE

BY ELMER D. MERRILL, DIRECTOR

The Bureau of Science, Manila, P. I., is wholly supported by the Philippine Government from local revenues; the appropriations for the support are made annually. It was established in 1901 under the name Bureau of Government Laboratories, becoming the Bureau of Science in 1906. The prime object in the establishment of the institution was to centralize scientific effort, so far as the Government was concerned, in order to avoid duplication in various Government units, of expensive technical personnel and equipment.

The institution is a very comprehensive one as may be seen from an outline of the work given below. Pure science, as such, is but a small part of the function of the institution as from the very nature of conditions in the Philippines the practical application of science must be stressed. The organization calls for all routine chemical work for the various units, including that necessary in connection with the enforcement of the pure food and drug laws, as well as original investigations of a chemical nature on Philippine problems. Provision is also made for chemical work for the general public, commercial units, etc. The institution does all work in connection with the standardization of weights and measures for the Philippines; the testing of all materials used in construction, such as cement, timber and steel; the manufacture of tikitiki extract for the cure of beriberi; the manufacture of all types of vaccines, serums and other biologic products; the administration of the Pasteur treatment; routine microscopic examination of all material submitted by the Bureau of Health in the detection and control of contagious diseases; and the investigation of diseases of a bacteriological nature as well as those caused by internal animal parasites. It maintains completely equipped laboratories for the work enumerated and also separate departments with the necessary laboratories, for geology and mining including assaying, botany, plant pathology, icthyology, including the maintenance of a large modern public aquarium, entomology, and orinthology. The Bureau of Science is the custodian of the governmental collection of natural history material, the herbarium containing upwards of 200,000 mounted sheets, while collections in icthyology, entomology, ornithology, and geology are relatively as extensive. The central scientific library of the Philippine Government is a part of the Bureau of Science, containing about 70,000 volumes on the sciences in general, while about 1100 technical periodicals are currently received. The Bureau publishes the Philippine Journal of Science, now in the 18th year, over 50 individual volumes having been issued, and also publishes a special series of monographs consisting of works too extensive for inclusion in a technical periodical. A completely equipped photographic laboratory is also maintained, now containing over 20,000 negatives. The Bureau maintains its own power plant, supplying electric power, steam, compressed air and vacuum to all laboratories.

It has been the constant policy of the Bureau of Science to cooperate to the greatest possible extent, not only with other governmental units in the Philippines but with scientific institutions all over the world. Requests for natural history material are complied with so far as the technical personnel available can meet the demands and so far as material is available. Visiting scientists are always welcome, and will be granted the full facilities of the institutions, laboratory space and equipment so far as it is available.

AUSTRALIAN MUSEUM, SYDNEY, NEW SOUTH WALES

By Charles Hedley, Curator

There is not now a single marine zoological station in Australia. About forty years ago a small one was formed in Sydney Harbor by Michlohou Maclay, a Russian zoologist. The site of this was afterwards resumed by the state government. Money paid as compensation for that resumption is in the hands of trustees and will be available for opening a station near Sydney.

Several Australian states have purchased trawlers and operated fishing as a public business. It has been represented that marine biological stations would be proper adjuncts to State fishing departments.

The lucrative pearl shell and bêche de mer fisheries have especial need of investigation. Until a more intimate knowledge of the life history is obtained of these animals and their associates these industries cannot be adequately organized and controlled. Establishment of such stations is being advocated by the Australian Bureau of Science and Industry.

THE CANTERBURY COLLEGE MOUNTAIN BIOLOGICAL STATION

BY CHARLES CHILTON, PROFESSOR OF BIOLOGY

One biological station at Cass, New Zealand, was established in 1913 primarily for the instruction in Zoology and Botany of the students of Canterbury College. It is situated at an elevation of about 2000 feet above sea-level and among mountains rising to a height of 6000 feet. The surrounding district is rich in indigenous vegetation and supplies examples of subalpine tussock grass land, mountain forests, scrubland, river bed and shingle-slip formations, swamp and fresh water streams. It is easily reached by rail from Christchurch and the building offers comfortable accommodations for students and workers. The station is within easy reach of the great natural forests of Westland and can be used for forestry instruction on the problems presented by the mountain pastures.

Though primarily intended for class instruction the station has already been used by graduates and workers from elsewhere for the purpose of research and the results have been published in the Transactions of the New Zealand Institute. The Station is under the control of the Professor of Biology of Canterbury College who will be glad to exchange publications and specimens with similar institutions.

THE PORTOBELLO MARINE FISH HATCHERY AND BIOLOGICAL STATION, OTAGO HARBOR, NEW ZEALAND

By W. J. Phillipps, Dominion Museum, Wellington, N. Z.

(Presented at the request of the Committee on Program.)

In a paper read before the Otago Institute on October 8, 1895, entitled "On New Zealand Fisheries and the desirability of introducing new species of Sea-fish," Mr. G. M. Thomson suggested that, before any further legislation was proceeded with in connection with the fisheries of the colony, it was necessary that a marine biological station be established where systematic observation of the habits and life-histories of the local species of fish might be carried out. The apparent feasibility of the suggestion commended itself to the Otago Institute and in the summer of 1896, a committee was appointed to consider the matter and to examine and report on the Otago harbor and its neighborhood in regard to its suitability for such an establishment. Following a favorable report by the committee and the Council of the Otago Institute and the Committee of the Otago Acclimatization Society each voted the sum of £250, conditionally to Government granting £500 for the work, and undertaking to carry on the station for a few years. In 1899, Government approval of the project was obtained and early in 1900 the site for the station was selected. After two years of negotiation and delay Government agreed to allow the work to proceed on the understanding that the cost of establishing the hatchery in working order should not exceed £1100, and the annual working expenses not exceed £250. An honorary advisory board was set up consisting of one member from the Otago Institute, one member from the Otago Acclimatization Society, the Collector of Customs, the Chief Surveyor, and the Superintendent of Mercantile Marine. In 1904, the Marine Fish Hatchery and Biological Station was formally opened and began its work under the curatorship of Mr. T. Anderton, followed in turn by Mr. W. Adams and Mr. S. Broadley, the officer now in charge.

The equipment of the station consists of eight tanks, a laboratory building and a motor launch specially built for fishery investigation.

Much valuable information is being collected yearly on the various fishes, their seasons of abundance, and wholesale prices realized in the markets. A list of the boats and of their class operating from different ports is also kept as a check on the statistical tables.

In regard to the introduction of food fishes advice obtained from England and the United States indicated that though success might not be anticipated in the introduction of ova which might be hatched on arrival, there was a possibility of successfully introducing adult or half-grown fishes. The attempt to introduce herring was unsuccessful but live turbot, lobsters, and crabs were brought in.

About three hundred of the turbot (*Rhombus maximus*) were successfully introduced. After remaining in the hatchery and being fed for a period of over three years, 128 were liberated at a suitable locality at midnight on May 19, 1916. The remaining stock of 54 fishes were retained in the hatchery. Some were at this time as much as 22 inches in length; but up to the present it has not been possible to obtain one in spawning condition. On September 1, 1917, 42 large turbot were liberated in about 15 fathoms of water; but have noe been since recorded.

Five shipments of the European lobster (*Homarus vulgaris*) were made and in all 39 males and the same number of females have arrived. A large number of eggs have been successfully hatched and larvae liberated. A total of 10 male and 6 female examples of the European edible crab (*Cancer pagurus*) were introduced up to 1911. Most have since died; but a number of eggs were successfully hatched and large plants of fry made on four separate occasions. Later in 1913, some 43 crabs were successfully landed (out of 50 shipped). Apart from eight which were retained in the hatchery and a number which died these were liberated soon after arrival.

As outlined by the Hon. G. M. Thomson, at present honorary director of the Portobello Marine Hatchery and Biological Station and who is mainly responsible for its establishment, the aims and objects may be summarized as follows:

1. To ascertain a thorough knowledge of the hatchery environment including such features as the salinity of the water, temperature, and tides.

2. To serve as a base for receiving such fishes or crustacea as it may be advisable to introduce.

3. To acquire an exact knowledge of the migration, food, rate of growth, spawning seasons of our local fishes in order that we may be in a position to conserve the supply of local fishes for future generations without undue restrictions on the fishing industry.

4. To serve as a base for those desirous of pursuing a purely scientific study of marine biology.

5. To place on record the results of experiments and investigations and the conclusions and deductions which may be drawn from these observations.

The work which has already been accomplished under difficulties of finance and unnecessary restrictions can only be regarded as preliminary; but the vast economic possibilities of the future arising from further successful attempts to acclimatize profitable marine fauna from the Northern Hemisphere will be immediately apparent when we consider the small amount which has already been attempted and its relative success.

UNITED STATES NATIONAL MUSEUM

By Paul Bartsch, Curator Division Marine Vertebrates

The United States National Museum, while it maintains no stations on or in the Pacific, nor a vessel for exploration, has nevertheless contributed an enormous amount of information on the fauna and the flora of this region, as evidenced by its publications.

The National Museum is the recipient of the material secured by all the Government surveys and explorations. For example, here reposes all the material gathered through the many years of splendid efforts of the United States Bureau of Fisheries' steamer *Albatross*. The National Museum at the present time contains the largest collection of mollusks of any institution in the world. From the Pacific, we have the most perfect series from its eastern shores. Not only that, we have the splendid collection made by the *Albatross* in the northern waters and along the coast of Japan, and from this region, also, the fine material obtained by Prof. Edward S. Morse while he was stationed at the University of Tokyo in the early '70s, and more recently the collection of Mr. Y. Hirase obtained by him and his co-workers during a lifetime of effort. From the Philippines, the Celebic, Flores and Banda seas we have the splendid material secured by the *Albatross* during its several years' explorations in those waters, and from the South Seas in general that material which the *Albatross* secured during its cruises under the late Dr. Agassiz. The Hawaiian group is represented by material obtained by the *Albatross,* and more recently by the donation of the Thaanum collection sent in by that indefatigable collector, Mr. D. Thaanum, which more than anything heretofore makes known to us the shallow water faunas of these islands. To these should be added material obtained by purchase and exchange from various sources, so that with the exception of the Australian region, from which also the early exploring expeditions have given us some collections, we are fairly equipped with the Pacific elements of these faunas.

Now the policy of the National Museum has ever been to help any institution or individual in its investigations, either by the loan of material or by furnishing study place in our own Institution for students where they may pursue comparative studies, or by actually having various members of the staff report upon material sent in for examination and report. I am sure there is not a single institution represented here which, if we were to call upon it, would not be able to say that the National Museum has always cooperated in the fullest measure with the members of its staff, in order to make the widest use of its collections, and I may say in behalf of our Institution that we shall always be glad to cooperate.

THE BUREAU OF FISHERIES

By H. F. Moore, Deputy Commissioner

I am surprised to be called on to speak at this symposium on biological stations of the Pacific, as the Bureau of Fisheries has no such station. A number of years ago we wished to establish one in the Puget Sound region and a bill making an appropriation for the purpose was introduced in Congress but failed of passage. That was before the establishment of stations at Nanaimo, Friday Harbor and at Port Renfrew on Vancouver Island, which have been here described by their respective directors. If the same proposal were to be made now I doubt if I should favor it as I believe that the interests of science and the fisheries can be advanced better by strengthening the existing institutions in that region rather than by increasing their number.

While we have no station on the Pacific Coast we have maintained a floating laboratory for many years, the steamer *Albatross*. This was the first vessel designed and built for oceanographic investigation her predecessors being warships or other vessels temporarily refitted for exploration and research. The *Albatross* is not of the exact type which would be built to-day but she has been refitted recently and provided with modern gear, so that notwithstanding 35 years of service she is apparently good for many more years of work in her field. She is now on the Atlantic coast where she will be engaged for two years, if all goes well, on a project of research off the south Atlantic coast of the United States and in the Gulf of Mexico and Caribbean Sea. This work will in some part supplement the investigations of the International Council for the Exploration of the Sea which are being extended as far as Bermuda. When this duty is accomplished I hope that she may be returned to the Pacific to take up investigations on the northwest coast of the United States and thence northwest to the Aleutian Islands, in cooperation with the biological stations in that region and such other agencies as may be available for a systematic study of the biological and other factors affecting the fisheries. With the biological stations conducting researches in the coastal areas and the *Albatross* at sea, I believe something of both scientific and economic value can be accomplished in a field which sadly needs attention.

In conclusion I wish to say that the Bureau of Fisheries still endeavors to maintain the traditions and the policy of Professor Baird. It is organized for service and is ready to assist so far as its means will permit in any work which will further the advancement of knowledge concerning the sea.

BERNICE P. BISHOP MUSEUM

By Herbert E. Gregory, Director

The history, scope and policy of Bishop Muesum is outlined by Mr. Albert F. Judd in his Address of Welcome printed in this volume.

The funds of the institution are expended on two closely related activities: the gathering of materials and investigation. The exhibition halls and laboratories contain large collections from Polynesia and to a less extent from other Pacific areas. In order of value for research work, the collections in ethnology rank first, followed in turn by conchology, botany, entomology, marine zoology and ornithology. Through gifts, purchase and field expeditions the collections for study are rapidly increasing in amount and value.

The investigation of problems in Pacific ethnology and natural history absorbs the larger part of the Muesum funds and the staff is organized primarily with this purpose in view. For example during the present year, in addition to laboratory investigations, four parties are at work in different parts of the Pacific following a program designed to shed light on the origin of the Polynesian race and the history of plant life in the Pacific. Through the Biological Laboratory the museum is cooperating with the University of Hawaii in the study of fish and littoral fauna of Oahu and other islands. The collections, laboratories and library, particularly strong in works relating to the Pacific, are available for use by properly qualified students. The publications of the museum: Memoirs, 7 volumes; Occasional Papers, 7 volumes; Miscellaneous Publications, 8 volumes, are distributed to institutions and to professional workers.

HAWAIIAN SUGAR PLANTERS EXPERIMENT STATION

See statement by H. P. Agee, Director, printed in this volume with Addresses of Welcome.

BIOLOGICAL LABORATORY, UNIVERSITY OF HAWAII

By C. H. Edmondson, Professor of Zoology

The biological laboratory for research of the University of Hawaii is now being erected through the generosity of the Cooke estate. It will be ready for occupancy in September of this year. This laboratory will be open to investigators, local or visiting, for the pursuance of research in biology during the entire year and every possible facility will be placed at their disposal.

Local problems in biology are numerous. Marine life about the islands naturally resolves itself into three zones, the life of the shore, the life of the reef and the life of the open sea. Much of the biology of the beach and of the reef can be studied very thoroughly without much equipment and by working from the shore. Work upon the open sea, however, cannot be carried on without the aid of a boat of some size, with which the laboratory is not yet equipped. It is my belief, however, that satisfactory arrangements can be made for the use of boats now in Honolulu harbor if it is desirable to carry on surface work outside the reef or dredging operations at comparatively shollow depths.

We hope to make the biological laboratory at Waikiki not only accessible to local workers but a place to which we can invite specialists in various fields of biology for work upon special problems. Biologists passing through Honolulu and wishing to stop and work for a time may have the privilege of carrying on their activities here. The University of Hawaii hopes also, by the better equipment and facilities offered by the completion of the laboratory, to stimulate interest in biology among her own students and encourage some, if possible, to continue in research.

THE PACIFIC COAST BIOLOGICAL STATION

By C. M. Fraser, Director

The Pacific coast Station at Nanaimo, B. C., under the control of the Biological Board of Canada, has been in operation since 1908. It is situated on the shore of Departure Bay, on the east coast of Vancouver Island, 40 miles across the strait of Georgia from the city of Vancouver and 75 miles northwest of Victoria.

The Biological Board, consisting of a representative of the Federal Department of Fisheries and several university representatives, is not responsible to any government department but is advisory to the Department of Fisheries.

The station is maintained solely for research work. The accommodations are somewhat limited but after investigators doing work directly for the Board are accommodated, the facilities of the Station are available for any other workers until that limit is reached. The Station is open throughout the year and except during a part of the summer there is always plenty of room.

As the Biological Board is closely associated with the Department of Fisheries, investigation of problems relating to the life history of food fishes has received much attention and will continue to do so. For such work the location is very suitable since there is easy access to plenty of material in nearly all species of economical value caught along the coast of the province.

Next in importance, as it is the basis of all other work, is the biological survey, which is gradually being extended in scope. Many of the animal groups have been worked up at the station or at other points where specialists were willing to undertake the work. Besides these many ecological, morphological, bacteriological, biochemical and physical problems have been attacked. As there are numerous islands with variety in coast line separated by channels of varying width and strength of current, there is plenty of chance to study the ecology of numerous species under much varied conditions. This is particularly true of inter-tidal and shallow water forms since there is a variation of 16 to 18 feet at spring tides, with a tide having a velocity up to 12 knots an hour.

The constantly changing amount of fresh water poured into the strait of Georgia by the large rivers makes the study of the effect of variation in salinity a complex question, particularly since with this may be coupled extensive variations in temperature of the surface water at least. Since the waters are well protected, almost inland waters, work can be carried on without danger or difficulty throughout the year.

Open ocean conditions do not prevail, hence the Station is not suitably situated for any work where such conditions are necessary. The equipment consists of a 40-foot and an 18-foot motor boat, several row boats, dredges, nets, water-bottle, etc., with considerable laboratory equipment for biological, chemical and physical work. The library consists of upwards of one thousand volumes besides separates.

If it were not for the assistance of university men, who can spend a little time in the summer, the question of workers would be rather acute; as it is, more full-time men are required. Possibly these could be obtained if the funds were forthcoming. The last six years have been lean years but better times are approaching.

THE MINNESOTA SEASIDE STATION

By Josephine E. Tilden, Professor of Biology

The Minnesota Seaside Station was established in 1901 at Port Renfrew, Vancouver Island, British Columbia. For seven years it was successfully maintained by certain members of the Botanical Department of the University of Minnesota. Parties of 25 to 40 investigators attended this summer laboratory each year. During the seven years 200 research workers in botany, zoology and geology from the United States, Canada and Japan were in attendance at this station in the wilds of Vancouver Island. It may be stated that this locality has been pronounced by experienced European travelers as one of the best in the world for biological research.

The Station is situated on the southwestern shore of Vancouver Island sixty miles west of Victoria, opposite Cape Flattery. The shores are exposed to the full force of the open waters of the Pacific. There are four different types of shore formation: slate, shale, sandstone and limestone. Each is found to support its own particular fauna and flora. Potholes of all shapes and sizes are found in the rocky shelf exposed at low tide. These afford a marvelous display of plant and animal forms and opportunity for a study of their life histories.

Because of the fact that the temperature of the air never reaches the freezing point there is an excellent opportunity of study of all-the-year-round problems. Bright sunny days are uncommon as foggy weather predominates.

During the years in which the station was regularly maintained about fifty botanical papers were published. The organ of publication of this station is "Postelsia," the Yearbook of the Minnesota Seaside Station. Two volumes have so far been published.

THE PUGET SOUND BIOLOGICAL STATION

By T. C. Frye, Director

The Puget Sound Biological Station of the University of Washington is located at Friday Harbor, Washington. Work was begun in 1904, but little attempt was made at research. The time was mostly devoted to classes and to collecting, with a view to studying geographical distribution. No buildings were erected until 1910, and equipment was returned to the university at the close of each summer session. Classes were held in rented canneries and other buildings. The chief aim in the class work was to produce better teachers of biology.

Beginning with 1914, research was made one of the chief aims of the Station. With this in view a library was begun, which has now reached about 750 volumes. With the same end in view, the publication of a series known as "Publications of the Puget Sound Biological Station" was begun in 1915. This series has reached nearly two volumes at present, and will likely increase annually for some time. It consists of 52 articles, about half botany and half zoology.

Its buildings have a floor space of about 4700 sq. ft. devoted to zoology, about 1500 sq. ft. devoted to botany and about 1500 sq. ft. devoted to mess, social gatherings and storage. Usual chemicals and glassware are at hand, as are also row boats. A shrimp steamer is rented for trawling purposes.

The chief lines of work have been ecological and physiological, with a view to explaining the distribution of plants and animals on the basis of their reactions to physical and chemical factors. This has grown out of work in geographical distribution.

The station is open for work only about 3 months during 6 weeks of which class work is given. The work of the Station must therefore be largely what those who come there are prepared to do. Work along almost all lines is done. Hard rocks and the swift tidal currents through the channels between the islands favor a rich fauna and flora, while tides of twelve or thirteen feet make the shore material easily available.

The attendance this year reached about 65, of whom about 10 per cent were under-graduates, and about 20 per cent had doctor's degrees.

The Station is supported almost wholly by the University of Washington, and at present costs the State about $4000 a year, in addition to the funds derived through a fee of $13 a person and through the sale of biological material. The last two items bring in about $1500 more, making a total of about $5500.

HOPKINS SEASIDE BIOLOGICAL STATION AND THE STEINHART AQUARIUM OF THE CALIFORNIA ACADEMY OF SCIENCES

By Barton W. Evermann

I cannot speak officially for the Hopkins Biological Station of Stanford University, but as there is no one present representing that station, I shall make a brief statement regarding it.

This station was established soon after the founding of Stanford University and is the oldest biological station on the Pacific Coast. It was established by funds supplied by Mr. Timothy Hopkins, one of the trustees of Stanford University, who has also supplied from time to time the funds necessary for its equipment and maintenance. The station is located at Pacific Grove on Monterey Bay.

It has largely functioned as an adjunct to the departments of zoölogy and botany, of Stanford University, and as a place where investigators from anywhere might come and study problems in which they are interested. The fauna and flora of Monterey Bay are so rich in species and individuals including numerous forms of unusual or special interest, that many investigators have availed themselves of the exceptional facilities there afforded.

Recently a new laboratory building has been erected. This building was carefully planned as to internal arrangement and architectural appearance. The equipment has been materially improved and provision made for more adequate funds for maintenance. Dr. Walter K. Fisher, of the Department of Zoölogy, Stanford University, and curator, Department of Invertebrate Zoölogy in the Museum of the California Academy of Sciences, is the permanent Director, and the station is open throughout the year. I am sure that Director Fisher and the other biologists at Stanford University will cordially coöperate with the biologists connected with the biological stations in the Pacific area.

The facilities of the California Academy of Sciences for biological research consist of the laboratories of the various departments, particularly those of botany, entomology, herpetology, invertebrate paleontology and conchology, invertebrate zoölogy, mammalogy, and ornithology and the library. Several of the departments of the museum are rich in collections from the Pacific and the countries bordering thereon. This is particularly true in entomology, ornithology, herpetology and conchology. The facilities of these departments are fairly good for the study of Pacific material in these lines.

Recently the Academy received a gift of $250,000 with which to build and equip an aquarium. The gift was made by Mr. Ignatz Steinhart, a public-spirited citizen of San Francisco, recently deceased. By the terms of the will, the aquarium will be located in Golden Gate Park, adjoining the Museum of the Academy of Sciences, and the management will be under the Academy of Sciences.

An amendment to the charter of San Francisco was recently adopted which directs the Board of Supervisors of the City of San Francisco to appropriate and pay over to the Academy of Sciences, annually, *not less* than $20,000 for the maintenance of the Steinhart Aquarium. This sum will probably be inadequate, but if the Aquarium proves the success we hope to make it, it is believed public sentiment will support the Supervisors in increasing the allotment.

The aquarium will have, as a part of its equipment, laboratory facilities for the study of aquatic life; indeed there is a very strong probability that another public-spirited citizen will supply a special fund for adequately equipping and endowing a thoroughly modern up-to-date biological laboratory in connection with the Steinhart Aquarium. When this is done the Academy of Sciences through its various departments, library and aquarium will, it is believed, be in a position to render efficient coöperation with investigators interested in Pacific problems.

Besides these facilities for coöperation offered by the California Academy of Sciences, there are the library and collections of the University of California, and the great ichthyological collections and library of Stanford University. And I must not neglect to mention the California Fish and Game Commission, which, with its various patrol boats, especially the *Albacore*, can and will no doubt be glad to assist materially in work along the California coast.

THE SCRIPPS INSTITUTION FOR BIOLOGICAL RESEARCH

By George F. McEwen, Oceanographer

ABSTRACT

In the absence of Dr. Ritter, Director, this outline of the history and scope of Scripps Institution is presented.

When, in 1891, Dr. Ritter was called to the newly formed department of biology of the University of California, he recognized that the Pacific waters along the west coast of North America constituted an almost virgin field for scientific investigation. He soon found, however, that the San Francisco Bay region did not contain many of the plants and animals that are most characteristic of the open ocean; and in 1892 a temporary laboratory for marine work was erected at Pacific Grove, from which station during the summer of 1892, and succeeding seasons, experiments were carried on as far south as San Diego. From 1896 to 1901 no seaside laboratory work was maintained, but collecting trips were made along the coast from San Diego to Alaska by various members of the biological department. The experience thus gained indicated that San Pedro was an especially favorable spot from which to carry on marine studies, and accordingly a seaside laboratory was established there, and dredging, trawling, collecting and also hydrographic work was done during 1901 and 1902.

During the following year better accommodations were found at Coronado and a local organization was formed and resident naturalists employed for the purpose of making a "Biological and Geographical Survey of the Waters of the Pacific Adjacent to the Coast of Southern California." The village of La Jolla, about twenty miles north of Coronado, was the home of the enterprise from 1905 to 1909. The present home is on the coast two miles north of La Jolla, a location determined by favorable conditions for collecting, abundance of pure ocean water and a large area uncontaminated by industrial plants of cities. On August 6, 1916, occurred the dedication of the latest additions to the present plant, consisting of the public aquarium, a concrete pier, two large concrete buildings for laboratories, library, museum and administration. In 1912 the local organization turned over the institution to the University of California and the name was changed from The Marine Biological Asso-

ciation of San Diego to the Scripps Institution of Biological Research of the University of California.

Financial support for the earlier activities was in part from the University of California and in part from private subscriptions. From 1905 to 1912 funds for extensive field work were provided by Miss Ellen Scripp and Mr. E. W. Scripp. Since 1912, when the institution was taken over by the University of California the public has contributed largely to its support in addition to the regular income of the Scripp endowment and from the small funds given from time to time for special purposes.

When plans for the investigation of the biology of the waters of the Pacific were formed, the need of the combined efforts of a number of individuals of varying qualifications was recognized, and particularly since 1905 provision has been made mainly for team work directed toward definite ends, and the solution of certain biological problems of the sea, has received a large share of attention. Although a salaried staff have devoted all their time to problems chosen by the institution, other investigators wishing to work on problems of their own, have always been welcome, and many have taken advantage of this opportunity. The resources of the institution are available also for investigators devoting their attention to land animals. The institution's program of marine biology and hydrography has been based largely on problems suggested by the general question of the seasonal distribution of each species of organisms, its horizontal and vertical distribution, its food and reproduction, migration and relation to the environmental factors, or physical and chemical conditions of the water. In other words, the major work of the institution has been in the field of what is now generally known as Ecology. These intensive investigations have been limited to a few groups of the most abundant plankton, the Chaetognaths, Copepods, Ascidians, Diatoms and Dinoflagellates. Such problems have been attacked mainly by means of quantitative field collections and observations, where control over the conditions was impossible. This field method has been supplemented by laboratory experiments, and it is recognized that both methods have their place in the attempt to answer such questions.

The need of giving special attention to the environment, that is, to the physical and chemical conditions in the sea, led to the addition of a physicist to the staff in 1908. Since then considerable attention has been directed not only to making observations relative to the water, but also to a few selected problems of physical oceanography suggested by these observations. Certain results of these studies have proved of value in interpreting the biological data and have clearly shown the close relation between ocean and atmospheric phenomena. Attention has been given also to quantitative methods of dealing with the data, with a view to getting at the deeper significance of the facts observed.

The work at sea has not been as continuous as the problems need, either from the standpoint of biology or physical oceanography—a situation which has been remedied to a certain extent, during the last five years, by regular daily collections and observations from the institution's pier and by daily collections by coöperative observers at a series of fixed positions along the coast from San Diego to Pacific Grove.

Although the Scripps Institution has been engaged primarily in research in pure science, it has coöperated for ten years with the bureau of soils in the study of kelp and to a limited extent with the bureau of fisheries, and with the State Fish and Game Commission.

Formal instruction is not carried on by the Scripps Institution, but opportunities are offered to graduate students for advanced work pertaining to the fields of investigation in which the institution is engaged and in connection with the work of the museum and aquarium, a supply department is operated for furnishing educational institutions with marine animals from the Pacific coast.

Further information regarding the Scripps Institution is presented in various published papers, especially in one by the director, entitled "The Marine Biological Station of San Diego, Its History, Present Condition, Achievements and Aims."

SUGGESTIONS FOR BIOLOGICAL WORK IN THE PACIFIC

THE IMPORTANCE OF SYSTEMATIC EXPLORATION OF THE LAND FAUNA OF ISLANDS IN THE PACIFIC

Based on data collected by C. W. Richmond and arranged by T. S. Palmer, with notes by R. C. Oberholser and Leonard Stejneger.

By E. W. Nelson, Chief, Bureau of Biological Survey, Department of Agriculture, Washington, D. C.

INTRODUCTION

Since the days of Darwin's investigations in the Galapagos Islands interest has steadily increased in the many problems relating to the life history and distribution of the higher vertebrates on the islands in the Pacific Ocean. Notwithstanding this, comparatively few of these islands have been thoroughly examined; in fact, aside from the Galapagos and Hawaiian islands and some collecting on Samoa and the Fiji islands, practically none of the small groups have been carefully studied. Birds naturally form the most interesting of the terrestrial vertebrates. Indigenous mammals are comparatively few and the number of species of reptilia and amphibians is relatively small. Even in the case of birds, our knowledge at this late date is extremely fragmentary and based on casual collecting rather than systematic exploration. On some of the more important expeditions zoölogical collecting was merely incidental to other work and the labors of naturalists were limited to a few hours on shore. The main object of Capt. Cook's voyages was not zoölogical collecting; the voyage of the *Blonde* was undertaken to convey home from England the remains of the deceased king of the Sandwich Islands; and the Wilkes Exploring Expedition was so occupied with other matters that the naturalists were often handicapped in their work and frequently had but a few hours to spend on shore on some of the islands, while others were passed untouched.

When these facts are recalled it is not surprising that even on the islands which have been most thoroughly worked, new species are still found. In fact so little is known of the zoölogy of the region that information regarding even the best explored of the larger islands is today in much the same condition as that of the Hawaiian islands thirty years ago when the Hawaiian group was regarded as fairly well known. More careful search since that date has brought to light at least ten new genera of birds, the last (Dysomorodrepanis) described in 1919. With one exception these are all land birds and are so distinct as to cause considerable discussion as to their family position. The larger islands in the Samoan group, the Fijis, and the Carolines may have similar novelties. On the other hand practically nothing is known of the birds of Easter Island, although it was visited by Capt. Cook a century and a half ago, and subsequently a small land bird was reported as present. The family to which this bird belongs is still unknown. It so happened that at the time of Capt. Cook's visit the naturalists, J. R. and Georg A. Forster, were ill, otherwise more definite knowledge might have been obtained regarding this species. In recent years the island has been utilized as a range for cattle, horses, and sheep and in 1886 supported about eighteen thousand sheep. A South American tinamou and probably other birds have been introduced, but from a distributional point of view the identity of the native land bird is of peculiar interest in view of the fact that the nearest island, Pitcairn, from which it might have been derived, is several hundred miles distant.

Even of some species which have been described existing knowledge is extremely vague and slight; no specimens have been received and the species are known only from drawings based upon field sketches. Aside from the Hawaiian birds practically nothing has been recorded concerning the anatomy of the great majority of the known species. If the results of Gadow's investigation of a small collection of Hawaiian birds in alcohol may be taken as a criterion, results of the highest importance may be looked for when the anatomy of other insular forms is better known.

Nowhere in the world perhaps are terrestrial forms of vertebrate life subject to greater dangers and vicissitudes than those in the isolated colonies on the Pacific islands. As mentioned further on, practically all the destructive agencies of nature, including fire, tidal waves, hurricanes, and the inevitable destruction due to occupation by man, such as deforestation, cultivation of the land, fire-arms, and the introduction of new enemies in the form of domesticated and wild animals and birds, are hastening the extermination of many species. With settlement of the islands have come also some of the worst pests from other countries such as the mongoose, rats, mice, and cats.

While much progress has been made in investigating problems in oceanography and vulcanology, and in studying the formation of coral islands and the wealth of marine life of the Pacific, and much still remains to be done in all of these subjects, strange to say comparatively little has been attempted in the direction of systematic exploration of the highly specialized and interesting land faunas. In the case of a number of species of birds there are no specimens in museums—and never have been any—since they are known only from drawings and descriptions. If the work of investigating the fauna of the islands is not soon undertaken, many of the most interesting forms will have vanished before any adequate information concerning their life history or even the bare fact of their occurrence is recorded. The presence of rats and mice and certain birds on some of the islands indicate former visits by man and careful study of all such cases may throw light on the distribution of the native races and add to our knowledge of some of the aborigines of Polynesia.

THE REGION UNDER CONSIDERATION

The wide expanse of the Pacific ocean is dotted with many islands and reefs, chiefly volcanic in origin or of coral formation, scattered over an area representing nearly one-fifth of the surface of the earth. Exclusive of continental islands, the area under consideration includes in broad terms the North and South Pacific from the Aleutian Islands to New Zealand and from the coast to America to the Philippines. It includes about 85 degrees of latitude from 50 degrees North to 35 degrees South, and 145 degrees of longitude, from 80 degrees West to 135 degrees East. It comprises the Hawaiian islands in the north, Juan Fernandez in the southeast and the Kermadec Islands, New Hebrides, New Caledonia, Solomon, and Marianne islands in the west, but does not include Japan, the Philippines, Celebes, New Guinea, Australia, or New Zealand. Within this area are hundreds of islands, some covered with dense vegetation and others bare reefs or sand spits. The majority are of great interest on account of the peculiar forms of life which occur on them, and because of the many problems involved in the distribution of species. Of birds the number of known species is probably not less than five hundred and of mammals the number now known is about fifty. These mammals are chiefly bats, rats, mice and seals but include several genera and a number of species peculiar to the islands. Many of the birds are rare and local, some of them are scarcely known and a few of them are now extinct. Among the number are some that are peculiar to one or more islands, and that represent genera not found elsewhere in the world.

There is no question that among the reptiles of Polynesia, few as the species are, many new ones yet remain to be discovered not only in the unexplored islands but even in those commonly visited by collectors. Among the lizards the most numerous families are those of the skinks and the geckos. Their distribution in Polynesia is very interesting and often puzzling, but more reliable material may solve some of the puzzles and a study of their geography may throw light upon the question of a former distribution of man in this part of the world. A boa-like genus of snakes Enygrus, the nearest alleged relations of which live in tropical America and Madagascar, seems to have its headquarters in the Solomon islands, where three out of its four species are said to occur. One of these species is supposed to inhabit New Britain, the New Hebrides, and the Loyalty Islands, as well as Rotuma and Samoa, while another is known outside the Solomons only from Fiji and Tonga. The enormous Iguanoid family of lizards, is with three alleged exceptions, confined to America; two genera occur in Madagascar and one genus with a single species is reported in the Fiji and Tonga islands.

Among Batrachians the occurrence of a frog of the genus Cornufer in the Fijis and its relationship with species of the same genus in the Philippines and New Guinea stand in great need of investigation.

EARLY EXPLORATIONS

Explorations of the islands in the Pacific date back almost exactly 400 years to the discovery of the Philippines and the Mariannes by Magellan in 1521. Other 16th century discoveries of importance in this connection are those of the Carolines by Vasco da Rocha in 1527, the Marshall Islands by Alvaro de Saavedra in 1529, the Pelews by Villalobos in 1543, Hawaii by Gaetano in 1555, the Solomon Islands by Mendaña in 1567 and the Marquesas by the same explorer in 1595.

The explorations in the 17th century resulted in the discovery of the New Hebrides, Society Islands and Tuamotus by

Quiros in 1606 and the Fiji and Tonga islands by Tasman in 1643.

The 18th century brought to the charts the additions of the Gilbert Islands, discovered by Byron in 1765, Pitcairn by Carteret, and Tahiti by Wallis, both in 1767, Samoa by Bougainville in 1768, the Austral, the Hervey or Cook Islands and New Caledonia, all by Cook in 1769, 1773, and 1774, respectively, and the Loyalty Islands by Butler in 1800-1803. Thus by the beginning of the 19th century most of the more important islands had been discovered, named, and charted.

PECULIAR GENERA AND SPECIES

An important part of the terrestrial mammals, birds, and reptiles, consists of species that are peculiar to the region. Among the mammals are three genera of fruit bats, Melonycteris, Nesonycteris, and Notopteris, each represented by a single species occurring on New Ireland, the Solomon Islands, and Fiji, respectively, and a bat (*Anthops ornatus*) of the family Rhinolophidae from the Solomon Islands. Among other peculiar and interesting species are *Nycteris semota* from Hawaii, and *N. brachyotis* from the Galapagos, both related to the red bat of North America. Of rats and mice there are a dozen or more peculiar species, among which may be mentioned *Mus macleari* and *Mus nativitatis* from Christmas Island; *Epimys rattus caledonicus* from New Caledonia; *E. rattus jacobiae* from the Galapagos; *Mus huegeli* and *Mus musculus vitiensis* from Fiji; and *Mus musculus taitiensis* from Tahiti.

Among the birds the most striking forms are peshaps the Kagu (Rhinochetos) of New Caledonia, a tooth-billed pigeon (Didunculus), and a rail (Pareudiastes) on Samoa. On the Marquesas is a remarkable fruit pigeon of the genus Serresius, in the Fiji Islands a timeline bird of the genus Lamprolia represented by two species, and an orange fruit pigeon (Chrysaena) comprising three species. On the Hawaiian islands are a number of genera including Chloridops, Ciridops, Chaetoptila, Drepanis, Moho, Palmeria, Pseudonestor, Rhodacanthis, and Viridonia. Of these perhaps the ones of most general interest are the Oo *(Moho nobilis)* and Mamo *(Drepanis pacifica)* which furnished the brilliant plumage for the royal robes formerly worn in the islands. South of the Hawaiian group, Juan Fernandez, the Galapagos, Solomons, New Ireland, New Britain, and the Kermadecs, are known to contain peculiar groups, including 2 families, 23 (or more) genera, and upwards of 300 species. How many unknown forms there may be, no one can say.

EXTINCT SPECIES

How many of the rare and interesting forms of terrestrial life are now extinct is unknown, owing to the rapid changes which have been going on in recent years and through increasing contact with civilization for a century or more. Zoölogical news from some of the islands is very infrequent, and an explorer may report a species from a certain island and fifty years later another reports it not found, but when the species became extinct is unknown. The equinoctial warbler of Latham was first observed in December 1777 on the occasion of Captain Cook's visit to Christmas island but no further information was received concerning it for nearly a hundred years until Dr. Streets, U. S. N., found it in 1873-74, but his specimens were unfortunately lost. There are still no specimens in collections and no additional information regarding the bird has been received since Streets' visit.

Among the birds which are now extinct the more important are: *Drepanis pacifica; Ciridops anna;* a peculiar honey-eater (Chaetoptila); and a rail *(Pennula millsi)* from the Hawaiian islands; *Aechmorhynchus cancellatus* from Christmas Island; *Prosobonia leucoptera;* and *Hypotaenidia pacifica* from Tahiti; and the monotypic *Traversia lyalli* from Stephen Island.

DESTRUCTIVE AGENCIES

The native fauna and flora of the Pacific islands are subject to destruction by several agencies, some natural and others due directly or indirectly to the work of man. Among natural agencies the more important are fire, volcanic eruptions, hurricanes, and tidal waves. Among those attributable to man may be mentioned clearing land for cultivation, introduction of firearms among the natives, introduction of domestic animals and grazing, introduction of wild mammals and birds, and plume hunting.

Fire. When the naturalist Labillardiere passed the island of St. Paul in the Indian Ocean in March, 1792, the forests of the island were on fire. The same thing may happen at any time and probably has already happened on some of the drier islands of Polynesia. Bennett in speaking of one of the islands of the Marquesas group says that wild hogs were sometimes caught by setting fire to the thickets in which they lurked.

Volcanic Eruptions. Agassiz in his report on the coral islands of the Pacific gives maps showing the geology of the islands of Polynesia, indicating the active volcanoes. Without going into detail it is sufficient to recall the destruction caused by the volcanoes of Mauna Loa and Mauna Kea in Hawaii, and some of the results of volcanic action in the New Hebrides and in the islands of the Tonga group. Since the date of Cook's explorations Yasua on the island of Tanna in the New Hebrides has been in eruption frequently and at times almost constantly. In August, 1847, Fonualei in the Tonga group was destroyed by an eruption during which the inhabitants escaped, but the vegetation and probably some of the fauna were destroyed. On Good Hope or Niuafoou an eruption occurred in 1853 and again in 1886 when the island was covered with ashes. Megapodes and probably other birds were nearly exterminated and the vegetation of the higher parts of the island probably was much damaged. This island is only three and a half miles long by three miles wide and has an altitude of 588 feet. Falcon island, of no special interest to zoölogists or botanists since it last rose from the sea, was at one time two or three miles long and reached an altitude of 250 feet and then subsided to the condition of a breaking shoal, all in the space of a few years. The same calamity may overtake and probably has overtaken other islands on which the native fauna and flora had long been established.

Tidal Waves. Tidal waves as a result of volcanic action and earthquakes have occurred at various times and places but are frequent in Tonga. According to a recent press report, a tidal wave swept over Pangai, one of the islands in this group on April 30, 1919, devastating the island and reducing its 250 inhabitants and 50 traders nearly to starvation.

Hurricanes. On some of the islands great damage is done by hurricanes. In the Hervey or Cook Islands hurricanes occur chiefly in the months between December and March; in the Fiji islands cyclones are frequent between the months of December and April; and in the Tonga group hurricanes likewise often take place. In the Marshall Islands the Kili islets were devastated by a hurricane in 1874. Several hurricanes swept over many of the islands of the Tuamotu group in September, 1877, February 7, 1878, and January, 1903. In the storm of 1878 much damage was done to the trees and in 1903 the small brush wood was destroyed on several of the islands. It is said that in the storms of 1877 and 1878 the sea washed completely across the island of Niau or Greig, probably destroying ground-inhabiting species of birds if the same fate had not overtaken them during previous storms.

Clearing the Land. Agricultural development seems likely to prove the chief menace of the native fauna in the immediate future. The demand for land for planting pineapples, sugar cane, and coconuts, particularly the last, has resulted in clearing the native forests on a number of islands, particularly in the Hawaiian Islands and in some of the smaller groups farther south. Some of the Austral group, unknown zoölogically, are being similarly exploited.

Introduction of Domestic Animals and Grazing. From the days of the earliest explorers, domestic animals have been repeatedly introduced, particularly horses, cattle, sheep, hogs, dogs, cats, and rabbits. Some of the larger islands now contain several thousand cattle or sheep. The effect of grazing animals, more particularly cattle, sheep and goats, on the native vegetation is too well known to require special comment, but the work of cattle in hastening deforestation on some of the larger islands is perhaps nowhere better exemplified than on the island of Hawaii. An early as 1743 Anson found wild hogs in abundance on Huaheine Island in the Society group, and on Tinian Island in the Mariannes. Thirty years later Cook found that the natives on Tahiti and on Nomuka in the Tonga group had many tame hogs. About 1869 hogs were kept on Carolina atoll where they were fattened for the Tahiti market. Dogs which the Spaniards had set ashore on Juan Fernandez to kill the goats were reported by Anson as extremely numerous in 1741 and as they were unable to catch many goats, they had taken to eating young seals. Cook in 1773 left a pair of dogs on Tongatabu in the Society Islands, two pairs on Nomuka in Tonga, and in 1774 one pair each on Malekula and Tanna in the New Hebrides. Contract laborers returning home to the New Hebrides and elsewhere, took back cats as pets. The destructive work of rabbits is not by any means confined to Australia and New Zealand but is exemplified in striking form on some of the smaller islands of the Pacific; for instance, on Lisianski, one of the smaller islands in the Hawaiian bird reservation, formerly covered with vegetation and utilized as a breeding ground by thousands of sea birds. Rabbits were introduced about twenty years ago, and in the absence of enemies they increased to a point where the food supplied by native vegetation proved insufficient and disastrous results speedily followed. The rabbits devoured the native vegetation and when this was gone, died of starvation, so that three or four years ago both rabbits and vegetation had disappeared and many of the sea birds which were accustomed to nest in the grass had departed. Thus in a space of less than twenty years the introduction of rabbits entirely changed the character of Lisianski, reduced it to the condition of a bare and sandy beach or spit and this resulted in a change in the character of the bird population.

A similar tragedy was enacted on Nepean Island, at an earlier date.

Introduction of Wild Animals and Birds. Experiments in acclimatization include some interesting transfers of native species from one island to another. The Laysan finch and the rail peculiar to Laysan Island have been transferred to Midway Island where they have done well. Domesticated canaries have also been liberated on Midway Island and are now breeding in a wild state. On the island of Guam the pigmy quail *(Excalfactoria sinensis)* was introduced from Manila about 1894. The introduction of other foreign animals and birds have been less successful. Mynahs *(Acridotheres tristis)* have been introduced in Hawaii, Tahiti, and the Fiji Islands and mynahs and house finches *(Carpodacus m. frontalis)* in Hawaii, weaver birds in the Society Islands, and other species on other islands. Perhaps the most striking example is that of Oahu, where most of the birds commonly seen in the vicinity of Honolulu are introduced species. These include not only the mynahs and house finches above mentioned, but also the European skylark, California valley quail, Japanese pheasants, ring-necked pheasants, and Chinese doves. On the island of Hawaii, an Australian parrot *(Platycercus palliceps)* has become well established. Some of the experiments involving introduction of foreign animals and birds have on the contrary had disastrous effects both on agriculture and on the native fauna. Conspicuous examples are the destruction caused by the mongoose in the Hawaiian Islands and in Fiji, and by the rice birds *(Munia nisoria punctata)* to rice in Hawaii.

Plume Hunting. The pursuit of certain bright-plumaged birds of the Hawaiian islands, the feathers of which were utilized in making the royal robes, has resulted in the extermination of the mamo and reduced the oo to a point where it is nearing extinction. The demand for terns and albatrosses and certain sea-birds which were utilized several years ago for millinery purposes caused expeditions to be dispatched to some of the smaller islands where these birds nested in enormous colonies. Three raids of plume hunters on Laysan and Lisianski during the last twenty years have resulted in the destruction of probably a million birds. Midway Island has also suffered from the visits of plume hunters and Marcus Island was devastated in the same way about 1902. These cases merely illustrate the enormous destruction of bird life which has probably occurred on other islands of which at present no record is available.

THE EFFECT OF EXPLOITATION ON THE NATIVE FAUNA

It is neither desirable nor possible to go into detail concerning the recent exploitation of the various islands, but a few cases will illustrate the radical changes which are likely to occur in the immediate future in the progress of development. As an example may be mentioned the four islands of the Fanning group, Palmyra, Washington, Christmas, and Fanning. All are now in private hands or leased to private individuals. Palmyra is the private property of a citizen of Hawaii and for administrative purposes is now attached to the County of Oahu. Inasmuch as an exhaustive report on this island has been recently published it is unnecessary to further refer to it in this connection. Christmas Island was leased some years ago to a firm in Auckland, New Zealand. This firm planted thousands of cocoanut trees and in 1886 had a lease on several other islands and was arranging to establish groves on them. Its native fauna includes two rats and a shearwater. Washington Island is about three and a half miles long by one and a quarter in width. Of its fauna we know a peculiar species of duck *(Chaulelasmus couesi)*, a parrot *(Coriphilus kuhli)*, and a warbler of the genus Conopoderas of which the species is still unknown and no specimens are extant in any museum. Foreign labor has been imported from Tahiti for the purpose of pressing coconut oil. Fanning Island now a cable station for the cable from Vancouver to Suva, Fiji, is about nine and a half miles in length by four in width and has a large shallow lagoon. The only land birds known from this island are *Conopoderas pistor* which is peculiar to the island, and the brilliant parrot *(Coriphilus kuhli)* which is also found on

Washington Island. The former species has never been compared with that on Christmas Island as no specimens from the latter island are now extant. Not only has Fanning Island been developed as a cable station, but labor has been introduced from other islands to collect copra, and a rifle range has been established for the employees. The effect of this development on the native fauna, comprising the two land birds and a species of duck, may be readily imagined.

In the Phoenix group immediately to the southwest, practically all of the islands were leased to the Pacific Islands Company in 1899 for coconut planting. These islands included Birnie, Canton, Enderbury, Gardner, Hull, McKean, Phoenix, and Sidney, together with the neighboring islands of Baker and Howland. Thus practically the entire group has been leased for private exploitation. Among the birds found on these islands is a species of duck *(Dafila modesta)* known only from Sidney Island and probably represented in museums only by the three original specimens. Its status is not fully understood and more facts concerning it are very desirable. The fate of such a bird at the hands of introduced laborers can readily be imagined, as it would be considered merely a wild duck and can be easily exterminated on an island which is only two miles long by one and a half miles in width.

SUGGESTIONS FOR A SURVEY OF PRESENT KNOWLEDGE

As a basis for systematic exploration and future work a general survey of all available data of the fauna of the islands should be made at once. Such a survey should include:

1. Lists of the mammals, birds, and reptiles showing the species now known from each island.
2. A check list of the birds of the Pacific region with a brief statement of the distribution of each species and a reference to the original description, type locality, and present location of the type if known.
3. A list of all introduced species including those transferred from one island to another, with full notes as to date of introduction, subsequent history, and other data regarding the experiments. This list should include also the dates of original introduction of domesticated animals.

4. A bibliography of all publications relating to the zoölogy of the islands or bearing in any way on the distribution, habits, or life history of the various species.
5. A series of topotypes should be assembled as rapidly as possible in some central museum so that nearly related forms from neighboring islands may be readily compared. Some of the original types are no longer in existence and others are widely scattered among the great museums of the world so that such a series of topotypes would be invaluable for reference.
6. Cave deposits and kitchen-midden material should be carefully examined; skeletons, etc., should be gathered, for many species are doomed and material must be soon collected, or not at all.

Nowhere in the world can the forms from these islands be studied with the same facility as is possible in the case of those of most of the regions of the mainland. With such information and material at hand a broad foundation will be laid for future work in connection with which changes in the fauna of the islands can be recorded with accuracy and precision.

STATUS OF WORK IN MALACOLOGY

By C. Montague Cooke, Jr., Malacologist, Bishop Museum

(Presented at the request of the Committee on Program.)

According to your request for a statement relative to the condition of work to date on terrestrial malacological problems in the Pacific, I would say that most of the work is still undone.

Valuable monographs dealing with different genera have been prepared and I might mention those by Pilsbry in "The Manual of Conchology," Crampton, Mayor, and Hartman. Since Garrett's time, in the eighties, as far as I know, very few lists have been published dealing with the total shell fauna of groups of islands except one by Tom Iredale, covering the Kermadec Islands. Up to the present time, far too little attention has been paid to genera of the small and minute specimens, nearly all collectors spending their time on the large and showy species, as, for example, the many monographs dealing with the genus Partula. The only minute families living in the Polynesian region that have been monographed to date, as far as I know, are Pilsbry's publications dealing with Tornatellinidae and Pupillidae in volumes 23 and 25 of "The Manual of Conchology."

My suggestion is that intensive collecting be done on each group of islands of the Pacific and that papers dealing with the entire shell fauna as known from a group of islands or a single island should be published. A large amount of time will be necessary to accomplish this, when we consider that probably not one-half of the species of the Oahu fauna have been described. Later, papers dealing with the different groups of islands could be generalized into a survey of the whole Pacific.

PROGRAM FOR WORK ON LAND MOLLUSKS

By Henry A. Pilsbry

As land mollusks are an important group in zoögeography, it is recommended that material for a comparative study of the soft anatomy of land snails should be obtained from all the high islands of Polynesia, Micronesia, and Melanesia. At the same time, faunistic collections should be increased as much as possible by examining islands not now known or only superficially collected over. At present the inequalities in our collections stand in the way of definite comparisons of island faunas. The reliability of our estimates of the relationships and probable source of a fauna increases directly with the completeness of our collections and the right appreciation of the systematic relations of the genera and species. In a number of Polynesian families, such as the Zonitidae, the taxonomy is now nebulous. Being based on the shells alone, it is empirical, since the important features are in the soft anatomy. In others, such as Partulidae, the relations of the groups on different islands are uncertain, and afford no solid basis for tracing the streams of migration. The collection and preservation of specimens with the soft parts is urgently needed.

It is believed that except in Hawaii, collectors have given their main attention to the larger shells. Where Partula, Placostylus and the like are to be found, the small and minute snails generally have received scant attention. By modern methods of collecting it is believed that large and important additions can be made on any high island. Such collecting has vastly increased our knowledge of the Hawaiian mollusk fauna in the last few years.

A beginning may well be made on especially important points. I would suggest the Marquesas, Rapa, any high islands of the Austral group, Samoa and Fiji. Further north, some of the Caroline group appear to be degraded high islands with interesting faunal peculiarities. The Pelew group also deserves attention.

Since over-sea drift is thought to be a factor in the dispersal of non-marine mollusks, the limit of toleration of sea water should be ascertained for small land snails of different genera. To be of any value the experiment should approximate the natural conditions in the open sea. For instance, snails should be allowed to seal themselves to branches, in knot holes, or to crawl under bark. The objects should then be moored to a stake by a line permitting free drifting. Among marine mollusks the duration of free-swimming stages should be ascertained for as many genera as possible. The distribution of forms without a floating larval stage should be determined in detail. Such work could be carried on at Honolulu or Pearl Harbor and would afford some definite data where now all is guesswork.

DIRECTIONS FOR COLLECTING LAND AND FRESH-WATER MOLLUSKS

By Henry A. Pilsbry

APPARATUS

The only apparatus absolutely essential are sharp eyes and a bottle or box to contain the specimens, but part or all of the following are needed for the most efficient collecting:

Forceps with very weak spring, fine points, ¾" long.

Eye, dental, or hypodermic syringe, the point blunted to give proper stream.

Hooks (readily made by heating and bending the point of a small hat pin).

Wide-mouthed, four-ounce bottles with corks.

Vials and small boxes for little shells, and chocolate-tin or other containers for larger specimens.

Cheesecloth—plenty of it—and cotton for packing.

A strong "landing net" frame, to be fitted with cheesecloth or unbleached muslin bag for "sweeping," or with burlap or other loose material for scraping the bottom in ponds or streams. A quarter-inch wire, bent into a circle, with two ends at an angle for lashing to a stick or pole serves equally well.

Alcohol.

Stout paper for labels.

When a snail is found in abundance, take plenty; it may not be found anywhere else. Many snails are very local—in a single valley or smaller area. A "dead" shell is far better than none, but get living ones if possible.

PREPARATION OF DRY SPECIMENS

After drowning, the animals of large snails may be "squirted" with the syringe or pulled with a hook or pin; those from one locality wrapped in cheesecloth, labeled, and hung up to dry in the shade. Pack only when thoroughly dry, as otherwise they are likely to mould.

Small and minute shells (except those preserved for dissection) may be placed in alcohol at once to kill them, then dried, or left in the alcohol. The latter is safer in hot, humid climates as there is danger of moulding. This applies to Pupillidae, Tornatellinidae, and others of that size. Never use formaline. In the absence of alcohol, use whiskey or other strong spirit.

Drown snails by immersion in a vessel full of water, 12 to 24 hours—until the extended animal is not sensitive to the touch. Transfer to about 33 per cent alcohol; after 24 hours to about

66 per cent. After curing thus, mollusks may be packed for shipment with only enough alcohol—66 per cent—to keep them moist. Alcohol used for curing may be used again by adding a little fresh alcohol; the exact proportions are not essential. Snails placed at once in alcohol contract so much that dissection is difficult or impossible. If single specimens or very few are found, the animal may be removed and pickled and the shell preserved dry, care being taken to give both the same number. This applies chiefly to large or medium-sized snails.

Small shells, up to half an inch long, may be collected in vials. Fill the vials with water over night, then replace most of the water with alcohol. Such vials may then be plugged with cotton and packed standing in fruit jars, with cotton between layers and a little alcohol added. Add a label in the vial.

Fresh water snails often cannot be killed extended, but slow narcotization by adding tobacco or tobacco and alcohol to the water is sometimes effective. Quite small operculate snails may be killed extended by suddenly pouring boiling water over them when active. If opportunity allows, observe the locomotion of land operculate snails, whether evenly gliding, advancing the right and left sides alternately, "stepping," etc. Is the muzzle (or oval disc) used in locomotion?

WHERE TO LOOK FOR SNAILS

Snails may be looked for on the bark and leaves of trees and shrubs; in knot holes and under bark; on bananas, ferns, and herbaceous plants, chiefly in the humid zone.

Many minute snails, like Pupillidae and Tornatellinidae, are found on trees—mossy trunks in the humid zone, but also in rather dry places, in crevices of bank or under loose bark. They are often very local, plentiful on one tree; rare or wanting on others. Don't give up the search too soon. Many species are as small as a tenth to a twenty-fifth of an inch in diameter.

Look on and under rotting wood on the ground; also in the leaf debris of woods and thickets. Collect a peck or so of this debris in bags (salt or flour bags serve very well), or in squares of cheesecloth, to be looked over at home, or dried, concentrated by rejection of coarsest materials, and shipped to be sieved and looked over with a lens in the laboratory. *This has proved to be one of the most productive methods.* By this method shells are found which would never be seen in the field.

Fallen palm and banana leaves should be looked over for small snails; they are often productive. Look also under stones, on ledges of cliffs and around ruins and abandoned buildings.

The "landing net" with bag of cheesecloth or unbleached muslin may be used to beat and sweep grass and ferns for minute leaf-inhabiting snails. A cyanide bottle should be at hand for killing the insects obtained incidentally.

Fossil shells are often to be found in quantity in superficial soil where there was formerly forest. They should be looked for also on and around raised reefs, sand dunes, aeolian rock, in ravines or gullies at low elevations, and on arid volcanic cones. Such deposits are very numerous in Hawaii, probably also in Polynesia. They usually contain species now extinct, sometimes extinct genera, and are of the first importance. Deforested places or islets are highly promising situations for exposures of such deposits. When shells are abundant, scoop up shells and sand or earth in quantity to be picked at home.

Fresh-water shells inhabit most streams. When possible, collect at several places in the same stream, noting distances and elevations. At different levels ecologic forms of the same species usually occur; also in the intertidal flats where streams debouch. Examine dripping rock faces.

Rice or taro plantations have other species. Look on lily pads and their stems. Masses of fine water plants should be hauled out, partially dried, and shaken over a paper or cloth.

The landing net frame fitted with a burlap bag is indispensable for collecting fresh-water shells living buried in mud or sand.

LABELS

Write with soft pencil on a tough paper. Note island, locality, station where found (as under stones, on ferns), and if few shells are collected, note approximate elevation, humid or arid conditions. If the locality is productive, the particulars may be entered in note book. The fuller the record is, the better; but if time presses, note at least the locality and elevation.

Collectors of mollusks should always carry a cyanide bottle for insects. The collection of insects and plants can be carried on very well with mollusks; but it is a mistake to collect in too many branches.

Collectors should be provided with a little handbook of a few pages with photographs, giving what is known of the island or archipelago under examination, and directing attention to particular desiderata. These can be supplied by Cooke, Pilsbry, or others on application to the Bishop Museum.

STATUS OF THE GENERAL KNOWLEDGE OF THE PACIFIC FORAMINIFERA

By Joseph A. Cushman

FAUNAS

In order to understand the foraminifera of any region it is necessary to study them as belonging to several distinct faunas as follows:

Pelagic. There are comparatively few species, about thirty, which are truly pelagic. Of these perhaps only ten are very common. These are largely species of the genera Globigerina, Orbulina, Candeiana, Hasterigerina, and Pulvinulina. These pelagic species are very widely distributed over the whole of the ocean. This is similar to what is known of other pelagic animals and plants. As far as the knowledge of the Pacific at present shows, the distribution of the pelagic foraminifera is very largely determined by the force and direction of the ocean currents. Most of the species belong to the family Globigerinidae.

Abyssal. In the case of the abyssal faunas, temperature seems to be the controlling factor in their distribution. The ocean bottom as a whole at considerable depth is cold, usually 40° F. or less. As a result in equatorial regions there are found species and genera under such conditions which are typical of the more shallow but cold water of polar and subpolar regions. In the deep-sea forms arenaceous types predominate, especially those belonging to the families Astrorhizidae and Lituolidae.

Reef Faunas. In this division are included those species which are found in very shallow waters, often in the lagoons inside coral reefs, mostly water of less than 20 fathoms, but extending out in some cases to 40 fathoms. These include many of the largest living foraminifera, such as Orbitolites, Amphistegina, Heterostegina, Operculina, etc. It is also the one great region in which the Miliolidae are obtained in greatest abundance. With these are many Nummulitidae, Rotaliidae, and some Textulariidae.

Medium-Depth Faunas. At depths from 100-300 fathoms, corresponding to the edge of the continental shelf, there is obtained a very rich fauna in which Lagenidae and Textularidae predominate.

The last two of these faunas, those of shallow water, and those of medium depths are much the most interesting as they are more apt to contain new species and those of restricted distribution.

RELATION OF THESE FAUNAS TO THOSE OF OTHER REGIONS

As has already been noted, the pelagic forms of all the great oceans are very similar in their species. The same may be said of the abyssal forms to a lesser degree. In the case of certain of the abyssal arenaceous forms there seems to be a very limited distribution as far as present knowledge shows. The genera are often very widely distributed and the species themselves are often very restricted. Oftentimes such species occur in enormous numbers as has been noted in the collections south of the Philippines where certain species make up almost the entire mass of the bottom. It is in the shallower water faunas, however, that the greatest diversity of species occurs. As a rule the coral reef faunas have in some cases a very local range, in others a range taking in the general Indo-Pacific region. There is often a great predominance of a few species, and a great many other species represented by a very few specimens. Certain of the species, however, are localized, as for example, *Baculogypsina sphaerulatus* and *Siderolites tetraedra,* the former occurring in the Australian region and very abundant in the shallow waters, the latter wanting in the Australian region and very abundant in the Philippines. In the faunas of medium depths while certain species are more abundant than others there does not seem to be a great predominance of any particular species at the expense of others. With these last faunas there is more or less localization of certain species if faunas from different regions are closely compared.

HISTORIC SKETCH OF WORK ON THE PACIFIC FORAMINIFERA

The Pacific has had much less work done on the foraminifera than most of the other great regions of the ocean basins. Certain areas, however, have been more carefully worked than others. While there are scattered records from the Philippines and other regions previous to the *Challenger* Expedition, they are mostly unrelated notes from small sporadic collections. The *Challenger* work in the Pacific covered the following route: from Melbourne and Sydney to New Zealand, north to the Fijis and thence through the East Indies to Hongkong, and back through the Philippines to the north coast of New Guinea and the Admiralty Islands, and thence north to Japan. Afterward the route swung eastward to the longitude of the Hawaiian Islands, thence south through that group and the Society Islands to about 40 degrees south; thence eastward to the coast of South America. In his work on the foraminifera of the *Challenger* Expedition, Brady describes many new species from this general region, especially from medium depths. Some of the faunas are very rich, such as that from Torres Strait, from the Philippines, and from some of the oceanic islands. A reference to his figures and descriptions shows that many of the species from this region referred to previously described forms should not be so referred and that the proportion of new and rare species is probably much greater than Brady recognized. Later work has shown that many of these species are rather localized in their distribution. Chapman has published numerous papers on the general Australian region and has worked up very much in detail the faunas in the region about the Funafuti Atoll. These cover both the shallow-water species of the region and the dredgings out into deep water, giving a very concise knowledge of a limited area of this general faunal region. Goës in 1896 published a paper on the foraminifera obtained by the *Albatross* from off the Galapagos Islands and the west coast of California, Mexico, and Central America. Very few of these records, however, are in anything but the deeper water dredgings and give very little information in regard to moderate or shallow depth. Millett published a detailed paper on the foraminiferal fauna of the general region of the Malay Archipelago, taking in mostly shallow water but some deeper stations. While he published a number of new species and varieties his figured specimens show that many of the species referred to older names are really very different and a study of the Philippine dredgings has confirmed this. Flint's work on the *Albatross* soundings published in 1899 is mostly on the Atlantic dredgings, but there are a few records from the east coast of the Pacific. These are, however, very scattering and add only slightly to Brady's knowledge of the area. Rhumbler worked up some rather meager collections from Laysan and Chatham Islands, mostly from shore sands. His paper shows that there is here a problem of localized species and this is probably typical of what would be found if such material from widely separated points in the Pacific were carefully studied. The large collections of the *Albatross* Hawaiian Expedition were largely destroyed, but a few remaining bottom samples, almost all from comparatively deep water, were worked up and published by Bagg in 1908. While the list of species is considerable it does not at all represent the most interesting faunas of this region which the *Challenger* dredgings from off the Honolulu reefs show to be rich and varied. Between 1910 and 1916 I published a series of papers on the north Pacific from the *Albatross, Nero,* and *Tuscarora* soundings. Most of these are from comparatively deep water but are from well scattered stations over the general region and give a very fair knowledge of what the deeper water faunas are in different parts of the Pacific. From off Japan a series of shallower water dredgings are available and give a better knowledge of this general region than most other parts of the Pacific as many of the species were plotted on maps and a study of their distribution showed that there were developed definite faunal regions. Sidebottom has written two detailed papers on the various species and varieties of Lagena found in the southwestern Pacific, showing what may be expected when other genera are worked up with equal detail. More recent papers by Chapman, Sidebottom, Mestayer, and myself have given a very good idea of the fauna of the New Zealand region as developed in water of medium depth. This has shown that there are here developed numerous localized species and varieties. This list of authors and papers would seem to show that a considerable amount of work has been done upon this area but when this is compared with the wide extent of the Pacific, the region as a whole has hardly been touched, especially some of the more interesting parts of it as will be noted later. There is in press a large report on the *Albatross* Philippine Expedition, the material of which was placed in my hands a number of years ago. This includes not only the Philippine Archipelago but also the region southward to the Equator and beyond, and includes a large number of carefully made dredgings, mainly in shallow water and that of medium depth, and also a few from fairly deep water. A study of these has revealed a large number of new and evidently localized species and probably makes this region the best known of any area of equal size in the Pacific.

REGIONS OF THE PACIFIC BEST KNOWN

As just noted, the Philippine area is the best known and as the area laps over that from which Millett's Malay material was obtained, this whole part of the Pacific is better known than most other parts of the world. The region of the Funafuti Atoll has been very carefully worked up in detail by Chapman, and the New Zealand area and some stations off the coast of Australia are fairly well known in detail.

REGIONS OF THE PACIFIC WHERE MOST WORK NEEDS TO BE DONE

From the foregoing it would be apparent that the general region of the Pacific, except those portions noted, needs much work before any fairly complete knowledge of its faunas can be obtained. Certain areas, however, need work more than others. A large part of the Pacific ocean basin is characterized by red clay which is not prolific in the number of foraminifera present. By far the most interesting areas will be those of shallow and medium depths. Very little is known of the local faunas of the great majority of the islands of the south Pacific and it is probable that in those many new species will be found, together with many interesting problems of distribution. Except for the few stations dredged by the *Challenger* off the coast of Chili, and the specimens described many years ago by d'Orbigny, almost nothing is known of the foraminiferal fauna of the shallow water and medium depths of the entire coast of western America, and this should prove to be very interesting, both in its problems of distribution and the new forms which will certainly be obtained. The region of the Hawaiian Islands including the Midway group should also give interesting data in regard to distribution northeast of many of the species of the Australian and East Indian regions.

PROBLEMS OF GEOGRAPHICAL DISTRIBUTION AND INTERPRETATION OF GEOLOGIC SEDIMENTS

In general it may be said that in the Indo-Pacific and Australian regions there are now living more ancient forms than are found in most other parts of the ocean. Certain genera such as Nevillina, which has been found only in the localized area in the Sulu Sea, represent such forms. The nearest relatives to Nevillina are found in the Cretaceous of southwestern Europe. A similar case is that of *Siderolites tetraedra* which in closely related forms may be traced from the Chalk of Meistricht, Holland, through the Eocene of Italy, to the recent waters of the Philippine region. There has also been a migration into the region from the east as shown by the close relation of the lower Oligocene of the coastal plain of the United States, such as that of the Byram Marl to the fauna now living in the region off Australia. Certain of the more ancient types of Frondicularia are now only to be found in the Indo-Pacific and Australian regions. In the shallower waters about many of the islands in the tropical Pacific are now living great numbers of the larger forms of Orbitolites, Operculina, and Heterostegina, which were characteristic of the Eocene of a very widely distributed area. These larger forms now so abundant only in this region were at one time characteristic of the dredgings throughout the world and are one of the larger constituents of the thick limestones built during the early Tertiary which extend across southern Europe, northern Africa, and southern Asia, and found also in tropical America. A study of the conditions under which these forms now live in the Indo-Pacific would do much to solve the ecologic conditions under which these great masses of limestone were originally formed.

A study of the borings from the various coral islands of the Pacific should do much to determine some of the questions now in dispute in regard to the formation of the coral reefs. A study of the foraminifera from such borings should be easily made and they could be compared with the present day faunas of similar localities.

In general a study of the foraminiferal faunas of shallow waters, and those of medium depths made in the various parts of the Pacific already indicated, can do much to solve many problems and would probably do more to advance the knowledge of this group than would the study of any other regions from which the collections can be obtained.

NOTES ON THE COMPARATIVE STUDY OF LITTORAL FAUNAS OF THE PACIFIC ISLANDS

By Hubert Lyman Clark, Museum of Comparative Zoölogy, Cambridge, Mass.

(Presented at the request of the Committee on Program.)

THE PROBLEM STATED

So far as I know very little work has been done on the comparative study of the faunas of different islands, in any group of marine invertebrates. The bibliography of the subject is very brief, if it exists at all. It has been a very generally held view that the littoral faunas of all the islands between Mauritius and Hawaii, inclusive, are essentially the same and that their comparative study would be of little value.

My visit to Torres Strait in 1913 and the study during the past seven years of the Echinoderms of that region has opened my eyes to the fact that the littoral faunas, or at any rate the littoral echinoderms, of different islands even only a relatively short distance apart may be quite unlike. One would have supposed that the echinoderms of Torres Strait would be identical throughout the Strait; that is, the echinoderms of an island at the eastern end of the district would be identical with those found at the western end. Such, however, is not the case. Moreover, now that we know it is not the case, a plausible explanation of the facts is possible and the whole investigation throws light on the geological history of Torres Strait as well as the history of the marine fauna of Australia.

If islands in the Torres Strait region only a little more than a hundred miles apart show such important differences in their littoral faunas, it is reasonable to believe that similar critical study of the faunas of eastern New Guinea, Fiji, Tahiti, the Paumotus, Easter Island, the Marquesas, Hawaii, the Marshalls, the Carolines and Pelews (not to mention a dozen more equally interesting) would throw light on the history of the Pacific islands which can be secured in no other way. Of course you will understand that I do not mean it is the *only* source of light on the subject. I mean rather that it offers a unique gleam of light from one particular point. I have no doubt that such a study would be amply justified by the results.

METHODS OF STUDY

As to the best method, I have no doubt that the most complete and the most reliable results would come from the intensive study of selected areas by selected men. Were sufficient money available, my plan would be as follows:

Select certain definite areas, preferably single islands, well distributed over the Pacific, for the stations. These should be about a dozen in number at least, more than that if possible. Their relation to ocean currents, to commercial routes, and to lines of human migration (so far as these are known) should be carefully considered. Their geological structure, climate, and present inhabitants must also be taken into account.

If only the problem I am concerned with were to be considered, two men could undertake the work but it would be much better to have the party consist of at least four or five men, perhaps six would be still better: One anthropologist, one geologist, one botanist, a "land" zoölogist and two marine zoölogists. Of course two marine zoölogists could not "cover the ground." They would have to work in certain selected groups, ignoring the rest. Any one of these six men could do his work without the others and perhaps it would not be feasible to correlate the field work of an anthropologist and a marine zoölogist. The latter might wish to spend weeks at an uninhabited island! Frankly, the number of men is a matter that varies directly with the amount of money available.

Each station ought to be visited at least twice at different seasons of the year. If one visit were in the spring, a second should be made six months later. The length of sojourn at a station would vary from two weeks to two months, according to local conditions. Probably not more than six stations a year could be occupied and since each must be occupied twice it would take four years to cover the dozen stations. It is moreover obvious that the best results would come from periods of museum work alternating with field work, and of course periods of complete vacation and change of scene would be necessary to keep the workers in shape. Evidently therefore a period of about ten years must be regarded as a minimum for the completion of such a survey as I am outlining.

During the stay at a station as intensive a study of the group in hand should be made as local conditions (of which weather would be most important) permit. At the same time, extensive field notes should be made and good series of every species preserved. At least once each year, return should be made to Honolulu, with the accumulated collections which could then be gone over and identified. At least once in three years a report should be prepared and published on the work accomplished. I sincerely believe the best results would come from one man doing both the field work and the report-preparing in each group, and it is of particular importance that the same man should visit *all* the stations. But of course time could be saved by having the reports prepared by men at home, leaving the field work to be done by others, for field work and report preparing could then go on side by side (in time, I mean; obviously not in space). Much could be done if anthropologists, geologists, botanists, et al, made general collections of everything in the way of animals to be found on the reefs, but such general collections are apt to contain only the more common things. The general collector unavoidably overlooks many animals that a specialist sees at once. I therefore favor very strongly sending specialists and having each specialist stick to his job so far as possible.

MEDICAL ENTOMOLOGY ABOUT THE PACIFIC

By David L. Crawford

The medical phase of entomology is comparatively new and of very greatly increasing importance all over the world. It is now recognized by the medical profession and health experts that the most direct method of combating certain diseases is to suppress or control certain insect species which act as transmitters of the disease-causing organisms ("germs").

The famous work of Walter Reed on yellow fever, of Ronald Ross on malaria, and of others on these and other diseases and their insect-transmission is so familiar to all that it needs no exposition here. The investigations of these men are having practical results in the extensive checking of malaria, yellow fever, bubonic plague, typhus and several other diseases which are insect-borne.

The lands about the Pacific Ocean are, of course, sharing in this great benefit to humanity and can do so even to a much greater extent by applying principles and methods already known by science. There are, however, several insect-borne diseases characteristic of the Pacific which must be studied carefully before their control can be effected. To these I would call special attention because of the challenge offered for research work of the utmost economic importance.

Elephantiasis is a horrible and extensively distributed disease caused by a nematode worm of the genus Filaria. It is known that mosquitoes are involved in the spreading of the disease, but there is a paucity of knowledge on the entomological phase of this problem which is greatly retarding its successful solution. A specialist stationed in Samoa, for example, could doubtless work out this problem in a few years and confer a tremendous benefit upon mankind.

Kala-azar is another destructive disease of the paleotropics which is believed to be insect-borne. Our knowledge of this, however, is very meager and must be extended without delay. Other fevers and deadly diseases caused by protozoa distributed by insects occur commonly in South America and humanity must be delivered from them by the work of entomologists.

A trypanosome disease allied to African sleeping sickness occurs in Brazil and threatens to be spread northward if we do not check it.

Dengue fever, though not commonly deadly, is a very troublesome disease which occurs throughout the tropical areas of the Pacific. And yet we are not even sure that it is, or is not, insect-borne! We must know this, and if it is insect-borne, we must know how the transmission is effected.

Still other diseases are demanding our attention: Oroyo fever, spotted fevers, espundia and others. Organized campaigns of study of each of these diseases in its most favorable localities are necessary before mankind can be freed from them.

The tropics cannot be utilized to their full, nor can they contribute their share of the world's goods, until certain of these diseases are under control. Thorough entomological study is essential before control of the diseases is possible. Moreover without this thorough study and subsequent control work, many countries and areas now free from these diseases are sure to be invaded sooner or later by dissemination of the insect agents or the disease germs.

Every consideration is an urge to immediate and thorough and fully sustained study, entomologically, of these Pacific diseases which are, or may be, transmitted by the agency of insects.

NEED OF FURTHER STUDY OF THE INSECT FAUNA OF HAWAII AND OTHER PACIFIC ISLANDS

By O. H. Swezey

In the "Fauna Hawaiiensis" we have a comprehensive presentation of what had been done up to that time with the land fauna of the Hawaiian Islands. A great part of this publication is taken up with the insects, which in number of species far exceeds any of the other classes of animals in the Hawaiian land fauna. Of the insects there are 3245 species listed in "Fauna Hawaiiensis," many of them described for the first time, of which 2740, or 84 per cent are considered as endemic species.

As is well known, this great monograph is based on the collection and study of the fauna by R. C. L. Perkins during a period of about 10 years (1893-1902). It furnishes the foundation for all future work on the native insects of Hawaii. At one time it was considered by some that there was no more to do, that the exploration and the discovery of new species was completed, and that no more new species could be found. In the "Introduction" to "Fauna Hawaiiensis" (which is composed largely of biological considerations of the insect fauna), Dr. Perkins states that he considers about half of the existing species of native insects to have been collected. The fact that about 300 species have been described since the "Fauna" was issued, chiefly from incidental collecting by local economic entomologists, shows what great possibilities there are and it is an indication that many more species would readily be found if one or more entomologists were devoting their whole time to the collecting and study of the native insects. In fact, whenever any one of the local entomologists spends a day collecting in what is to him a new location in the native forest, he hardly ever fails to secure something new. Considerable recently collected material has accumulated at the Bishop Museum which is yet unworked; and in the hands of members of the Entomological Society is new material waiting to be described, while some lots have been sent away to be worked up. Much information of a biological nature has been published in the Proceedings of the Hawaiian Entomological Society. Thus progress is continually being made towards a more complete knowledge of the native insect fauna.

At the Bishop Museum, an attempt is being made to build up as complete a collection as possible of the Hawaiian insects.

That there is great need of much collecting for this is evidenced by the "Summary of Insects in the Museum Collection" published in the Director's Report for 1909, which showed that at that time the collection contained only 64 per cent of the species included in "Fauna Hawaiiensis." Since that time more material of the Perkins' collection has been received and some later numbers of the "Fauna" have been issued. A revision of the above summary with respect to these later additions shows that the Museum collection has specimens of only 55 per cent of the insects described in "Fauna Hawaiiensis," and as the Museum collection is at present the most complete of any in Hawaii, it is evident that a great deal more collecting must be done in order that there may be in existence in Honolulu specimens of as many of the already known Hawaiian insects as possible.

The collection of new species is also very important. We have sufficient evidence that there are many more species yet to procure before we can have complete knowledge of our insect fauna. The fact that by incidental collecting, new species, and an occasional new genus also, are continually being brought to light, is sufficient indication that there are many more yet to be obtained. This is evident also from the fact that in "Fauna Hawaiiensis" there are a great number of species described from single specimens. Take for example the Microlepidoptera with 440 species. Dr. Perkins secured only a single specimen of 25 per cent of these species. This is of itself an indication that there are many more species to be found, for the catching of a single specimen of a species may be considered as an accidental catch, which, if missed, would have left it among the many others which likewise missed being caught.

In the "Fauna" each specialist who worked up a group of insects, dwelt somewhat on the consideration of the inter-island distribution of the species, and showed from the collection at his disposal that a large proportion of the species occurred only on a single island. Since, as shown above, so many of the species are based on single specimens which are to be considered as accidental captures, and since more recent collecting has shown that some of the species previously considered single-island species are widely distributed, it is certain that more thorough collecting would modify conclusions previously arrived at concerning the inter-island distribution. The evidence that this may give toward solving such problems as whether the islands were ever connected, and, if so, how long they have been separated, or whether they have always been isolated, makes an exhaustive entomological survey of large importance.

Dr. Perkins considered that about 300 species of native insects might have been exterminated before they were known to entomologists, by agricultural and grazing operations, and particularly by a species of foreign ant (*Pheidole megacephala*) which has continued its spread up the ridges into the native forests, much to the deteriment of the endemic insect fauna. There are large regions in which the native forests have been destroyed by cattle, and such depredations are continuing. The forests in places are dying off for other reasons, in some places no doubt from old age. The disappearance of the forests for whatever reason, results in the destruction of many of the native insects of those regions; and it is certain that many species are now being exterminated in this way, some of which may never have been collected, and others though they may have been recorded, are not at present represented in any collection.

The importance is thus emphasized of more extensive collecting before it is too late, particularly in the regions where the native forests are disappearing, and also in regions not previously visited by entomological collectors, some of which are now more accessible than formerly, by trails following irrigation ditches, or penetrating the forests for other reasons.

Besides the mere collecting of specimens, there is great need of observations and further study of the habits, life histories, seasonal occurrence, parasite relations, plant faunas and other problems. The habits and hosts of many of the well-known insects have not yet been ascertained, and it is self-evident that nothing is known of those many species of which but a single specimen has yet been seen.

The insect fauna of the Hawaiian Islands has been more thoroughly explored and studied than has that of any other Pacific island group, yet much is lacking. The fullest knowledge possible of the Hawaiian insect fauna is essential to one making an entomological exploration of any of the other Pacific island groups for the purpose of studying relationships of faunas of the different groups of islands, or of the Pacific as a whole. Not only should he know what kinds of insects to look for but how to find them; for it is of great importance to ascertain whether any, or many of our most obscure insects have allies in these other island groups. Anyone not knowing them and how to find them in Hawaii, would be most likely to overlook much of importance in collecting in the other islands. The collector should be familiar especially with the Hawaiian flora and with the insects attached to the different plants and trees so as to know what to look for on the trees of the same or related genera. For example, the trees of the Hawaiian islands which are most remarkable for their large insect faunas, or which have very peculiar or interesting species attached to them, should be particularly worked over in any future explorations. We want very much to know what kinds of insects are found on Metrosideros in other Pacific islands, whether similar or related to the interesting fauna which this genus of trees has in Hawaii. The same could be said of the koa, and the genus Euphorbia, the various members of the Lobelioidea, the Rubiaceae, the banana, and many others; in fact, nearly all of the common genera in Hawaii should be the object of special search for insects occurring on them, if these genera are found in the islands being explored.

Knowledge gained in collecting work in the Hawaiian islands is of eminent importance in fitting one for such collecting in other islands. The collector should also become familiar enough with the foreign insects in Hawaii to distinguish them readily from the endemic species. There are many species of insects which will no doubt be found common to all the islands of the Pacific, especially those carried by modern commerce, as well as those to be considered as natural immigrants that have become widely dispersed throughout the Pacific in quite recent times. The ability to distinguish these from what would more properly be endemic, would be gained by extensive collecting in the Hawaiian group, and such knowledge would save much valuable time and efforts on the part of the explorer in foreign fields.

AN AREA SUITABLE FOR OCEANOGRAPHIC RESEARCH

By C. M. Fraser

The portion of the Pacific bordering the coast of North America from Cape Flattery northward to the Bering sea and including Puget sound and the Vancouver island region provides a situation where it should be possible to get far-reaching results from the very beginning of operations, with the minimum of effort.

The much indented coast-line with its deep fjords, the myriads of islands, large and small, make an endless variety of channels through which the waters of the great rivers are permitted to mix with the saline waters of the open Pacific, over a continental shelf, which, in places, reaches a width of more than one hundred miles. The great variation of current and tide, of temperature and salinity, induced by such conditions in the inshore waters, finds a suitable parallel farther out to sea, since at one time the Japan current or its offspring, the Alaska current, may seem to predominate in its influence and at times the northern drift, usually nearer shore, is more significant.

From the standpoint of physical oceanography, the problem is a complicated one, but the work already done serves as a good basis for future work. The Canadian Hydrographic Survey and the United States Coast and Geodetic Survey have charted much of the inshore waters, particularly in the vicinity of the harbors and along established traffic routes. The tide and current survey of the Canadian Department of Naval Service has been obtaining information for several years as to the time, direction and force of tides and currents but their efforts have been largely confined to the same regions as those taken by the hydrographers.

An extension of this work to less frequented areas and out farther from shore to embrace the more distinctly oceanic currents, is urgently needed. Even with vessels and apparatus of the nature of those used at present there is no special difficulty in the way of making this extension, but since the present equipment is being used full time, the extension can be made only by an increase in equipment and personnel.

The work is, and presumably must be, done largely under the authority of the governments of the respective countries, hence only to them can an appeal for greater facilities be directed.

From a biological and biochemical standpoint the region offers equally favorable opportunities, particularly when taken in correlation with an expansion in physical oceanography. The province of British Columbia alone, although it reaches through little more than eleven degrees of latitude, is credited with seven thousand miles of general coast-line and twenty-five thousand miles of tide line. In a portion of the coast of Alaska the coast-line is multiplied in a somewhat similar way. With this naturally goes an endless variety of shore, with an endless variety of conditions along the shore, due to differences in strength of current, degree of salinity and change of tide (which in some areas reaches twenty-five feet or more). This with the great width of the continental shelf provides for an extraordinary richness both in biological species and in the number of each species.

On account of the various physical and chemical differences, it is a difficult matter to explain the distribution of many of the species, as species commonly found as far south as the tropics or nearly related to these may appear almost side by side with others from the Polar seas. The ecology of the region can therefore be understood only when a more complete oceanographic survey, physical and biological, supplies the necessary data.

From an economic standpoint this is of great importance since so many of the species are of economic value. One naturally thinks of such fishes as the salmon, the herring and the halibut, but they are by no means the only forms of importance. To know something of the life-history of these species of economic value as well as others directly or indirectly related to these, a biological and biochemical survey is necessary.

Here again, although the problem is complex, immediate results of value would accompany the extension of the work. A good start has been made in the three biological stations in this region, at which work has been done; the Pacific Coast station of the Biological Board of Canada, at Nanaimo, B. C.; the Puget Sound Marine Biological station at Friday Harbor, Wash., and the Minnesota Seaside station at Port Renfrew on the southwest coast of Vancouver island. The work at these stations has as yet been confined to rather restricted areas surrounding each station. Besides this, at wide intervals, expeditions have been sent to other parts of the coast and these have collected material and data.

Since in the resolution in the section of marine zoology, passed by the Conference, it is stated "that the investigation be carried on, insofar as possible, through existing agencies, such agencies to be provided with the additional apparatus and facilities necessary, such investigation to be carried on under such cooperation as will prevent duplication of effort," here is surely a case in point. The biological stations already in the region have made a start on the work. There can be no great difficulty in extending it, particularly as such cities as Seattle, Bellingham, Victoria, Nanaimo, Vancouver, Prince Rupert and Ketchikan, together with many smaller centers are all interested in the fisheries and through the fishermen could give valuable assistance as well as serving as bases of supplies, so that no matter where the work was being done, it would be within easy reach of at least one of these.

Although this work has received Government assistance, there is nothing to prevent the making use of assistance from any or every other source from which it may come. The main need is that for a boat, suitably manned and equipped for work on the continental shelf. Such a boat should be large enough to stand the buffeting of the open ocean but not too large to be expensive to run. One type of the larger halibut boats, 80 or 90 feet in length, and fitted up for gettting hydrographic, physical, biochemical, bacteriological and biological material and data, would be very satisfactory. With such a boat, $50,000 a year for carrying on the work and a suitable personnel, results of value could be obtained from the beginning.

An area on the Swiftsure shoal, to the southwest of Vancouver island at the entrance to the strait of Fuca and a larger area extending northward from Vancouver island, through Hecate strait, past the Queen Charlotte islands, would serve as excellent points of attack. Later such work should be supplemented by and correlated with work done by a larger vessel in deeper water further off shore.

BREEDING EXPERIMENTS

By Paul Bartsch

The reason why I wish to bring before you the results of some of the breeding experiments which it has been my good fortune to make under the auspices of the Carnegie Institution is because I felt that here in Hawaii and in the islands to the south and even in the Philippines we have groups of organisms that would lend themselves to parallel efforts; and I believe that by making these parallel experiments it will be possible to determine whether the results are merely individual expression or whether they express a biological law.

In the Hawaiian Islands we have the Achatinellas, that wonderful group of beautiful land shells, and the Amastras. A little farther south and west we have the Partulas, another greately diversified group of snails, while in the Philippines the Cochlostylas should lend themselves to similar work.

In 1912 Dr. Mayor asked me to join him in an expedition to the Bahamas, and while there I came for the first time into contact with a large family of ground-dwelling mollusks known as Cerions. The natives call them peanut shells because they look a bit like peanuts. They vary in size from 1/3 of an inch to 1½ inches. The largest have a diameter of ¾ of an inch, so you see they are rather large objects. They are so abundant where they occur that I have picked up 4000 in a space 20 feet square. There is therefore no difficulty in getting material.

While in the Bahamas we secured many specimens because we wanted to see if there was any uniformity expressed in the different colonies for all the Cerions occur there in colonies. You sometimes find one colony separated from another by just a little swale which seems to be a sufficient barrier to keep them apart. I measured many of these shells to determine modes, to see if I might by the use of bimetric methods determine sub-species among certain groups. It was found that while you may have quite a range of variation in size in each colony, you do meet more or less definite modes.

It has been held that Cerions were the most easily changed organisms that could be imagined, that practically a breath of wind would affect growing individuals and thus make variations. A year of great humidity, it was believed, might produce larger forms; while a year of dry conditions might produce dwarfed forms, etc. In fact they were looked upon more or less askance by systematists on account of the lack of definite information as to the stability of the races. We all admired Dr. Pillsbry's courage when he published his monograph on the group, and we likewise deplored Mr. Maynard's efforts for it seemed as if he had given a name to almost every accidental form expressed in the shell of individuals of each colony.

We deemed it wise to transport colonies to the Florida Keys in order to determine whether Cerion characteristics as expressed in the shell had a fixed status. By so doing we would subject them to a change in environment which would settle the stability question. We therefore gathered many thousands of two species. One species was taken from about the White House at the southeast corner of South Bight, and the other from King's Road, which is on the northeast corner of South Bight. The two places are separated by about two miles of water. So far as shell characters go I feel that if you photograph one and reduce it one-third the same specimen might serve as a figure of a specimen from the other group. It was this close resemblance that made me hesitate to use even a sub-specific name for these species in the earliest reports and you will find them referred to in the Year Book of the Carnegie Institution as the King's Road and White House type of *Cerion glans*.

The transported material was planted on the Florida Keys in colonies of 500 each. We though it well to try mass breeding first, for if we took only one pair accidents might happen to prevent the success of the experiment. A colony of 500 was planted on the Ragged Keys immediately south of Miami and from there on south to the Tortugas we put colonies on various Keys. You will recall that the Florida Keys extend over a long distance and have a varied flora and a varied temperature. The temperature sometimes goes down to freezing at Miami, while at the Tortugas it has never dropped below 48 degrees. We also have quite a range in humidity variation from the northern Keys to those of the Gulf.

When we started the experiment we believed that each year would yield at least one generation, and it was indeed a great surprise when we found that it required three years to produce it. The results, therefore, were obtained much more slowly than we had anticipated.

We alternated the two species experimented with, putting one on one Key and the other on an adjacent Key so that the two species should be subjected to practically the same set of environmental conditions. We also separated each generation into new colonies, thus preventing crossing with the parent stock.

Summing up the results so far obtained we find that the first generation of Florida born material presents no change in measurable shell characters. In other words the measurement of measurable characters in the first Florida born Cerions were the same as those of the parent stock. From a breeder's standpoint that was not remarkable. We know that the germplasm had received its impress in the Bahamas so we might expect to obtain no results in the first generation.

Two years ago a second generation was obtained and we were surprised when we measured the measurable characters to find it just like the material planted. It had bred true to type. The range of variation was not at all different from that of the Bahama material. This, then, was one thing gained; for it showed that changed environment, the thing that most people held responsible for the production of the various races, did not seem to be an operative factor in the first generation of Cerions. Usually, however, a response is obtained in the second generation, for here the germplasm becomes involved and it is here that the impress of the changed environment should show its effect upon the offspring. This generation, however, like the first showed the same stability of characters as the first generation of Florida born specimens. They bred true to type.

However, we obtained some other results much more significant than the above. On the Florida Keys we have another group of Cerions decidedly different from those of the Bahamas. It is a group that has been here for a very long time and is known as *Cerion incanum*. I believe that this too is a complex. For when the anatomy of the animals forming the various colonies will have been examined, we shall probably find that more than one species exists on the Florida Keys.

In making our planting of Bahama mollusks on the Florida Keys we tried to avoid putting the Bahama species where the native species occurred. On one, Newfound Key, there were indications of the Florida species. But the 1909 hurricanes seemed to have wiped them out completely leaving only dead shells. Here we put a colony of 500 of *Cerion viaregis* because it seemed such a splendid place for them. We were greatly surprised when upon rounding up the Cerions on this Key (for we rounded them up annually and photographed and measured the new generation when mature) to find that there were some specimens which showed that something had happened.

Four specimens were found on one bush which showed unmistakable evidence that *Cerion viaregis* had crossed with *Cerion incanum.* For characters of both species were expressed in these shells. *Cerion viaregis* is strongly axially ribbed and more or less flecked with brown, and has the interior of the shell buff or light brown—while *Cerion incanum* is almost smooth, of different outline, and usually almost white, though at times vermiculated with pale brown. The four shells referred to above combined the characters of the two.

On a subsequent visit we found the place of planting simply swarming with Cerions. The mollusks, however, were neither *Cerion viaregis* nor *Cerion incanum* but presented what Dr. Dall long ago termed a state of flux, that is no two specimens were exactly alike. The range of variation not only presented all possible gradients from the one species to the other but included the production of entirely new forms which one not familiar with their history would unhesitatingly assign to entirely different groups of Cerion than those to which either parent belonged.

There are no end of interesting problems tied up in this experiment, not the least of which is the fact that we shall have to modify our idea about always producing sterile offspring when we cross widely unrelated species. In the present case it seems to have energized reproduction rather than retarded it for the place was swarming with individuals.

It is possible that these experiments may explain how fluxed conditions are produced. I am sure each of you can recall such cases in your own field, which may have been produced in this manner. It is possible that from such fluxed elements new species may be produced by isolation and fixation.

This cross of *Cerion viaregis* and *Cerion incanum* was a great surprise to us, the more so since the two Bahama species which we had purposely mixed on one of the Keys absolutely refused to cross but have continued to breed true. These two we have since found to possess anatomical barriers responsible for this, and yet we are quite certain that they are very closely phylogenetically related.

A new set of experiments was started in 1919 but the hurricane of last August swept all of our cages to the sea. Next December, however, a new set of experiments will be begun in which we intend to carry out the following plan: Large cages 4 ft. x 6ft. x 3 ft., and small cages 2 ft. x 3 ft. x 3 ft. will be used. In the large cages 50 each of two species will be placed, while in the small cages only one of two species will be put. Of the small cages we shall have ten for each combination. Only adolescent mollusks will be used to make sure that fertilization has not taken place before they are placed in the cages. We intend to experiment with the following species:

Cerion viaregis from the Bahamas
Cerion casablanca from the Bahamas
Cerion incanum from the Florida Keys
Cerion uva from Curacao
Cerion crassilabris from Porto Rico.

The question to what extent this work on the Cerion throw light on bigger biological problems and to what extent does it throw light on the production of new species could best be determined if it were checked up by work of a similar nature in other fields. We hope, therefore, that work similar to ours may be undertaken out here. It could be done so readily by someone on the ground.

The Cerion work so far as it has gone is written up in the Bulletin recently published by the Carnegie Institution. Anyone wishing to do similar work should consult this paper and so far as possible work along parallel lines.

One thing interesting and somewhat unusual in our experiment is the fact that we actually know what material we started with. When one looks at much of the breeding experiments that have been made, one usually finds a complete indifference to the question of what the experimenter is breeding—a fact which has made it impossible to really understand what was at the bottom of the results obtained. It is to be hoped that in the future this point may receive the attention it really deserves so that it may be possible for any one to repeat the work and check up any point about which the least doubt may be presented.

Some of the recent results obtained in the breeding of Drosophyla and other organisms suggest parallel features to the Cerion work but unfortunately nothing definite seems to be known as to what has been combined in these experiments. It is therefore to be hoped if experiments with Achatinella, Amastra, Partula or Helicostyla are undertaken that a careful record will be kept of the species combined.

You may be interested to know that the distribution of Cerions is from Dutch Guiana to the Bahamas, Greater Antilles and the Florida Keys, one occurring upon Curacoa. We have not been able to find a single Cerion living on the shores of the Lesser Antilles. The center of distribution at present is in the Bahamas where, as I stated before, every swale separates a distinct form.