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INSECTS OF CAMPBELL ISLAND: INTRODUCTION[1]

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Abstract: The land arthropod fauna of Campbell I. (52°33′ S. Lat.; 169°8′ E. Long.) numbers about 300 species of about 105 families treated in this work, with a few groups remaining to be reported upon later. Eighty-two species and 13 genera are described as new from Campbell in this volume, and an additional 31 species and 5 genera are described as new from Auckland Is., Macquarie, Snares or Antipodes. The zoogeographical affinities of the Campbell fauna cannot yet be fully elucidated because of incomplete knowledge of the fauna of New Zealand, of neighboring islands, and of more distant faunally related areas, such as southern South America. However, close affinities with New Zealand are numerous and trans-Antarctic links seem to be in the minority. This suggests that the Campbell fauna is made up of relicts from a former larger subcontinent and/or that populating of the island was at least partly by post-glacial waif infiltration, perhaps largely by air transport from New Zealand and Tasmania. A number of elements are in common between Campbell and the Aucklands, and some also with Macquarie, but rather few with Kerguelen and Heard, although there are some analogous developments.

A nearly year-long experiment in dispersal is reported. Results indicate that insects fly more when wind is less strong, but that many of those which are caught up in sudden stronger gusts are carried out to sea. A very low percentage of wingless forms was trapped. This suggests that wing-loss is favored by natural selection. Variability in wing development of some species, such as *Kleidotoma* n. sp. and *Schoenophilus pedestris* Lamb, and other facts, suggest that wing-loss is proceeding rapidly on Campbell I., where strong winds prevail.

BACKGROUND

Campbell I. is the more central, in terms of latitude, of the three major and more southern groups of subantarctic islands south of New Zealand and SE of Australia and Tasmania. Macquarie I. is the more southern and the Auckland Is. the more northern group. North of the Aucklands and south of New Zealand also lie the Snares Is., Antipodes Is. and Bounty Is. These are more strictly subantarctic islands, whereas Stewart I., directly south of the South Island, and the Chatham Is., east of the South Island, are integral parts of the New Zealand faunal area.

The faunal relationships among the three main southern groups, Macquarie, Campbell and the Aucklands, and between them and other islands or continents, form a fascinating subject. The break between Macquarie (the southernmost isolated major subantarctic

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island) and the Antarctic continent is very great, with a ratio of about 12 to 5 orders, respectively, of true insects represented, as well as a reduction in the number of families of the orders of mites and insects common to both areas. Also, spiders occur on Macquarie, and probably do not occur on Antarctica. The contrast between Macquarie and Campbell is not quite so great as between Antarctica and Macquarie, in terms of numbers of orders of hexapods represented. There are about 5 additional orders, and many families, of true insects on Campbell which are not found on Macquarie. And there are additional orders of other classes of arthropods added. Probably Campbell has nearly three times as many species as does Macquarie. As much collecting has been done on Campbell as on Macquarie, but it is difficult to say whether an equally high percentage of the fauna has been made known, because of the richer biota on Campbell.

Between Campbell and the Aucklands there is again a great increase in fauna, with perhaps another 3 orders of hexapods added in the Aucklands. Many more families are found in the Aucklands than on Campbell, and perhaps twice as many species. The other neighboring subantarctic islands, the Snares, Antipodes and Bounty are much smaller islands, with apparently much less representation than on Campbell or the Aucklands.

Until the fauna of the Aucklands is better known, and until the faunal origins and relationships of all these islands is further clarified, it will be difficult to make an adequate zoogeographical appraisal of the Campbell fauna. A preliminary discussion is presented in a later chapter of this volume.

Among significant aspects of the Campbell I. fauna is the lack of many important groups found in most parts of the world. Among these absent groups are leafhoppers, true bugs, locusts, butterflies, leaf-beetles, wood-boring beetles, mosquitoes, ants, bees, and predaceous wasps, to mention only a few. Also, the fairly high ratio of wingless to winged species is conspicuous. These problems and the question of dispersal are discussed in a later chapter.

Field work

In recent years Bishop Museum has taken a special interest in the fauna of these subantarctic islands. In late 1960 I collected briefly on Macquarie I. More extensive work was done on Macquarie by Keith Watson for the Australian National Antarctic Research Expeditions, starting at the time of my visit and lasting for one year. Also, John Calaby collected for A. N. A. R. E. at the same time as my visit. The taxonomic results from all of this collecting combined has been appearing in "Pacific Insects", most of the articles in Vol. 4, no. 4, 1962, but some also in Vol. 5, nos. 2 and 4, and forthcoming issues. A preliminary discussion of the subantarctic arthropod fauna was presented in 1960 (Gressitt & Weber), and further zoogeographical data, particularly concerning Macquarie, in Gressitt (1961), and on all subantarctic islands (Gressitt, 1963 a, b and in press).

In late 1961 I collected for nearly 5 weeks on Campbell I. A visit of a few hours had been made shortly before my stay by Keith A. J. Wise, also of Bishop Museum. Mr. Wise returned again to Campbell in early 1963, after the Auckland Is. expedition, and also stayed for about five weeks. Between my visit and Wise's second visit, a period of about 13 months, and during the visits of both of us, Mr. Kelvin Rennell carried on periodic collecting during his free time while a member of the meteorological staff of the New Zealand research station. Mr. Rennell's contribution of assembling extensive collections during his term on the island has been a very significant one. He was able to accumulate extensive

series of species of which I had only obtained a specimen or two during my stay, and he was also able to investigate a number of environments, such as the nests of certain birds, which I did not have time or opportunity to sample. Rennell was also able to assemble biological information for a number of species, and continued the dispersal experiment I started.

During December 1962 and January 1963, for a period of not quite four weeks, Wise and I (representing Bishop Museum and the U. S. Antarctic Research Program) participated in the Auckland Is. expedition, organized by the the Dominion Museum and the New Zealand D. S. I. R. Various circumstances cut short the field time for the expedition and permitted work only in the northern half of the islands. The completion of the expedition is anticipated for the 1964–65 season. Further field work in the Aucklands is necessary before a thorough study can be made of the fauna of the group.

Collections

In the time available, it has not been possible to completely process all our Campbell I. collections. This is particularly true for the mites and Collembola. Extensive use of the Berlese funnel collecting method provided such abundant material that it could not all be slide-mounted and prepared for study. Thus some supplements will undoubtedly be necessary later, although these might be incorporated with future Auckland Is. studies. Also, time has not permitted all of the collaborators to complete their studies, and some papers will have to be published at later dates. Furthermore, certain collaborators wished to include available material from the Aucklands or other subantarctic islands in their papers for this volume. Thus some articles, such as those of Forster, Richards and Kuschel, concern not merely Campbell I., but a wider scope. In the zoogeographic treatment in the latter part of this volume a complete list is presented of the species known from Campbell I.

Most of the specimens reported in this volume are housed at Bishop Museum, Honolulu. Through an exchange agreement with the Dominion Museum, Wellington, and the New Zealand Department of Scientific and Industrial Research (D. S. I. R.), types of Campbell I. species from Bishop Museum collections are being deposited in the aforementioned New Zealand institutions in exchange for existing or future type specimens from Polynesia, Fiji and New Caledonia. Most of the arachnid and Collembola types are going to the Dominion Museum and most of the rest to the D. S. I. R. Duplicates of many species are being deposited in the aforementioned collections, and in the British Museum (Nat. Hist.), th U. S. National Museum, the California Academy of Sciences and the Canterbury Museum, Christchurch.

Acknowledgements

I am very grateful to the many authors of this volume for their kind cooperation in giving time to this study in order to make it as complete as it is. I am indebted to Drs. W. Cottier, Robert A. Falla, Fulton Fisher, Charles Fleming, George Knox, Eric Godley and Graham Turbott for providing information, advice, bird and plant identifications, or other help. We are specially grateful to the New Zealand Civil Aviation Administration, the New Zealand Meteorological Service, the Department of Lands, the Antarctic Division, the Royal New Zealand Navy, and other New Zealand authorities for permission to live

and work on Campbell Island, and for extensive facilities put at our disposal. We are specially indebted to New Zealand Meteorological Service staff and other personnel stationed on Campbell I. over the past few years. We are particularly grateful to Kelvin Rennell for his great contribution to the success of this undertaking. Mr. K. A. J. Wise has also made a major contribution to the project. We are indebted to the U. S. Navy (Task Force 43) for providing most of the transportation to and from Campbell I., but also to the Royal New Zealand Navy. We are indebted to officers and crews of the USS Vance, USS Durant and HMNZS Endeavour II. We are grateful to the U. S. Antarctic Research Program for financial support for the field work and for some other aspects of the study. Some of the systematic research was financed by grants from the National Institutes of Health and the U. S. Army Medical Research and Development Command.

We are deeply indebted to Mr. E. E. Goodale of U. S. A. R. P. for making the arrangements for transportation and for facilitation of contacts with various departments of the New Zealand Government, and for help in communication. We are indebted to Mrs. S. V. H. Rennell for transmitting messages by radiotelephone to her son while he was on Campbell. While Keith Wise and I were in the Auckland Is., we were able to have a number of lengthy radiophone conversations with Kelvin Rennell on Campbell through the kindness of R. A. Falla and Fulton Fisher, and some conversations were had by radiophone from Christchurch, as well as from U. S. Naval ships en route to Antarctica. Some conversations passed through G. A. Samuelson of Bishop Museum while he was at the New Zealand C. A. A. station at Raoul I. in the Kermadecs, and messages were kindly transmitted there by Wallace C. Mitchell of Honolulu and relayed to Rennell from Raoul by Colin Clark, who was Officer-in-Charge at Campbell during my visit and who contributed much to the success of our undertakings. I am grateful to Carol Nakashige and Eugene Bojarski for preparing the maps. Extensive help in the sorting of Campbell I. specimens has been given by Setsuko Nakata, C. M. Yoshimoto, W. A. Steffan, Grace Nakahashi, K. A. J. Wise, Mabel Watanabe, Melanie Von Bamberger and J. Harrell. I am indebted to the Department of Scientific and Industrial Research, New Zealand, and respective authors, for permission to use maps and other information from Cape Expedition reports.

HISTORY

Campbell I., though not prehistorically inhabited, as far as known, has had a number of attempts at colonization during the past century or more. These events have had a profound effect on the biota of the island, primarily through the establishment of several species of mammals—sheep, rats, cattle and cats—as well as a few birds.

The island was discovered in 1810 by Captain Frederick Hasselbourgh (Hasselburgh, Hazelburgh) of the "Perseverance," a sealing brig owned by Campbell & Co. of Sydney, while searching for new sealing grounds. As soon as the news of the discovery of Campbell I. (and of Macquarie I.) reached Sydney, several ships set sail to exploit the seals, and many visits were made to the island. The result was near extinction of fur seals, hair seals and elephant seals. Captain Hasselbourgh, on his second visit to Campbell, late in the same year, was drowned (4 November 1810) with two others in Perseverance Harbor when a gust of wind filled and sank their ship's boat. There are no printed records of many of the early sealing visits to the island. Of six men put ashore to seal by the "Mary and Sally" in 1811, only one was still alive when the "Cumberland" stop-

ped to pick them up a few months later. John Balleny, an early antarctic explorer, left London in the schooner "Eliza Scott", and by chance met John Briscoe, a sealer from London, with the "Tula" and "Lively" (wrecked) on Campbell on 17 January 1839. Sir James Ross, with the "Erebus" and the "Terror", arrived at Campbell on 13 December 1840 for a four day stop, during which Sir Joseph Hooker (with Dr. D. Lyall), collected plants. Captain T. Musgrave, in the "Grafton", spent a month prospecting on Campbell early in 1864. Then the ship was wrecked in the Auckland Is. and the crew was marooned for 20 months there. As a result of many shipwrecks, particularly in the Auckland Is., food depots were established at several points on the islands. Also, domestic animals were liberated on various islands, and periodical searches made for castaways. In 1865 Capt. Norman was said to have introduced pigs, game birds and guinea fowls to Campbell, but these did not survive.

A French expedition to study the transit of Venus went to Campbell on the "Vire" in December 1874. There was no visibility for this purpose, but much scientific data was collected, particularly by the naturalist H. Filhol, and a map of the island was made. In June 1878, E. Jennings from the Otago Museum had an hour and a half on the island, and his observations were included in a report by F. W. Hutton (Trans. New Zealand Inst. for 1879). In 1883 the crew of the "Sarah W. Hunt" was deliberately marooned on the island. The men were later rescued by the government steamer "Stella." Other visits of government steamers permitted J. Buchanan to do botanical work in 1884, and also T. Kirk, another botanist, in 1890. The "Hinemoa" visited Campbell in 1891 and the sealer "Antarctic" made two visits in 1894.

In 1883 goats, pigs and rabbits are said to have been introduced to Campbell, but they did not survive. In 1890 sheep and goats were introduced to the island. Of these, three goats were said to be alive a few years later, but they did not persist.

In 1895 an attempt was started to raise sheep on Campbell, and about 4500 or 5000 Lincoln and Romney sheep were brought down by 1896. In 1903 there were 4500 sheep on the island (Cockayne, 1904); and in 1907, there were said to be 8000 sheep (Laing, 1909). The shepherds lived at Tucker Cove and endured a miserable existence. The venture failed and the plan was abandoned in 1927, but some shepherds were on the island until 1931. Perhaps 3000 sheep then remained on the island, and these gradually decreased to between 1500 and 2000 in 1950. The lambing rate was said to have fallen to about 30 % (Sorensen, 1951b). The population was down to about 1000 or less in 1962, when an extermination program was planned by the New Zealand Government. This plan has not yet been put into effect. The island is a nature preserve and hunting or sealing are forbidden.

Rats were unintentially introduced, perhaps when the sheep were established. Cats were later introdued to control the rats; however, rats are still abundant.

A group of cattle (Ayrshire-Shorthorn cross) was colonized at about the beginning of this century. With the abandonment of the island, these maintained themselves to date at a population of nearly 20 head, while restricting themselves to a small area south of Northwest Bay.

F. W. Hutton visited in 1900 (Trans. N. Z. Inst. for 1901), and L. Cockayne in 1903. The expedition of the Philosophical Institute of Canterbury visited for eight days in November 1907 and the results were included in "The Subantarctic Islands of New Zealand" (Chilton

et al, 1909, 2 vols). C. Chilton and G. R. Marriner were the zoologists, and a number of species of arthropods were described from Campbell and the Aucklands. Between 1908 and 1914 a shore-based whaling station was maintained on Campbell.

During 1941–1945, a volunteer coast-watching group, also represented on the Auckland Is. and known as "Cape Expedition" carried on scientific observations and collecting. The group included some prominent New Zealand naturalists. Among those who spent periods on Campbell was J. H. Sorensen who spent four years on the island and collected many insects. As a result of the scientific work done on this program, a series of 26 publications, the "Cape Expedition Reports" were published. Nos. 4, 5, 14, 19, 20, 21 and 26 concern entomology (Brookes 1951; Dumbleton 1953; Forster 1955; Harrison (and Alexander, Richards, Oldroyd) 1955; Salmon 1949; Salmon (and Salmon & Bradley) 1956; Illies 1963.

Since World War II the New Zealand Government has maintained a permanently staffed weather and research station on the island, first at Tucker Cove where the "Cape Expedition" had its camp, and since 1959 at Beeman Point. There are generally about 11 men at the station during the summer and about 8 during the winter. Some of the men have collected insects for the Dominion Museum.

In the first week of 1952 the Danish round-the-world Galathea Deep Sea Expedition visited Campbell, with Dr. R. A. Falla, Director of the Dominion Museum, aboard. Some insects were collected and a few described (Viette, 1954).

In January 1958, the Denver Museum of Natural History sent an expedition to Campbell for six weeks, led by Alfred M. Bailey and including two New Zealand naturalists,

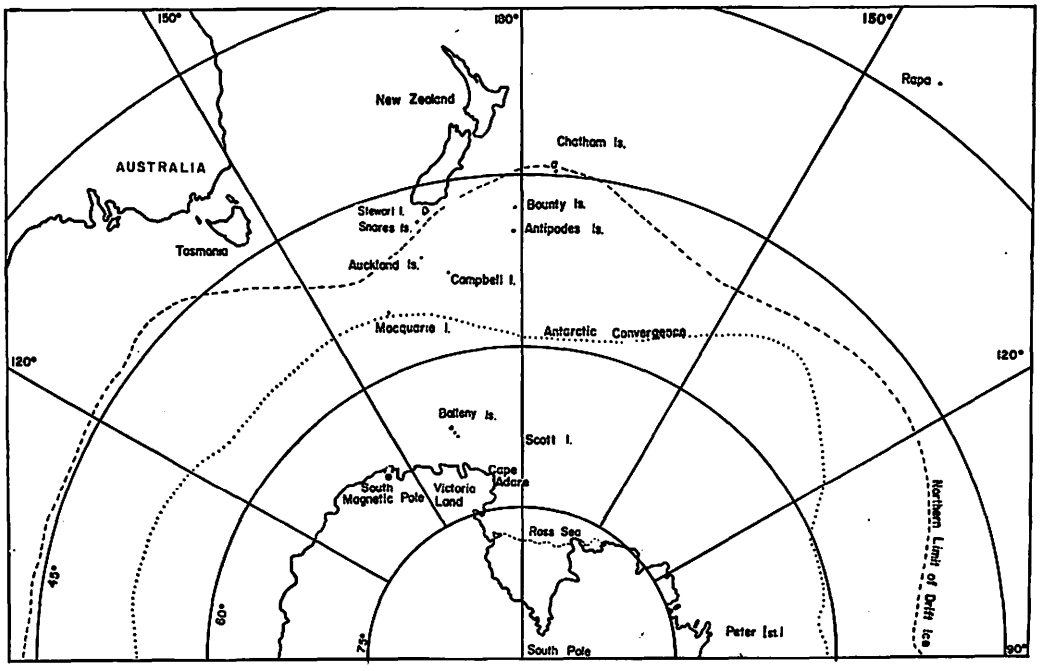

Fig. 1. Map of the 90° to 270° portion of the Antarctic-subantarctic area showing Campbell and nearby islands.

Kaj Westerkov and Robert Street (Bailey & Sorensen, 1962).

The Bishop Museum expedition consisted of a five-week stay by me in late 1961; a similar stay by K. A. J. Wise early in 1963 (plus a stop of a few hours just before my visit); and spare-time work by Kelvin Rennell from late 1961 to early 1963, while a weather observer on the island.

GEOGRAPHY

Campbell I. is situated 640 km S of the lower tip of South Island, New Zealand, about 590 km S of Stewart I., 300 km SSE of the Auckland Is., 730 km NE of Macquarie, and about 1760 km N of Antarctica. With an area of 109 sq. km, it is a deeply eroded, fairly small island with a number of hills. Most of the western coasts consists of high cliffs resulting from very strong wave and wind erosion. There are only a fews and beaches on the west, primarily inside Northwest Bay. In some cases, the cliffs cut mountains, such as Azimuth, Eboulé, Paris, and Yvon Villarceau almost in half. In other cases, only small fractions of mountains remain. This is evidence that the island was once much larger, and has lost much of its western portion from marine erosion, as with Macquarie and the Aucklands.

Much of Campbell is covered with peat, and is very marshy, even on fairly steep slopes and lower ridges. There are marine terraces, glaciated valleys, fairly regular conical hills, a few tarns, many small streams, but no rivers, and no volcanic activity. True soil is scarce, but the peat may be up to 12 m in depth. Soil is acid, with high organic and low nitrogen content.

The highest point is Mt. Honey, 569 m. Other peaks nearly as high are Mt. Fizeau, 505 m; Mt. Dumas, 503 m; Mt. Azimuth, 488 m; Mt. Paris, 465 m; Mt. Lyall, 413 m; Mt. Puiseux, 403 m. Ten peaks are higher than 300 m, and two others are nearly as high.

Campbell is situated on a submarine or "subcontinental" shelf, along with the Aucklands, Snares, Antipodes, Bounty and New Zealand. It is more separated from Macquarie. These islands were once larger and might possibly have formed a subcontinent. Or they might be fragments left after continental drift.

Knowledge of the ocean bottom contours (fig. 2) in the area of Campbell and Macquarie have been modified somewhat in recent months on the basis of preliminary reports (as in Dawson, 1963), pending publication of a new map by the New Zealand Oceanographic Institute (J. W. Brodie, *in litt.*). These modifications have only been guessed at in fig. 2, since precise data are not available. However, it is interesting that there is the suggestion of a submarine ridge connecting Macquarie with the New Zealand shelf joining Campbell, the Aucklands and Snares with the South Island of New Zealand. As will be shown below, there is great faunal difference between Macquarie and Campbell. Probably this submarine ridge, which rises in spots to 600–800 m below sea level, served only in the spread of bottom-living marine animals and plants. The ridge goes from Macquarie in the direction of the Snares, but it is not a continuous shallow ridge, but a ridge with a series of peaks. The new soundings have reduced the gaps between peaks by bringing to light new peaks.

One of the characteristics of Campbell I. is the prevalence of strong winds. This has a great effect on the island, primarily through wave and wind erosion, forming the westward cliffs (fig. 11 a, b). Also the effect on vegetation is conspicuous (figs. 8, 13c).

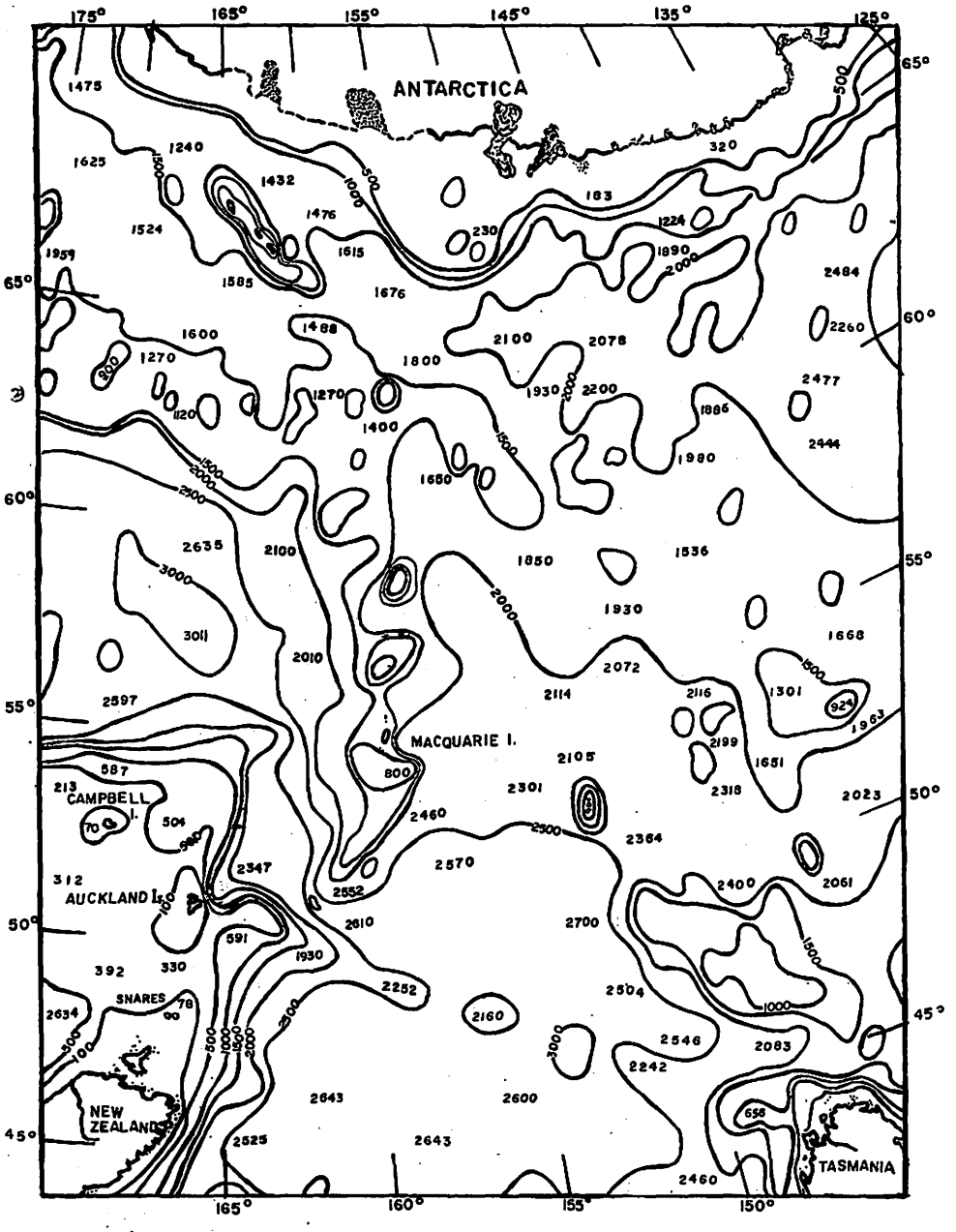

Fig. 2. Rough map of ocean bottom in area between Antarctica, New Zealand and Tasmania, showing submarine contours, with soundings in fathoms. North is towards the bottom of the map and slightly to the right (modified from U. S. Hydrographic Office #2562, 1956, revised 1962).

GEOLOGY

Campbell I. is a much dissected volcanic cone which was mildly glaciated during the Pleistocene. Underneath the volcano was a basement of schist, perhaps early Mesozoic in age. This basement is overlain with younger sediments, some Upper Cretaceous, and by lavas. Deposits of argillaceous limestone are dated at Lower Eocene to Mid Oligocene.

The evolution of the island has been characterized by the development of erosion caldera, by strong marine erosion, by glaciation, and by submergence. This geological history is similar to those of New Zealand, the Auckland Is., and Macquarie I.

The several major valleys on Campbell were formed by glaciers, probably in the Pleistocene. With subsidence, some of these valleys became inlets of the sea, such as Northeast Harbor, Perseverance Harbor and Southeast Harbor. Northwest Bay represents the

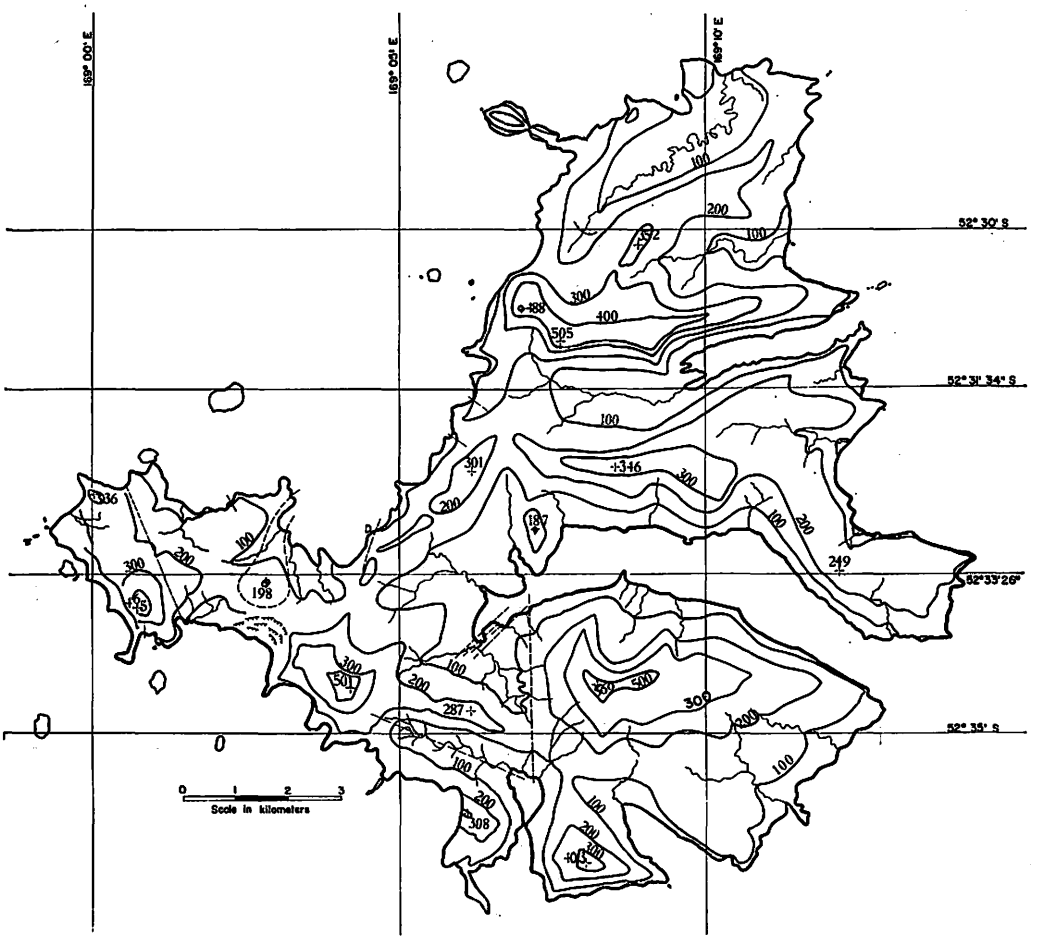

Fig 3. Map of Campbell I. showing 100 meter contours, peaks (+), some of fault lines (---), and landslides (TTTT), partly from Oliver, Finlay & Fleming, 1950. See fig. 14 for place names.

sunken center of the main original volcano. The island is essentially a sunken and eroded volcanic dome, of which much of the northern and western parts, particularly the northwestern, are gone.

Some of the characteristic formations on Campbell include schist, as at Complex Point; quartz sandstone, conglomerate and carbonaceous mudstone, as at Garden Cove; foraminiferal limestone, of Lower Eocene to Mid Oligocene age, in several areas; volcanic tuff and volcanic breccia of the Shoal Point (Perseverance Harbor) Formation. Also, much igneous rock is present, including gabbros, columnar basalt and dykes. Columnar basalt is conspicuous on Beeman Hill and dykes are in evidence on St. Col Ridge, Mt. Lyall, Mt. Dumas and elsewhere.

The history of the island may be roughly outlined as follows. In Late Cretaceous the schist land mass was eroded and submerged, with subsequent deposit of marine limestone.

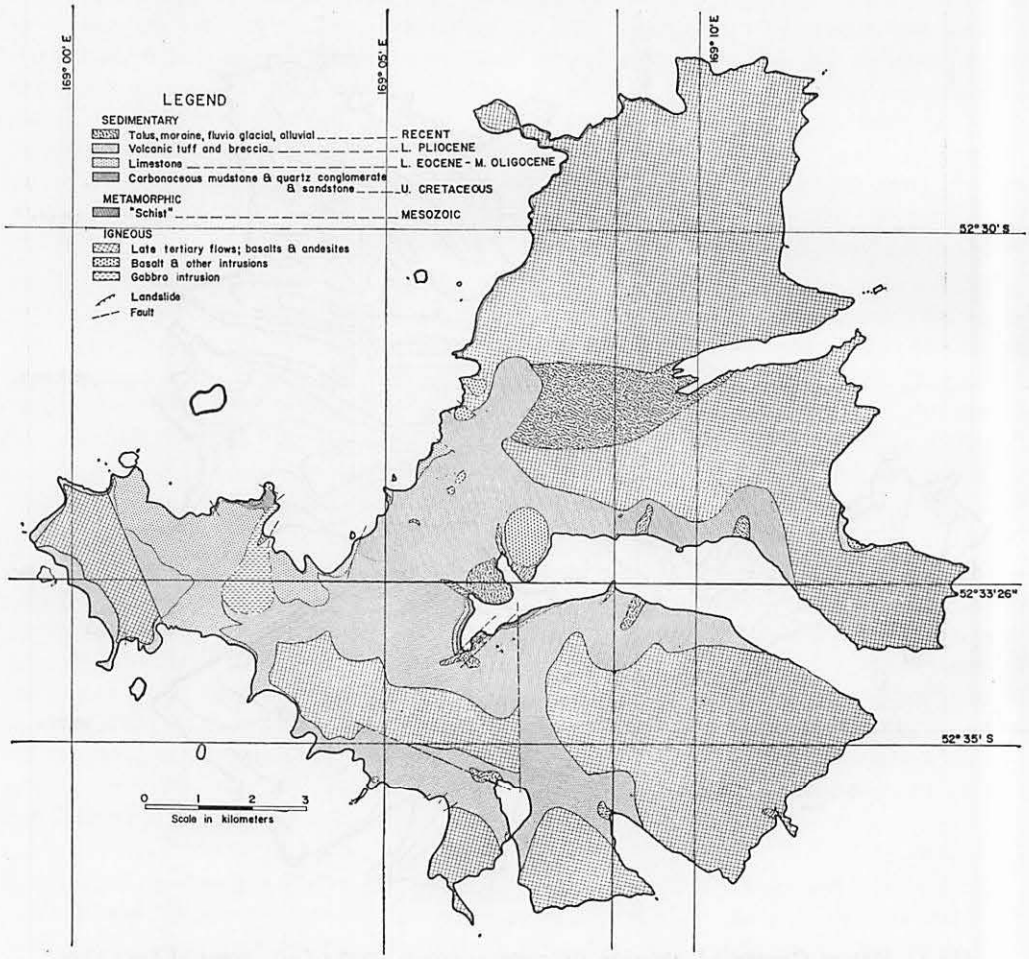

Fig. 4. Map of Campbell I. showing principal geological formations and remainder of fault lines (adapted from Oliver, Finlay & Fleming, 1950).

In Mid Oligocene there was some folding of limestone, probably with some elevation. In early Pliocene there was some explosive vulcanicity, depositing tuff. In late Pliocene there were lava flows. Subsequently there has been further erosion, including glacial erosion and marine and wind erosion. There are cirques as well as glacial valleys, but no proof of a continuous ice sheet (Largely after Oliver, Finlay & Fleming, 1950).

Campbell is generally classified as a continental island, or island on a subcontinental, or submarine, plateau, whereas Macquarie is generally termed an oceanic island.

FLORA AND VEGETATION

The native vascular plants of Campbell I. number about 116 species of ferns and higher plants. Of these, 22 are ferns and lycopods, 10 are grasses, 5 are sedges, and 79 are other flowering plants. In addition to these, there are at least 47 species of introduced plants (Oliver & Sorensen, 1951; Sorensen, 1951). Included in the nativa flora are 9 kinds of woody plants of 4 genera. Thus the flora is much more extensive than that of Macquarie I., which has only 35 species of vascular plants in its native flora, with no shrubs except one of insignificant size. The Auckland Islands, however, have about 50% more kinds of vascular plants than Campbell. The Aucklands have two large trees, and several small trees or large shrubs. Although there are no native trees on Campbell, a planted spruce tree (*Picea* sp.) has survived for many years and has grown to a height of about 3 meters, with a trunk diameter of 35 cm, and a spread of about 4 meters.

The Campbell flora is closely related to that of Macquarie and the Aucklands. There are some 38 genera of vascular plants found on Campbell but not on Macquarie. One genus (*Azorella*) found on Macquarie is lacking on Campbell and the Auckland Is., and 14 genera occurring in the Auckland Is. are lacking on Campbell I. A number of the genera on Campbell are characteristically subantarctic, having a wide range around the Antarctic continent, while others are more widespread. Several are cosmopolitan.

Mosses, lichens and other lower plants are well represented on Campbell I. The mosses have been recently studied by Sainsbury & Allison (1962), and the hepatics by Hodgson (1962).

The vegetation of Campbell I. is in part distinctly zoned, although certain plants may occur from sea level to almost the highest altitudes on the island. Tussock grass covers this span, but has more than one genus involved. Shrubs of the genus *Hebe* are represented by one species along the shore and another on rocky ridges and cliffs. *Dracophyllum*, the tallest shrubs (2 species), form dense stands on gentle or protected slopes from near shore to about 180 meters in altitude (fig. 13e). The other shrubs, *Coprosma* and *Myrsine*, occur in this altitudinal range, partly in more exposed situations where their form may be "molded" by the prevailing wind directions. *Coprosma* and *Myrsine*, however, occur also within the tussock grass formation. *Coprosma pumila* is characteristic of tussock grassland and peat-bogs.

Among the herbs, *Bulbinella* (*Chrysobactron*), is conspicuous and extensive in occurrence, from low to high altitudes. It does not grow within the *Dracophyllum* scrub, but in clearings, along paths, and above the scrub. The three species of *Pleurophyllum* may occur from low to high altitudes, but *P. speciosum* is now largely limited to inaccessible rocky areas, and the top of Beeman Hill where sheep no longer come. *P. hookeri* occurs primarily on

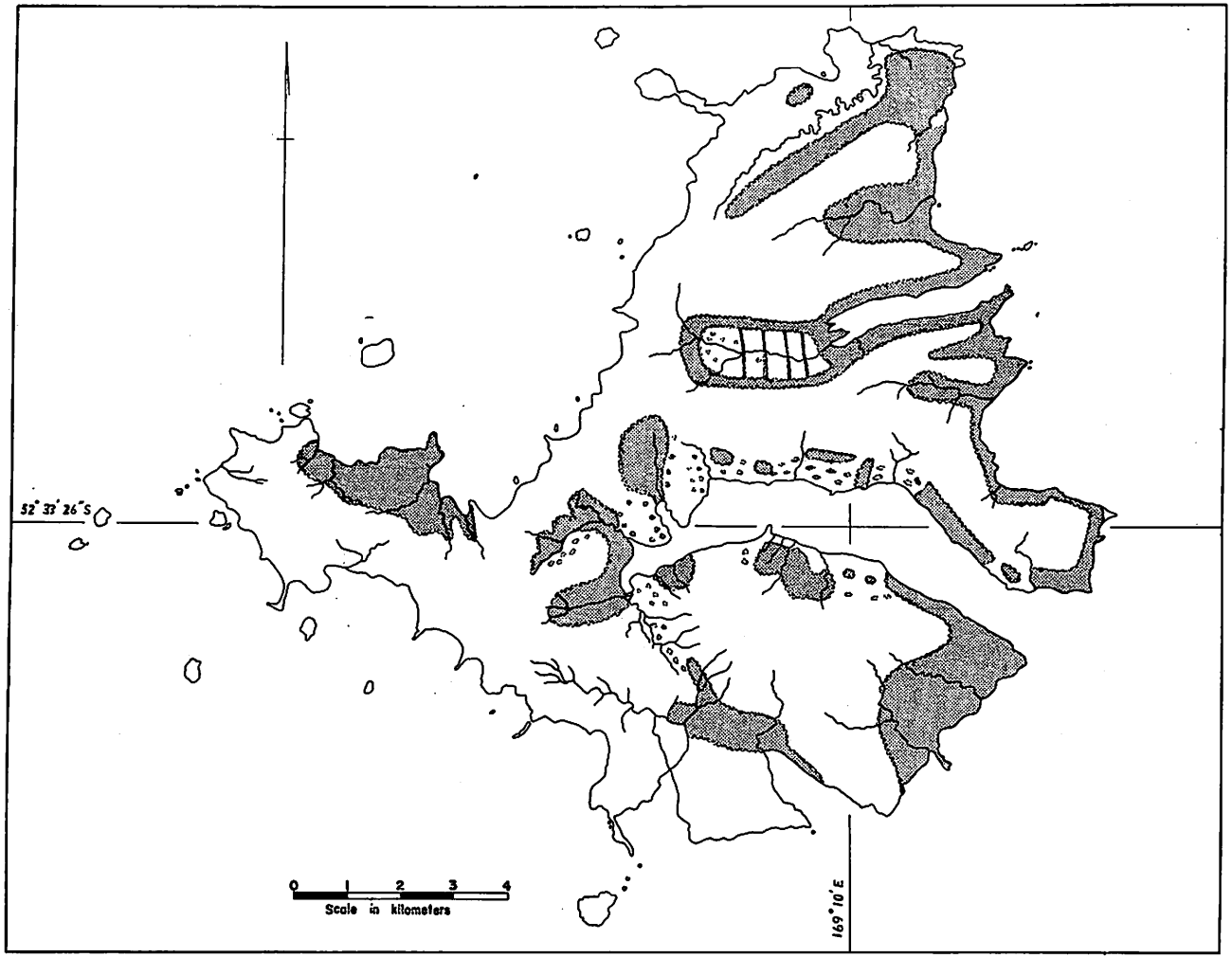

Fig. 5. Vegetation: distribution of *Dracophyllum* scrub on Campbell I. (by courtesy of Dr. E. J. Godley, Botany Div., D. S. I. R., Christchurch, New Zealand).

upland peat-bogs, and *P. criniferum* primarily among tussock. *Stilbocarpa polaris*, another large herb, occurs at low and medium altitudes, but is rare because of depredation by sheep.

Many of the other herbs are restricted in occurrence. Several of them are minute in size but occur as cushions or mats. These sometimes dominate locally, covering rocks, or ground between boulders, or covering peat-bogs. They, with many of the lower plants, are more conspicuous on ridges, steep slopes and at higher altitudes.

The *Rostkovia* Formation is a characteristic zone between the upper border of the tussock and the summit rocks. It comprises *Rostkovia gracilis* (Juncaceae), of meager height, and other herbs including *Luzula*, *Craspedia*, *Myosotis*, *Cardamine*, *Celmisia*, *Ranunculus*, and others.

The subalpine rock area, on the peaks and higher ridges, has a vegetation including many herbs, as well as ferns, mosses, lichens and others. *Anisotome antipoda* and *Hymenophyllum multifidum* are characteristic plants. Other plants of this formation are *Myosotis*, *Ranunculus*, *Abrotanella*, *Celmisia*, *Pleurophyllum speciosum*, *Grammitis*, *Hymenophyllum*, *Colobanthus*, *Phyllachne*, mosses and lichens.

Littoral vegetation includes a number of characteristic plants. Among large plants, *Hebe elliptica* and *Anisotome latifolia* were characteristic, but largely eliminated by sheep. *Dracophyllum scoparium* comes close to the shore in protected areas. *Poa foliosa* used to be dominant near the shore, but has been largely replaced by *P. litorosa* and introduced grasses, sedges or herbs. Other littoral plants include *Tillaea moschata*, *Scirpus aucklandicus*, *Cotula lanata*, *Urtica australis*, *Celmisia vernicosa*, and *Blechnum durum*. On steeper slopes and cliffs inaccessible to sheep, the following may occur near the shore: *Stilbocarpa polaris*, *Anisotome latifolia*, *Pleurophyllum speciosum*, *P. criniferum*, *Urtica australis*, *Asplenium obtusatum* and *Poa ramosisssima*.

Most of the introduced plants are confined to coastal areas in Perseverance Harbor. Some, including *Poa annua*, *Stellaria media*, *Cerastium vulgatum* and *Sagina procumbens*, have spread over wide areas of the island. *Holcus lanatus*, *Dactylis glomerata* and *Rumex obtusifolius* are tending to spread.

(Preceding data largely from Oliver & Sorensen 1951 and Sorensen 1951, augmented and corrected by Dr. E. J. Godley.)

Affect of man and domestic animals: A great change has taken place in the vegetation of Campbell I. over the past half century and more. The most conspicuous aspect of the change has been the great reduction in extent of tussock grass and its substitution by the large herb *Bulbinella*. This is particularly true at the medium-high altitudes, where the tussock *Chionochloa* has been almost eliminated by sheep-grazing. The *Bulbinella*, not eaten by sheep, replaced the tussock (fig. 8). At lower altitudes, tussock grasses of genus *Poa* are still common, but there has been replacement of *P. foliosa* by *P. litorosa* and other grasses, as well as sedges or herbs.

The *Rostkovia* formation at higher altitudes has also suffered in recent decades. The sheep have also largely exterminated the *Pleurophyllum speciosum*, *Stilbocarpa polaris*, and other large herbs, except in steep areas inaccessible to them.

In some areas the *Dracophyllum* scrub has been reduced by activities of man. Introduced plants have tended to replace native plants in the areas disturbed by man, particularly near the shores at the inner end of Perseverance Harbor. The increase in the population

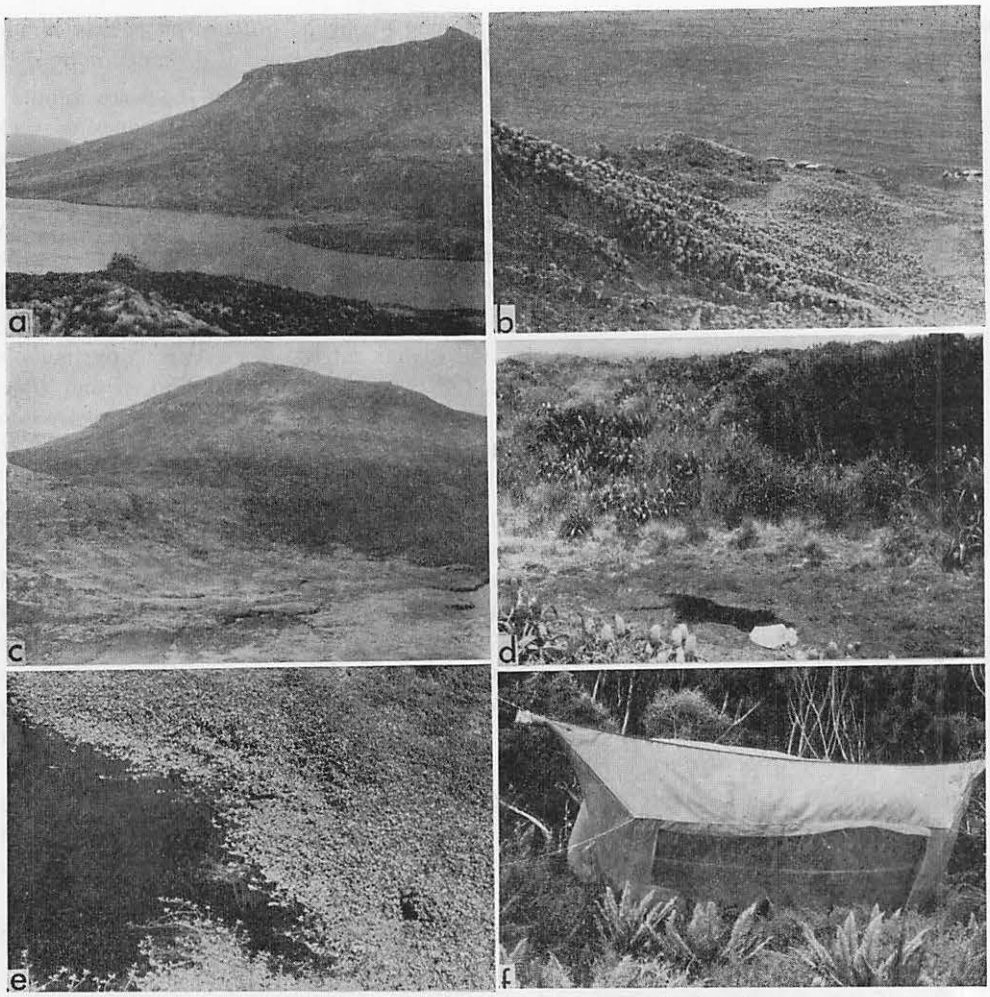

Fig. 6. a, Mt. Honey from nr. Camp Cove (Perseverance Hbr.): dark areas are *Dracophyllum* scrub; b, less precipitous portion of northwest coast, showing tussock (pale) and *Bulbinella* (dark); c, S. side of Mt. Honey from slope of Mt. Eboulé, with dark *Dracophyllum* scrub and Six Foot Lake at lower right; d, small pond among herbs in old elephant seal wallowing area, with *Dracophyllum* upper right and *Bulbinella* upper and lower left; e, pond in old elephant seal wallow with *Montia fontana*; f, modified Malaise trap in *Dracophyllum* scrub by stream below old camp, Tucker Cove, with *Myrcine* at left and far right, *Polystichum* in foreground.

of elephant seals has also resulted in encouragement of introduced plants where by their wallowing the seals have tended to destroy the native plants, particularly *Poa foliosa* (fig. 10a).

List of the vascular plants of Campbell I.

Native species: The following list of native higher plants of Campbell I. is after Soren-

son (1951) with corrections and nomenclatorial changes kindly supplied by Dr. Eric J. Godley.

Filices:	*Hymenophyllum villosum* Col.
	minimum A. Rich.
	multifidum Swartz
	Polystichum vestitum (Forst. f.) Presl.
	cystostegia J. B. Armstr.
	Asplenium obtusatum Forst.
	obtusatum var. *obliquum* Hook. f.
	obtusatum var. *scleropium* Moore
	Blechnum durum C. Christen
	penna-marina Kuhn.
	procerum Forst. f.
	minus (R. Br.) Allan
	banksii Matt.
	Hypolepis millefolium Hook. f.
	rugosula Labill.
	Histiopteris incisa J. Smith
	Grammitis billardieri Willd.
	pumila J. B. Armst.
	Schizaea fistulosa Labill.
Lycopodiaceae:	*Lycopodium varium* R. Br.
	fastigatum R. Br.
Gramineae:	*Hierochloe redolens* Vahl.
	brunonis Hook. f.
	Agrostis magellanica Lam.
	Deyeuxia filiformis (Forst.) Hook. f.
	Deschampsia chapmani Petrie
	Trisetum spicatum (Linn.) Richter
	Chionochloa antarctica (Hook. f.) Zotov.
	Poa foliosa Hook. f.
	litorosa Cheesm.
	ramosissima Hook. f.
Cyperaceae:	*Scirpus aucklandicus* Boeck.
	Oreobolus pectinatus Hook. f.
	Uncinia hookeri Boot.
	Carex appressa R. Br.
	trifida Cav.
Centrolepidaceae:	*Gaimardia pallida* Hook. f.
	ciliata Hook. f.
Juncaceae:	*Rostkovia gracilis* Hook. f.
	Juncus effusus Hook. f.
	bufonius Linn.
	antarcticus Hook. f.
	scheuchzeroides Gand.
	Luzula campestris var. *crinita* Buch.

Liliaceae:	*Astelia subulata* Cheesm.
	Bulbinella rossii Hook. f.
Orchidaceae:	*Aporostylis bifida* Hook. f.
	Lyperanthus antarcticus Hook. f.
	Chiloglottis cornuta Hook. f.
	Corybas oblongus Hook. f.
	trilobus Hook. f.
Urticaceae:	*Urtica australis* Hook. f.
Portulaceae:	*Claytonia australasica* Hook. f.
	Montia fontana Linn.
Caryophyllaceae:	*Stellaria decipiens* Hook. f.
	Colobanthus muscoides Hook. f.
	hookeri Cheesm.
	apetalus (Labill.) Druce.
	apetalus var. *alpinus* (Kirk) L. B. Moore
Ranunculaceae:	*Ranunculus pinguis* Hook. f.
	subscaposus Hook. f.
Cruciferae:	*Cardamine subcarnosa* (Hook. f.) Allan
	corymbosa Hook. f.
	depressa Hook. f.
	depressa var. *stellata* Hook. f.
Droseraceae:	*Drosera stenopetala* Hook. f.
Crassulaceae:	*Tillaea moschata* D. C.
Rosaceae:	*Acaena pusilla* var. *antarctica* (Ckn) Allan
	minor Hook. f.
Geraniaceae:	*Geranium microphyllum* Hook. f.
Callitrichaceae:	*Callitriche antarctica* Engelm.
Onagraceae:	*Epilobium confertifolium* Hook. f.
	alsinoides A. Cunn.
	linnaeoides Hook. f.
	findlayi Allan.
Haloragidaceae:	*Haloragis uniflora* T. Kirk
Araliaceae:	*Stilbocarpa polaris* A. Gray
Umbelliferae:	*Hydrocotyle* sp.
	Anisotome latifolia Hook. f.
	antipoda Hook. f.
Epacridaceae:	*Dracophyllum longifolium* R. Br.
	scoparium Hook. f.
Myrsinaceae:	*Myrsine divaricata* A. Cunn.
Gentianaceae:	*Gentiana antarctica* T. Kirk
Boraginaceae:	*Myosotis antarctica* Hook. f.
	capitata Hook. f.
	pygmaea var. *drucei* L. B. Moore
Scrophulariaceae:	*Hebe elliptica* Forst.
	benthami Hook. f.
Rubiaceae:	*Coprosma parviflora* Hook. f.

ciliata Hook. f.
cuneata Hook. f.
pumila Hook. f.

Campanulaceae: *Pratia arenaria* Hook. f.
Stylidaceae: *Phyllachne clavigera* F. Muell.
Compositae: *Lagenophora pumila* Cheesm. (Forst. f.)
Brachycome radicata Hook. f.
Pleurophyllum speciosum Hook. f.
criniferum Hook. f.
hookeri Buch.
Celmisia vernicosa Hook. f.
Helichrysum bellidioides Willd.
Craspedia uniflora Forst.
Cotula plumosa Hook. f.
lanata Hook. f.
minor Hook. f. (?sp.)
Abrotanella spathulata Hook. f.
rosulata Hook. f.
Taraxacum magellanicum Comm.

Introduced species: This list is taken directly from Sorensen (1951). These plants were noted growing on the island, but some may not have survived. Many are limited to the camp areas.

Pinaceae: *Picea* sp. Spruce.
Gramineae: *Anthoxanthum odoratum* Linn. Sweet Vernal.
Alopecurus geniculatus Linn. Foxtail.
Agrostis tenuis Sibth.
Holcus lanatus Linn. Yorkshire Fog.
Avena sativa Linn. Common Oat.
Arrhenatherum elatius (L.) Mert. et Koch. False Oat-grass.
Cynosurus cristatus Linn. Dogstail.
Dactylis glomerata Linn. Cocksfoot.
Poa annua Linn. Annual meadow-grass.
pratensis Linn. Meadow-grass.
trivialis Linn. Roughish Meadow-grass.
Festuca rubra Linn.
Lolium perenne Linn. Rye-grass.
multiflorum Lam.
Liliaceae: *Phormium tenax* Forst. New Zealand Flax.
Polygonaceae: *Polygonum persicaria* Linn. Willow-weed.
aviculare Linn. Wire-weed.
Rumex obtusifolius Linn. Common Dock.
crispus Linn. Curled Dock.
acetosella Linn. Sheep's Sorrel.
sp.
Caryophyllaceae: *Cerastium vulgatum* Linn. Mouse-ear Chickweed.
Stellaria media (L.) Vill. Common Chickweed.

	graminea Linn. Lesser Stitchwort.
	Sagina procumbens Linn.
	Spergula arvensis Linn. Yarr or Spurrey.
Ranunculaceae:	*Ranunculus repens* Linn. Creeping Buttercup.
Papaveraceae:	*Fumaria officinalis* Linn. Fumitory.
Cruciferae:	*Capsella bursa-pastoris* Medic. Shepherd's Purse.
	Coronopus didymus (L.) Sm. Wart-cress.
Leguminosae:	*Trifolium repens* Linn. White Clover.
	pratense Linn. Red Clover.
	dubium Sibth. Yellow Suckling Clover.
Ericaceae:	*Calluna vulgaris* Salisb. Ling or Heather.
Primulaceae:	*Anagallis arvensis* Linn. Pimpernel.
Convolvulaceae:	*Convolvulus ?arvensis* Linn. Smaller Bindweed.
Labiatae:	*Prunella vulgaris* Linn. Self-heal.
Solanaceae:	*Solanum tuberosum* Linn. Potato.
	sp.
Scrophulariaceae:	*Veronica tournefortii* Gmel.
	agrestis Linn.
	Digitalis purpurea Linn. Foxglove.
Plantaginaceae:	*Plantago lanceolata* Linn. Ribwort.
Compositae:	*Bellis perennis* Linn. Daisy.
	Achillea millefolium Linn. Yarrow.
	Hypochaeris radicata Linn. Catsear.

ARTHROPOD ENVIRONMENTS ON CAMPBELL ISLAND

The niches of insects and other arthropods on Campbell are largely terrestrial or involve low-lying plants such as mosses, lichens, other primitive plants, and cushions or mats consisting of higher plants in low dense growth form like mosses, as well as the extensive tussock grass. The few taller plants such as *Dracophyllum*, the tallest and most predominant woody plant, and *Coprosma*, *Hebe*, and *Myrsine* (fig. 6f), are to some extent less populated by insects, although they do provide a significant environment. Other important environments are the various bird rookeries, the stony beaches, particularly under decomposing *Durvillea* kelp, as well as seal wallows, streams and various herbs, large and small in size.

Mosses and cushion plants: Various herbs appear like mosses, have low dense growth form, forming cushions or mats (fig. 7b), and provide quite an important environment. Important plant elements are: *Colobanthus*, *Gaimardia*, *Oreobolus*. Under these, as well as mosses, including tundra, may be found some of the richest arthropod assemblages on the island. Springtails, and various beetles, particularly tenebrionids of the genus *Pseudhelops*, carabids of the genus *Pseudoopterus*, staphylinids of the genus *Omalium*, and weevils of the genus *Gromilus*, are fairly abundant under these plants. Most of them may be found at the bottom of the plants or their roots, next to the ground, when the plants are pulled upward. Of most of the beetles, larvae, pupae and adults occur in more or less the same layer, and may be observed more or less together. Often these mat plants grow on boulders, or rocky ground, and when lifted up they more or less separate from the rock at

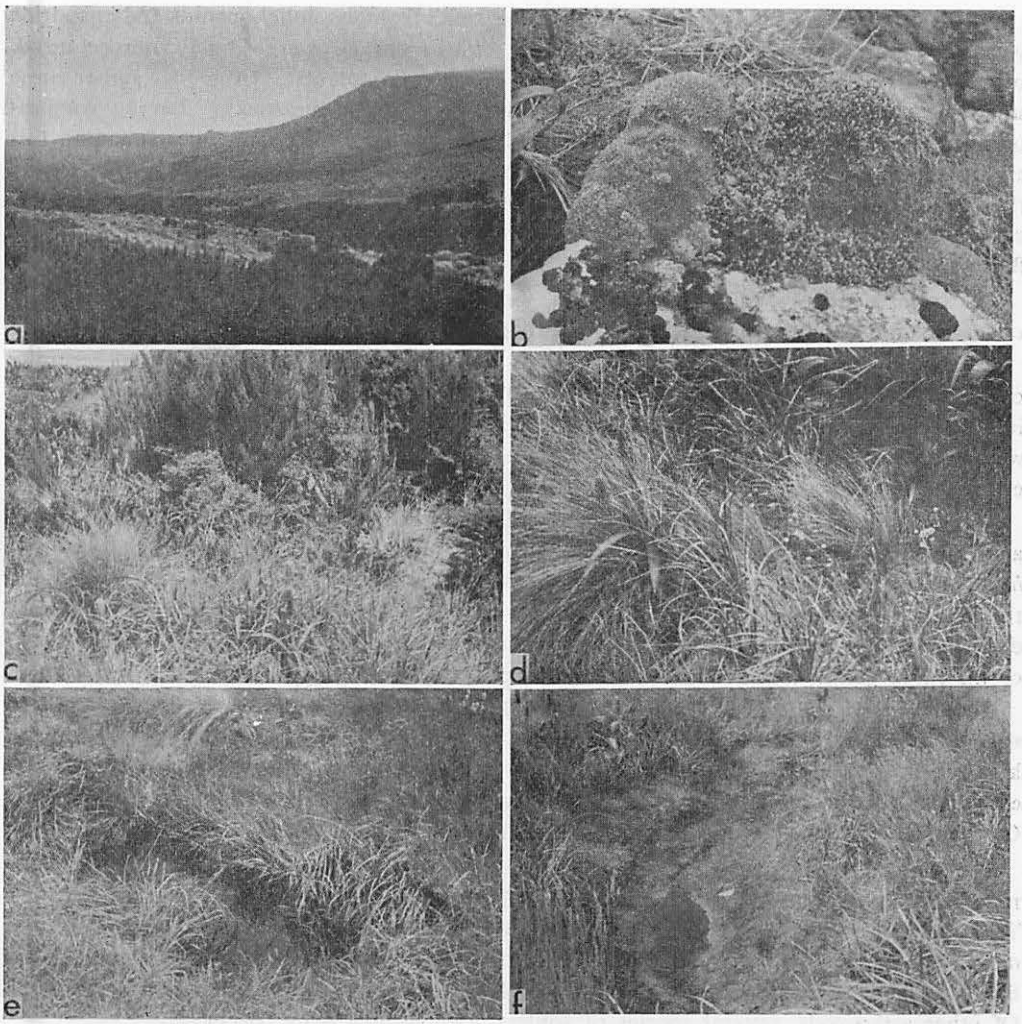

Fig. 7. a, valley above old camp, Tucker Cove, showing saddle between St. Col Ridge and Mt. Lyall, with pale tussock, dark *Dracophyllum* and old sheep path; b, cushion vegetation (mosses and lichens) on rocks on W. side Beeman Hill; c, mixed *Dracophyllum scoparium* and *Coprosma* in background, *Bulbinella* lower left and *Carex appressa* to its right, grass at right: in Beeman-Lyall Saddle; d, *Poa, Bulbinella,* sedge, *Helichrysum bellidioides,* Beeman-Lyall Saddle; e, old elephant seal wallow with sedges, *Carex appressa* and *Bulbinella,* nr. Tucker Cove; f, old elephant seal wallow with sedges, *Poa, Carex appressa* and *Bulbinella,* nr. Tucker Cove.

the substrate, with often a thin layer of soil between the plants and the rock. It is in this layer, or higher among the roots, where most of the insects are found. In addition to the above there are several other families of beetles, mealybugs, lepidopterous larvae, various flies and undoubtedly some Hymenoptera. Besides the insects, there are various mites, small spiders, millipedes, centipedes, a pseudoscorpion, and isopods.

Of the flies in this environment, some of the small flightless dolichopodids and ephydrids were most numerous, though rarely abundant. Their larvae were largely unrecognized, but may live higher among the denser parts of the same plants. In good weather these small flies run about on the surface of the cushion plants or the rocks. Larger wingless or short-winged flies, such as the anthomyid *Coenosia* are also sometimes found in this environment, although the adults are most often seen on the flowers of *Bulbinella*, where they walk about on the flower heads and run or jump downward when disturbed. The completely wingless dolichopodid, *Acropsilus borboroides*, is also found on the *Bulbinella* flowers.

The small slender wingless ichneumonid wasp was also found on one or two occasions under cushion plants. Presumably it parasitizes larvae of a moth or fly.

Peat bogs: These occur at both low and high altitudes (fig. 8). They are generally covered with cushion plants and mosses. These are wet environments less favorable to insects than the cushion plants and mosses on rock or soil. Though the bogs are always wet and spongy, they are not as wet as the occasional *Sphagnum* "sumps", which are composed entirely of mosses.

Tussock: Tussock grasses (figs. 6b, 7a) dominate much of the surface of Campbell except at the higher altitudes, and except for much of the medium-low altitudes where *Dracophyllum* scrub may predominate. Actually, tussock was even more predominant originally, and the grazing of sheep for several decades has reduced the tussock and tended to produce dominance by *Bulbinella* in many of the medium higher altitudes, particularly on the tops of the more gently rounded and lower hill-tops.

Dense growth of tussock still occurs to the tops of even some of the higher hills, to slightly over 300 m alt., but becomes much lower in growth and sparser or lacking at higher altitudes. The dominant species of the tussock is *Poa litorosa*. *Poa foliosa*, however, has a much larger growth form, and seems to be particularly rich in insect fauna. *Chionochloa antarctica* grows at the higher altitudes (fig. 6b).

The insect fauna of larger heads of tussock at low to medium altitudes may be quite rich. Much of the fauna occurs among the bases of the stems and among the roots. These include as many as four species of mealybugs in both of these niches, carabid beetles of the genus *Pseudoopterus*, occasional staphylinid beetles and weevils, lepidopterans, some flies, and at least two species of wasps (wingless ichneumonid; shorter wingless diapriid). Of other arthropods, several species of spiders, and various mites, occur.

Other grasses: Certain species of grasses (*Hierochloe*, *Agrostis* and *Deschampsia*) more or less cover the ground or develop mat-like growth. Among these may be found adults of some of the brachypterous moths, and presumably their larvae may live in the grass stems, or among the roots.

Sedges: One of the small, pale, slender-winged jumping moths (*Euproteodes*) is particularly abundant on common sedges (mostly *Scirpus* and *Carex*) on protected lowland slopes, as at Tucker Cove and Beeman Point (fig. 7 d-f). A leaf-mining larva found also to be abundant in the same sedge is probably the larva of this species (reported from tussock by Sorenson, but "tussock" may also include sedges). Some of the common flies (including *Pseudohaeterella*) were frequently taken from the same sedges.

Larger herbs: *Bulbinella rossii* (figs. 6b, 12a) is at present the most abundant larger herb on Campbell. It is surprisingly poor in insects. The adult of the brachypterous anthomyid

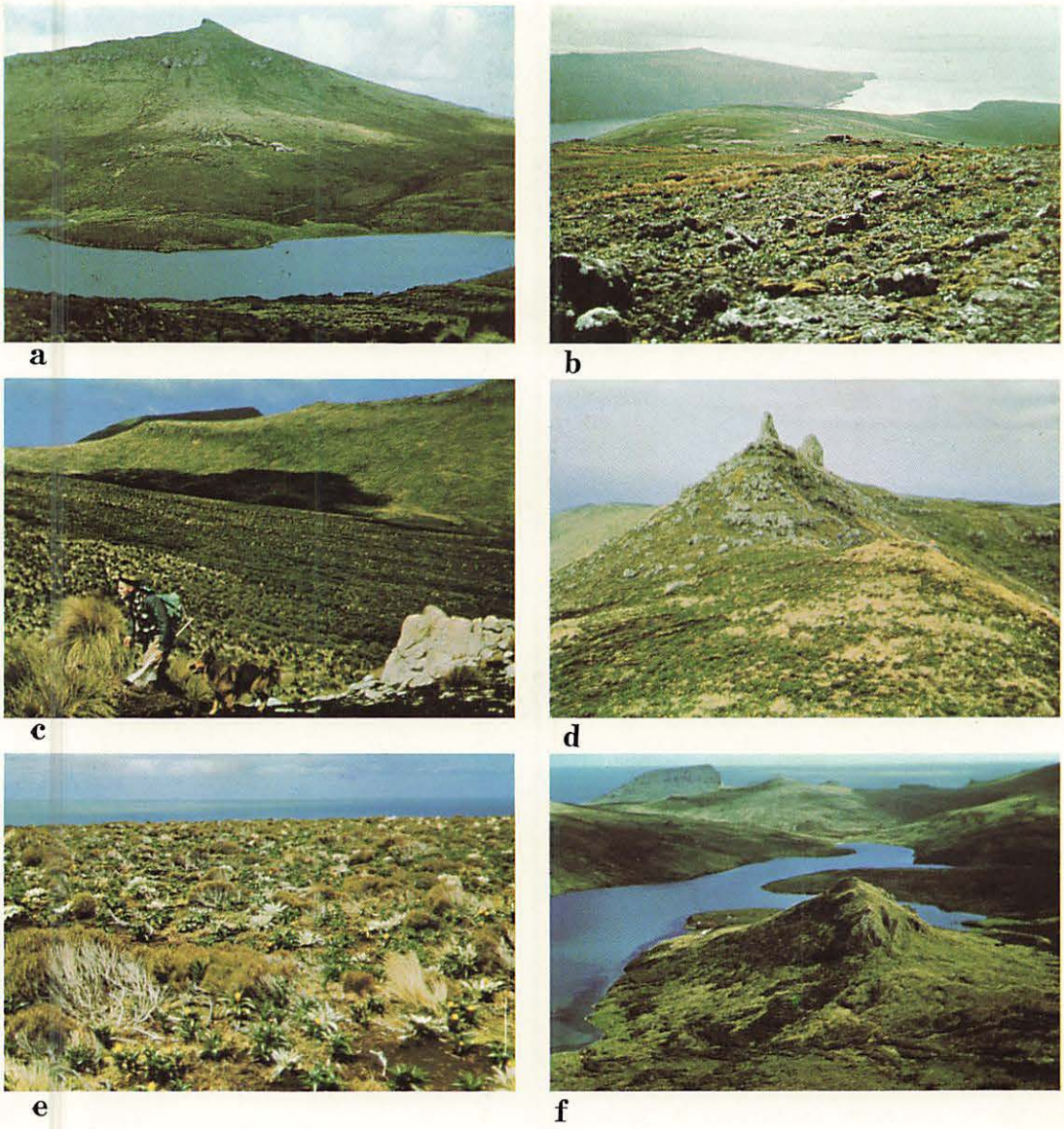

Fig. 8. a, Mt. Honey across Perseverance Hbr. from Mt. Lyall: lower dark areas are *Dracophyllum* scrub; b, looking towards mouth of Perseverance Hbr. from nr. summit of Mt. Honey: mostly moss and lichens (almost feldmark) in foreground; c, between Mt. Honey and Filhol Peak: Rennell between tussock and volcanic outcrop, low *Dracophyllum* scrub interspersed with tussock in center and tussock with *Bulbinella* in back; d, summit of Mt. Lyall with tussock and *Bulbinella* in foreground; e, plateau towards Mt. Lyall from Moubray Hill, with dwarfed *Bulbinella*, tussock, *Coprosma* and *Dracophyllum*, and bared peat at lower right; f, Beeman Hill looking down from Mt. Lyall: Beeman Camp at left center and inner end of Perseverance Hbr. with Lookout Bay at lower left, Tucker Cove at far right center, Camp Cove behind it, Garden Cove at end and Venus Bay in upper center; Mt. Honey at left, Mt. Eboulé in left distance, Filhol Peak in middle distance and Mt. Dumas slopes at far right.

Fig. 9. a, Collecting site in mollymawk rookery on N. side Courrejolles Pen.: gray-headed mollymawks in foreground and black-browed mollymawks in center; b, rockhopper penguin rookery behind boulder beach in Rocky Bay; c, wind-contoured *Coprosma* bush in center, with *Polystichum* fern in front, tussock at side, *Bulbinella* at left and *Dracophyllum* behind; d, boulders with lichens, moss, mat plants and scattered *Bulbinella* (yellow flowers) on SW slopes of Mt. Lyall; e, cushion of *Phyllachne clavigera* with *Pleurophyllum hookeri* above and *Bulbinella rossi* at left; f, air-borne insect nets on frame nr. Beeman Point on windy day with waves going out from shore; one net downed by wind.

fly *Coenosia* is frequently seen on the flower heads, and jumps or runs downward when disturbed. Presumably its larva might live among the roots, or in rotten stems and leaves. The small wingless dolichopodid (*Acropsilus borboroides*) was found on the flower heads near the summit of Mt. Azimuth, although at lower altitudes it was found among mat plants. The largest weevils (*Oclandius*) feed on *Bulbinella*.

Large herbs of the genus *Pleurophyllum* (Compositae) are rich in insects. The largest, *P. speciosum* is a particular favorite, but being especially prized by sheep, it is rare except in inaccessible spots. Among the fauna of this species are several spiders, mites, springtails, mealybugs, a common greenish caterpillar, occasional carabids, staphylinids and weevils, several flies (maggots feeding in decaying leaves and stems), and the wingless ichneumonid wasp. Two other species, *P. hookeri* (fig. 9) and *P. criniferum* are more abundant, but slightly poorer in fauna.

One of the small herbs, *Cotula plumosa*, which is particularly abundant around elephant seal wallows and low protected places, is a favorite host of some of the common species of aphids. The large herb *Stilbocarpa polaris* is a host to a number of kinds of insects, but the plant has been badly eaten out by sheep and only grows in inaccessible places.

Two species of the large herb *Anisotome* are conspicuous where safe from sheep, one in rocky places at higher altitudes. Their abundant flowers were not noted to attract many insects. Nor were insects found feeding on the plants. Rather few of the plants were closely examined, however, because of their scarcity, primarily occurring on inaccessible cliffs.

Dracophyllum: This is a dominant woody plant, and includes two abundant species. They grow on the lower slopes in slightly protected environments. Often the *Dracophyllum* scrub forms a dense band along the lower slopes of the hills (figs. 5, 6 a, c, f, 13e). In favorable places it grows to a height of more than 3 meters. The long slender leaves accumulate in a thick layer beneath the shrubs, and the lower portions of this layer provide a rich environment when sufficiently damp and decaying. Here there may be large numbers of springtails and mites, and sometimes some spiders and certain beetles. On the leaves, some green and brown caterpillars are fairly abundant. These may be the young of some of the abundant geometrid moths. A slender pale-winged weevil (*Peristoreus*) is abundant on the pale flowers of *Dracophyllum*. This is possibly the only flying beetle on the island. A medium-small winged chalcidoid (Eulophidae: *Ardalus*) is also found on the flowers. The larger winged ichneumonid and a braconid (*Rogas*) are both quite abundant around this shrub, and probably parasitize the above moth larvae. Two species of Psocoptera occur on the branches.

Streams: Water insects are rather few on Campbell, but interestingly there are three species of stoneflies. However, only two of these occur in streams. One of the latter has aquatic nymphs and winged adults; the other has aquatic nymphs and wingless terrestrial adults. One species of simuliid fly ("black fly", "sand fly") is moderately common near the lower portions of streams, but is rarely very abundant.

Ponds: There are rather few ponds on Campbell, and the few tarns (fig. 11b) seem to harbor rather little insect life—perhaps only a few chironomid midges. The bogs and elephant seal wallows, however, are richer, and support chironomid midges as well as other types of midges and flies. Insect life does not seem to be abundant in Six-foot Lake (fig. 6c).

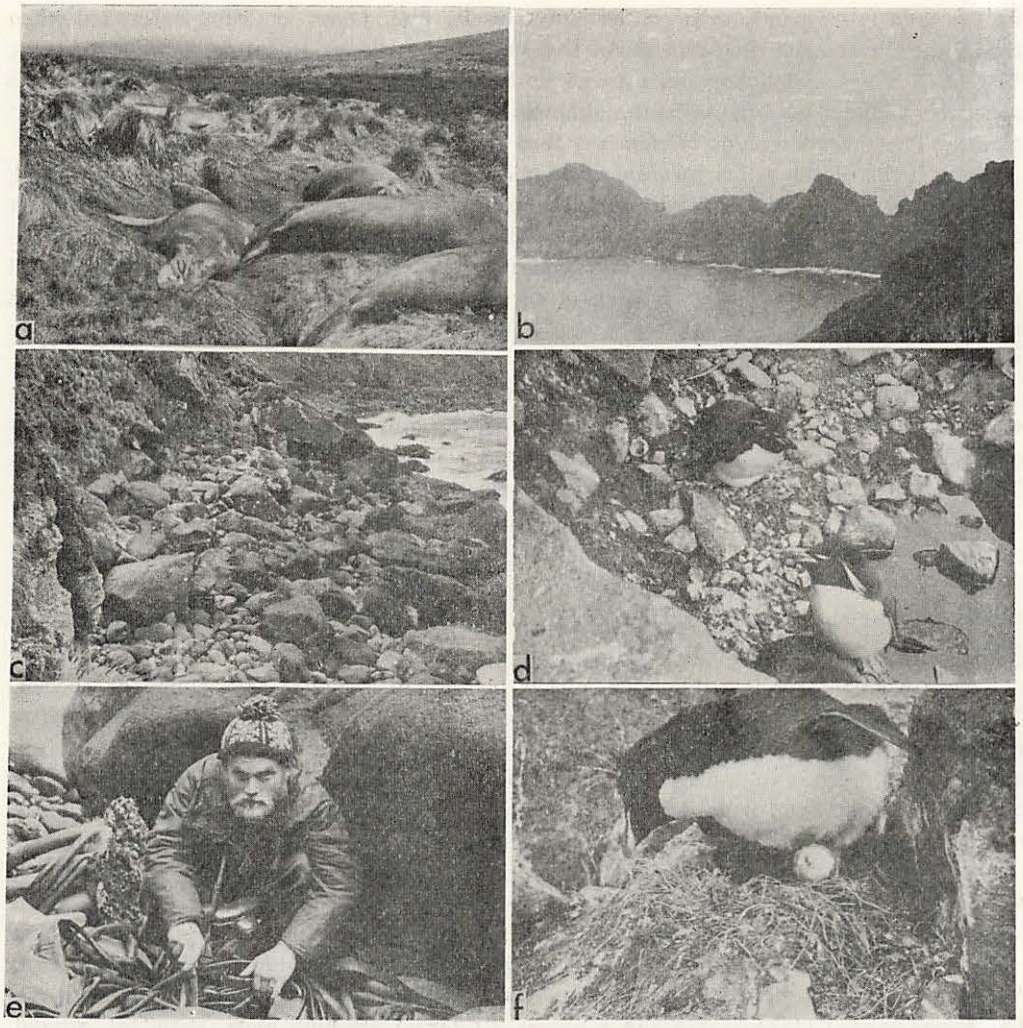

Fig. 10. a, young male elephant seals showing effect on *Poa* tussock, with low *Dracophyllum* in mid background; b, S. side of major portion of Courrejolles Pen. (most of slopes covered with mollymawk nests); c, boulder beach, Rocky Bay with rockhopper penguin rookery in left center and four penguins on boulder at lower right; d, rockhopper penguin rookery showing nests largely of stones, Rocky Bay; e, K. Rennell searching for flightless coelopid flies in *Durvillea* kelp washed up on shingle-boulder beach, Rocky Bay, with coelopid egg masses at lower left; f, rockhopper penguin with egg, on nest partly of grass in upper portion of rookery, Rocky Bay.

Rocks on hills: Under rocks at higher altitudes (fig. 8) a few kinds of insects may be fairly abundant, even though vegetation may be scarce. One of these is the third stonefly, which is terrestrial both as a nymph and wingless adult, and is found quite high up under flattish rocks even in only slightly damp places. Others commonly found under rocks are tenebrionids (*Pseudhelops*), carabids (*Pseudoopterus*), weevils and others. Some of these live under thin growth of grass, and move under the rocks to pupate.

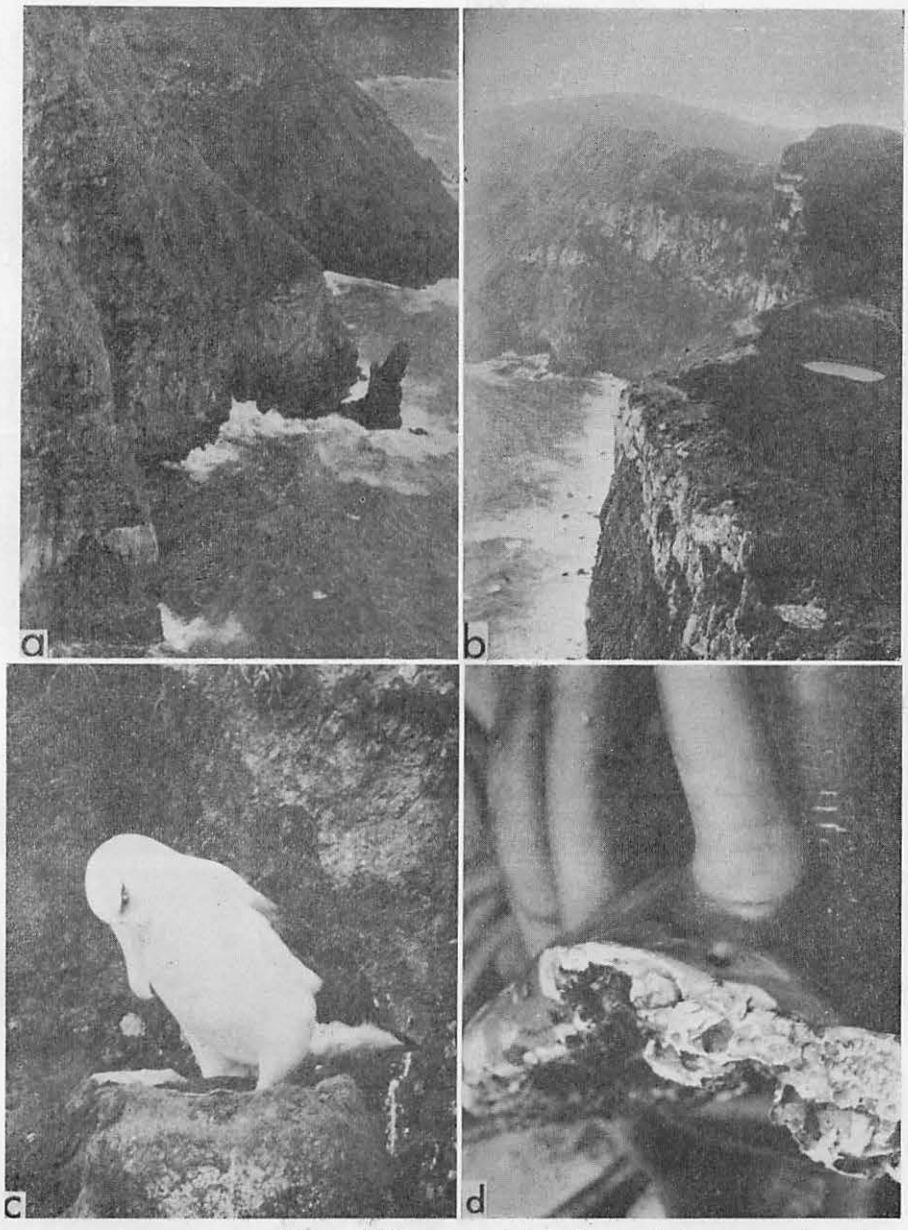

Fig. 11. a, looking south, cliffs on NW coast nr. Mt. Azimuth; b, looking north, cliffs on NW coast N of Mt. Azimuth; c, black-browed mollymawk on nest, N. side of Courrejolles Pen.; d, holdfast of washed up *Durvillea* kelp with winged coelopid flies (center and upper left), Rocky Bay.

Rocks in inter-tidal zone: A fairly rich fauna occurs under rocks in the inter-tidal zone in coves in Perseverance Harbor. In cavities under some of the larger rocks in Tucker Cove, we found springtails, including a bright purple species, mites, including a bright red

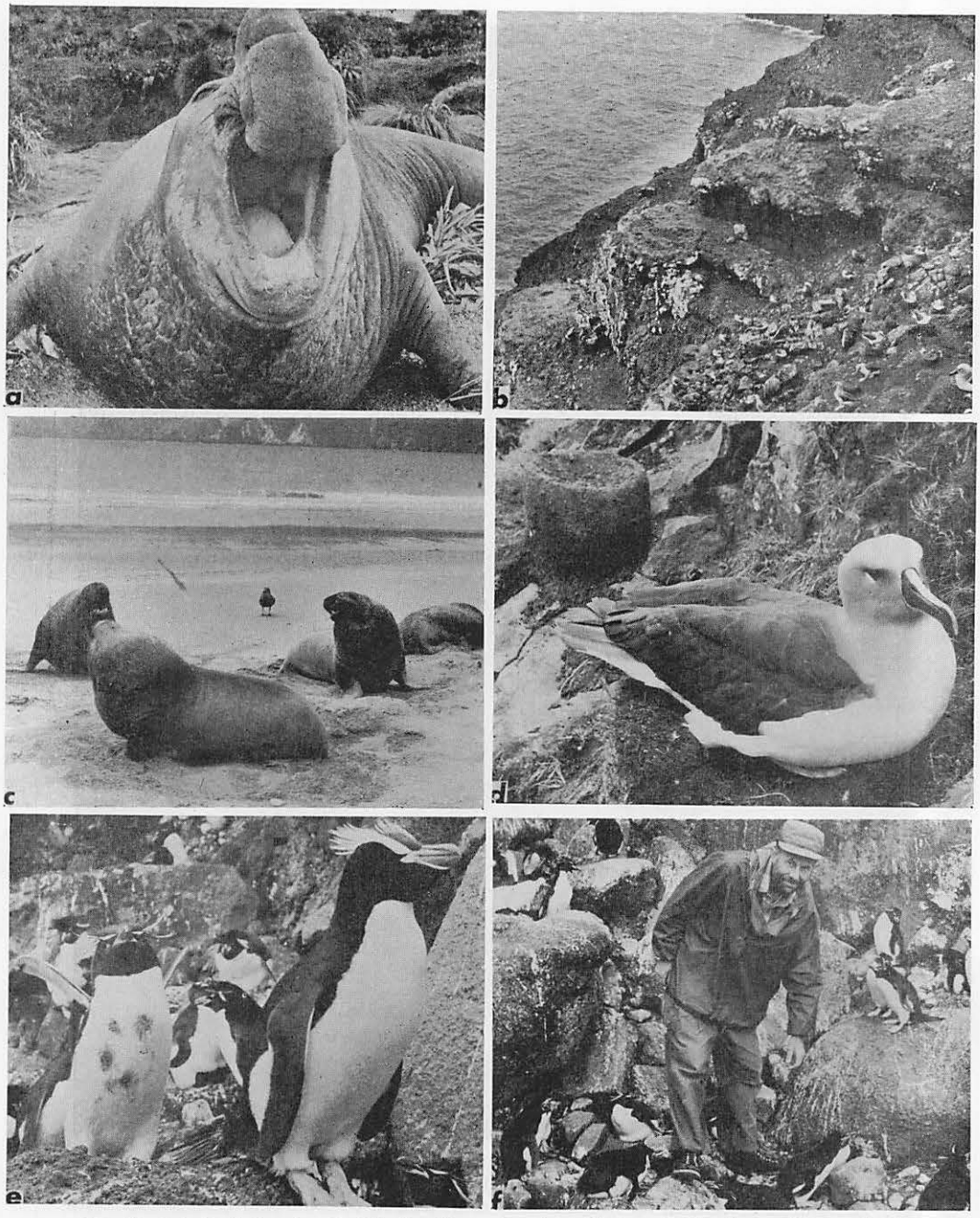

Fig. 12. a, bull elephant seal at Tucker Cove, showing effect on *Bulbinella*, and *Poa* and other grasses; b, rookery of gray-headed mollymawk (right foreground) and black-browed mollymawk (below) on north side, Courrejolles Pen.; c, New Zealand sea lion, bulls fighting on middle beach, Northwest Bay, with skua in center and red-billed gull at far right; d, gray-headed mollymawk on nest, with abandoned nest at upper left, N. side of Courrejolles Pen., nr. ridge (type locality for a number of arthropods); e, rockhopper penguin rookery, Rocky Bay, with erect-crested penguin visitor at right; f, Gressitt in rockhopper penguin rookery, Rocky Bay (latter taken by Rennell).

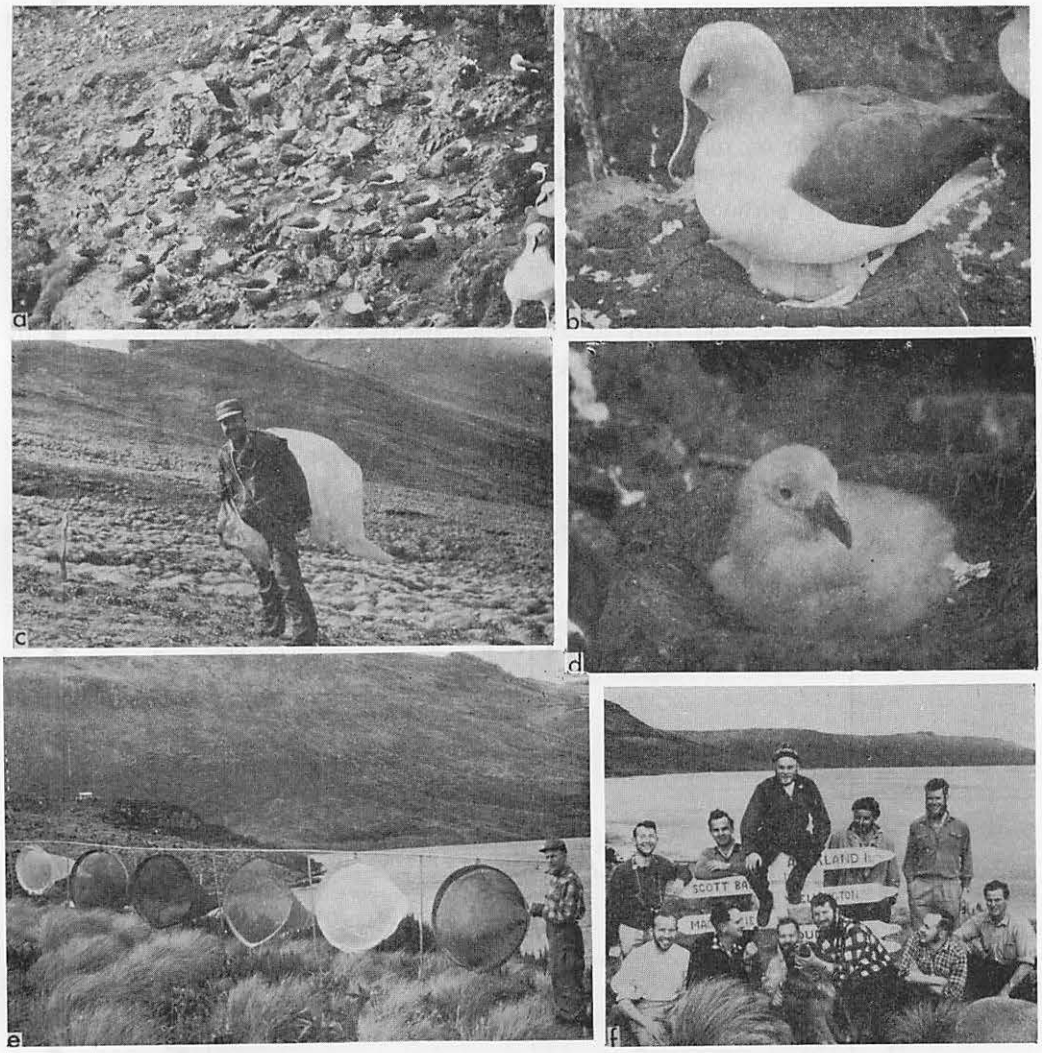

Fig. 13. a, rookery on N. side Courrejolles Pen.: black-browed mollymawks, with two gray-headed mollymawks in lower right corner; b, gray-headed mollymawk on nest, with chick, Courrejolles Pen.; c, Gressitt with nets leeward of tops of cliffs between St. Col Ridge and Mt. Azimuth, showing effect of wind on tussock and *Bulbinella*, and wind erosion on old sheep fence post; d, young mollymawk in nest, where fleas were abundant; e, Beeman Point, with battery of nets for dispersal study (before elevation), with Gressitt, and slopes of Mt. Lyall in background with *Dracophyllum* scrub at left center (b-e taken by Rennell); f, summer 1961–62 population of Campbell I.; front row (L to R): S. Smith, I. G. Fisher, I. Johnson, D. Polson, R. Lamb, G. Voigt; back row: R. B. Goffin, L. Rush, K. Rennell, C. Clark (officer in charge), L. Cooper; pet dog and pet lamb in front.

kind, carabid beetles (particularly *Kenodactylus*), several species of staphylinid beetles, the pselaphid, and others.

Rocky shores: On rocky points and terraces above the normal waveline, a brachypter-

ous moth (*Tinearupa sorenseni* Salmon & Bradley) is fairly common, blending well with the rocks and lichens, its larvae presumably feeding on the latter.

Shingle beaches: On some of the fairly steep beaches, of large pebbles to large rounded rocks or boulders, kelp flies may be quite abundant. These are members of the Coelopidae. They oviposit on rotting *Durvillea* kelp (figs. 10e, 11d), and the maggots feed inside the kelp. The adult flies roam about on the kelp and within its cavities and the eaten or rotted-out portions. The largest species, *Baeopterus robustus*, which has much reduced wings, has slightly larger wings and body in the male, and was found only on windward beaches, such as at Rocky Bay on the SW. It occurred there in large numbers, however. *Icaridion nasutum*, a totally wingless species of quite variable size, was very abundant at Rocky Bay, and fairly scarce around Beeman Point. Other species, mostly belonging to the genus *Coelopa*, are winged, but do very little flying

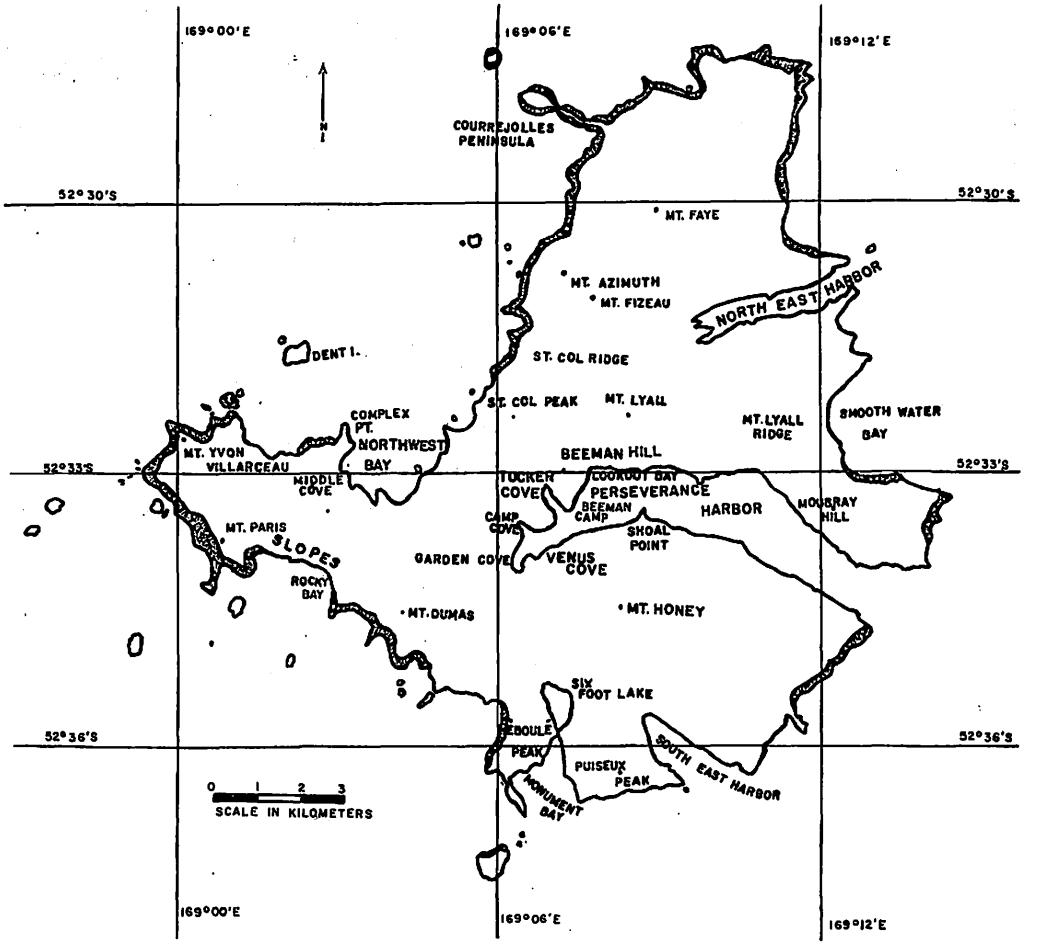

Fig. 14. Map of Campbell I. indicating principal arthropod collecting localities. "Slopes" by Rocky Bay indicates the locality "slopes above rocky Bay."

Carrion: In the corpses of seals maggots of various flies occur, including blow flies, psychodids and muscids. Also staphylinids and secondarily others occur here. Dead birds also attract more or less the same insects.

Bird nests: The environments of rookeries, particularly of mollymawks (*Diomedea chrysostoma, D. melanophrys*), provide some of the richest arthropod habitats on Campbell (figs. 11c, 12 b, d, 13 a, b, d). Although the most numerous bird species is the rockhopper penguin (several million), its rookeries are not as favorable for arthropods as are those of albatrosses or other birds, because its nests consist largely of rock and pebbles, with rather little soil, moss or other plants or materials. The mollymawk nests (both species nesting close together), as observed on Courejolles Peninsula, are cylindrical, being built up of moss, turf, excrement and debris, with a distinct cavity on the top. Within the nests fleas and their larvae were found to be quite abundant. Also mites were found in the nests. On the steep slopes around the nests there is an abundance of moss and other small plants. This environment was very rich in arthropods, with numerous adult ticks and their egg-masses in the moss (early December), various mites, spiders, moths (Sorenson found here the same species we found primarily lower on exposed rocks above the sea). Also there were various kinds of beetles, including carabids, staphylinids, the salpingid, weevils, and others. Flies including the wingless crane-fly, short-winged psychodid, some brachypterous dolichopodids, small-winged ephydrids, and others, were also found.

Other bird nests examined yielded varying results. Skua nests generally containing fairly dry loose grass, seemed rather poor. Sooty albatross nests were rather productive, being quite solid and matted, with quite a bit of vegetation, debris and soil. Arthropods typical of soil and cushion plants were found in these nests. Royal albatross nests are somewhat intermediate in consistency between those of sooty albatross and skua, and produced some insects.

Rockhopper penguin nests are much less rich than mollymawk nests, but have some variety of arthropods if not too wet. Lower and wetter nests (figs. 10d, 12 e, f) are poor in insects, but those higher and near vegetation (fig. 10f) have more species. Yellow-eyed penguin nests also vary in suitability for insects, sometimes being quite wet and slimy with mud and excrement.

VERTEBRATE FAUNA

There are no native land mammals or native land birds, and no reptiles, amphibians or true fresh-water fish (galaxids are present) on Campbell I. Thus the native vertebrate fauna is almost entirely associated with the sea, as characteristic of oceanic islands. Most of the mammals and all of the native sea birds breed on land. Disregarding whales (of which the right whale is most numerous), the native mammals are all seals. Elephant seal, hair seal (sea lion) and fur seal are most numerous, in that order. The leopard seal is an occasional visitor.

Introduced mammals still present include the Norway rat, cat, sheep and cattle. The rats are abundant, but the cats rather scarce. I saw many rats, but only two cats. There are about 1000 sheep and about 20 cattle on the island. There was one pet male dog on the island.

The native birds consist of many kinds of sea birds, particularly albatrosses, penguins,

petrels, shags, ducks, shore birds, skua, gulls and terns. Introduced birds (some perhaps spread by wind) include thrushes, sparrow, pipit, white-eye, finches and starling. Following is a systematic list of the mammals and birds of Campbell I. Those asterisked are stragglers and do not breed on the island (After Bailey & Sorensen, 1962).

MAMMALS

Pinnipedia: Otariidae: *Neophoca hookeri* (Gray). New Zealand sea lion
Arctocephalus forsteri (Lesson). New Zealand fur seal
Phocidae: *Hydrurga leptonyx* (Blainville). Leopard seal
Mirounga leonina (Linn.). Southern elephant seal

BIRDS

Sphenisciformes: Spheniscidae: *Aptenodytes patagonicus* Miller. King penguin*
Megadyptes antipodes (Homb. & Jacq.). Yellow-eyed penguin
Eudyptes c. crestatus Miller. Rockhopper penguin
chrysolophus schlegeli Finsch. Royal penguin*
p. pachyrhynchus Gray. Crested penguin*
p. sclateri Buller. Erect-crested penguin

Podicipediformes: Podicipedidae: *Podiceps cristatus australis* Gould. Southern crested grebe*

Procellariiformes: Diomedeidae: *Diomedea ex. exulans* Linn. Wandering albatross
ep. epomophora Less. Southern royal albatross
melanophris impavida (Mathews). Black-browed mollymawk
chrysostoma Forster. Grey-headed mollymawk
c. cauta Gould. White-capped mollymawk*
Phoebetria palpebrata (Forster). Light-mantled sooty albatross

Procellariidae: *Macronectes giganteus* (Gmelin). Giant petrel
Daption c. capensis (Linn.). Cape pigeon*
Pachyptila desolata alter (Mathews). Auckland Island prion*
belcheri (Mathews). Narrow-billed prion*
Puffinus griseus (Gmelin). Sooty shearwater
tenuirostris (Temminck). Short-tailed shearwater*
Procellaria cinerea Gmelin. Grey petrel
aequinoctialis steadi Mathews. White-chinned petrel
Pterodroma lessoni (Garnot). White-headed petrel*

Hydrobatidae: *Garrodia nereis* (Gould). Grey-backed storm petrel*
Fregetta tropica (Gould). Black-bellied storm petrel*

Pelecanoididae: *Pelecanoides urinatrix exsul* Salvin. Subantarctic diving petrel*

Pelecaniformes: Phalacrocoracidae: *Phalacrocorax carbo novaehollandiae* Stephens. Black shag*

melanoleucos brevirostris Gould. Whitethroated shag*

cam. campbelli (Filhol). Campbell Island shag

Ciconiiformes: Ardeidae: *Egretta alba modesta* (Gray). White heron*

Notophoyx novaehollandiae (Latham). White-faced heron*

Anseriformes: Anatidae: *Anas castanea nesiotis* (Fleming). Campbell Island teal*

s. superciliosa Gmelin. Grey duck

p. platyrhynchos Linn. Mallard*

Falconiformes: Accipitridae: *Circus approximans gouldi* Bonaparte. Australasian harrier*

Falconidae: *Falco novaeseelandiae* Gmelin. New Zealand falcon*

Gruiformes: Rallidae: *Porphyrio porphyrio melanotus* Temminck. Pukeko*

Charadriiformes: Haematopodidae: *Haematopus ostralegus finschi* Martens. South Island pied oystercatcher*

Charadriidae: *Lobibyx novaehollandiae* (Stephens). Spur-winged plover*

Charadrius bicinctus Jardine & Selby. Banded dotterel*

Scolopacidae: *Limosa lapponica baueri* Naumann. Bar-tailed godwit*

haemastica (Linn.). Hudsonian godwit*

Calidris c. canutus (Linn.). Knot*

Stercorariidae: *Catharacta skua lonnbergi* (Mathews). Southern skua

Laridae: *Larus dominicanus* Lichtenstein. Southern black-backed gull

novaehollandiae scopulinus Forster. Red-billed gull

Sterna vittata bethunei Buller. Antarctic tern

paradisaea Pontoppidan. Arctic tern*

striata (Gmelin). White-fronted tern*

Apodiformes: Apodidae: *Chaetura c. caudacuta* (Latham). Spine-tailed swift*

Passeriformes: Hirundinidae: *Hirundo neoxena* Gould. Welcome swallow*

Turdidae: *Turdus philomelos* Brehm. Song thrush

merula Linn. Black thrush; blackbird

Prunellidae: *Prunella modularis occidentalis* (Hartert). British hedge sparrow

Motacillidae: *Anthus n. novaeseelandiae* (Gmelin). New Zealand pipit

Zosteropidae: *Zosterops lateralis* (Latham). White-eye

Fringillidae: *Chloris chloris* (Linn.). Greenfinch*

Carduelis carduelis britannica (Hartert). Goldfinch*

flammea cabaret (P.L.S. Mueller). Lesser redpoll

Fringilla coelebs gengleri Kleinschmidt. Chaffinch

Emberiza c. citrinella Linn. Yellow hammer*

Sturnidae: *Sturnus v. vulgaris* Linn. Starling

Note: For references cited, see BIBLIOGRAPHY, page, 596.