

Colony No. 4. In December, 1946, Major G. A. Buddle succeeded in landing upon the formerly considered inaccessible North-East Island, which lies immediately to the North-East of Great Island. Here, amidst luxuriant vegetation dominated by the large puka, Major Buddle found *Placostylus bollonsi* to be quite abundant.

A point of special interest is that these snails are identical with those of the north-east colony on Great Island, in spite of the intervening waterway. North-East Island, however, showed abundant evidence of Maori occupation, and so it seems very probable that the Maoris either intentionally or unintentionally were responsible for acclimatising the snails to this island. The South-West King was visited by Major Buddle also, but no *Placostylus* was seen.

Considerations.

If the differentiation into three forms of *Placostylus* on Great Island is the result of induced isolation caused by Maori occupation during a period of at least three centuries, why is the North-East Island population identical with one of the colonies on Great Island? A probable reason may be that the utilization of the almost inaccessible North-East Island as a kitchen garden by the Maoris was a late development after the land on Great Island had deteriorated through over-cultivation.* The presence of stone contour walls to retard the washing away of the soil on the steep slopes of Great Island is sufficient evidence of the problem that beset the former Maori occupants.

GENERAL.

With all work on snail populations the determination of the length of time requisite for the development of a new form is the most difficult to assess. My present work, which is largely descriptive of existing colonies, provides a basis for future checks, but it is anticipated that the lapse of many years will be required to show any marked differences.

To return to *Paryphanta unicolorata* of the Seddonville flat, it may be noted that the type specimen collected in 1906, when the locality was in virgin bush, can be matched exactly with the present population of the area, which is persisting under greatly altered conditions.

THE CONSTITUTION AND RELATIONS OF THE NEW ZEALAND ECHINODERM FAUNA

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External Relations of the Fauna.

TH. MORTENSEN (1925) has already given reasons for including in the New Zealand faunal region the Kermadec and Auckland-Campbell Islands as well as the Chathams and the main islands. Within the region thus defined, and taking into account eight species awaiting publication, there are known to occur 177 species. As is shown in the histogram (Fig. 1), 141 species (c. 80%) are endemic, 29 (c. 16%) comprise Australian and Indo-Pacific species, 4 (c. 2%) are Magellanic, and 3 (c. 2%) are cosmopolitan. The high proportion of endemic species may be correlated with the supposed prolonged isolation of the region; the external relations are chiefly with the Australian-Indo-Pacific faunas; the relation to the Magellanic region is very weak—and as shown later in this paper—occurs in the southern provinces only and in an area of mixed waters.

The above figures confirm Mortensen's earlier deductions, and as he has discussed the external relations in some detail, the main part of this paper is devoted to a survey of the internal constitution of the faunal region, based on fuller data on the distribution of echinoderms which are now available. It is obviously desirable to establish whether the echinoderms provide any evidence as to the existence of mafine provinces within the New Zealand region. If such can be shown to exist, their relation to the distribution of other recent groups will be of interest; at the same time some further guide may be provided for palaeontological studies since echinoids are commonly found in the fossil state.

*D'Entrecasteaux observed smoke rising from North-East Island in 1792.

Bathymetric Zonation.

Echinoderms generally exhibit a marked zonal distribution. The following bathymetric zones are customarily recognized:—

1. Littoral—
 - (a) Eulittoral—0–50 metres
 - (b) Sublittoral—50–200 metres.
2. Abyssal—200 metres and over

The majority of New Zealand echinoderms appear to be rather strictly stenozonal, i.e., each species is confined to a single zone. The few euryzonal forms are referred to later. There appear to be some 44 abyssal species. Since these cannot be utilised in delineating provinces, they are not further considered here, but for reference a check-list follows.

Check-list of Abyssal Echinoderms.

- (a) Recorded hitherto only from Kermadec Islands:

<i>Astroschema horridum</i>	<i>Ophiomusium scalare</i>
<i>A. salix</i>	<i>Ophiophyllum petilum</i>
<i>Ophiacantha cornuta</i>	<i>Solaster torulatus</i>
<i>O. vepraticea</i>	<i>Phormosoma rigidum</i>
<i>Ophioplinthaca plicata</i>	<i>Aglaometra incerta</i>
<i>Ophiomoeris clausa</i>	<i>Stiremetra brevirostris</i>
<i>Ophiurases obstrictus</i>	<i>Thalassometra echinata</i>
<i>Amphiura argentea</i>	<i>Glyptometra inaequalis</i>
<i>A. lanceolata</i>	<i>Charitometra basicurva</i>
<i>Ophiactis flexuosa</i>	<i>C. incisa</i>
<i>O. cuspidata</i>	<i>Metacrinus nodosus</i>
<i>O. nama</i>	<i>M. wyvillii</i>
<i>O. canescens</i>	<i>Saracrinus varians</i>
<i>Ophiochiton lentus</i>	<i>Diplocrinus alternicirrus</i>
<i>Ophiocoma brevipes</i>	<i>Hypalocrinus naresianus</i>

- (b) Recorded from near Kermadec Islands and from off East Coast of North Island:

Thaumatometra alternata

- (c) Recorded from off North Cape:

Ophiocreas longipes
Astrotoma benhami
Ophiactis hirta

- (d) Recorded from off East Coast of North Island:

<i>Ophiacantha vilis</i>	<i>Ophiozonella stellata</i>
<i>Ophiomastus tegulitius</i>	<i>Cosmasterias fragilis</i>
<i>Amphiophiura ornata</i>	<i>Pourtalesia laguncula</i>
<i>Homalophiura irrorata</i>	<i>Temnopleurus reynaudi</i>
<i>Ophiocten hastatum</i>	<i>Pentametrocrinus semperi</i>

Most of the above records were made by the Challenger Expedition from only a few stations. The lists may require augmentation by one or two species the zonation of which is dubious, and doubtless many species occur which are yet unknown.

Marine Provinces within the New Zealand Region.

If New Zealand echinoderms are listed according to their occurrence in the North Island, Cook Strait, South Island, Stewart Island, etc., no satisfactory grouping emerges; most of the species overlap geographically. As a result of molluscan studies, Finlay (1925 and later) has established certain marine provinces within the region. It is satisfactory to find that if the echinoderm distribution is compared with that of the mollusca a close measure of agreement is seen, save for some minor divergences to be noted below—probably attributable to incomplete data. The provinces may be considered from north to south in order, and stenotopic species designated for each. It should be noted that the check-lists must be regarded as provisional, as it is almost certain that a number of species at present known only from one province will later prove to be more or less eurytopic. On the other hand, any association of species generally corresponding with one or other of these check-lists—as may be found in late Tertiary strata—is likely to indicate environmental conditions approximating to those of the corresponding extant province.

Kermadecian Province. From the Kermadec Islands only a small eulittoral fauna is known. It includes a number of forms highly characteristic of the New Zealand region as a whole, but also includes six distinctive species which may be listed as stenotopic.

Amphiura kermadecensis

Petricia imperialis

Asterope lissotergum

Asterina oliveri

Astrostole rodolphi

Coscinasterias edmondi

Considering the Kermadecian fauna as a whole, 75% of its 11 species are forms endemic to the New Zealand region. The relationship with Australian-Indo-Pacific faunas is marked, comprising 21% of the fauna. There is no sign of any Magellanic element.

Aupourian Province. This province has been variously defined, but includes the northernmost part of the North Island. Echinoderm evidence would suggest that the southern boundary on the eastern side cannot fall north of Whangarei—for otherwise species such as *Asterodiscus truncata* and *Brisus gigas*, with distinct Australian-Indo-Pacific facies would present an anomalous distribution. The proportion of species occurring in the area north of Whangarei and endemic to the New Zealand region is 70%, a figure again lower than the average for the entire region. The stenotopic fauna may be listed at present as follows:

Eulittoral:

Cucumaria bollonsi

Sublittoral:

Astroceras elegans

Astroporpa wilsoni

Ophiothrix aristulata

Astropecten dubiosus

Asterodiscus truncatus

Ogmocidaris benhami

Aracosoma thetidis

Pseudochinus variegatus

Laqanum depressum

Brissus gigas

Holothuria neozelandica

Cucumaria farquhari

Psolus neozelandicus

Comanthus novaezelandiae

Argyrometra mortenseni

In this province the relationship with Australian-Indo-Pacific faunas is most marked, comprising 27.5% of the entire fauna. Again, as in the case of the Kermadecian province, there is no discernible Magellanic element.

Cookian Province. This is taken as comprising the remainder of the North Island as well as Cook Strait and the northern half of the South Island. It is an area rich in species both eurytopic and stenotopic. The stenotopic species comprise 29 out of a total list of 74 littoral forms, and are as follows:

Eulittoral:

Amphiura aster

A. norae

A. rosea

A. annulifera

Diplodontias dilatatus

Stegnaster inflatus

Echinaster farquhari

Astrostole scabra

Arachnoides zelandica

Cucumaria ocnoides

Phyllophorus longidentis

P. dearmatus

Candina coracea (also sublitt.)

Protankyra uncinata (also sublitt.)

Sublittoral:

Gorgoncephalus chilensis

var. *novaezelandiae*

Ophiocentrus novaezelandiae

Amphiura sp. nov.

Ophionereis novaezelandiae

Ophiocoma sp. nov.

Pectinura sp. nov.

Ophiozonella megaloplax

Astropecten primigenius

Psilaster acuminatus

Persephonaster neozelandicus

Luidia var. *a*

L. neozelandica

Eurygonias hylacanthus

Spatangus multispinus

Brissoptis zelandiae

The proportion of species endemic to New Zealand here reaches 78% of the entire littoral fauna for the province, a figure which approximates the average for the New Zealand region as a whole. The Australian-Indo-Pacific element shows a corresponding drop to 16%, also equal to that of the whole New Zealand region. Here for the first time a Magellanic element occurs, equal to some 3.4%. Thus the Cookian fauna, apart from its stenotopic forms, presents a broad section of the whole New Zealand echinoderm fauna.

Mororian Province. Unfortunately, the evidence from echinoderms as to the existence of a distinct province for the Chatham Islands is completely negative. Only a small number of species are known, and all are eurytopic. The need for a survey of Chatham Islands echinoderms is obvious.

Forsterian Province. From the southern part of the South Island and Stewart Island a fauna of 46 echinoderms is known, but of these the great majority are eurytopic; the 8 stenotopic species are all eulittoral, as follow:

<i>Ophiomyxa duskiensis</i>	<i>Cucumaria huttoni</i>
<i>Ophionephthys stewartensis</i>	<i>Pseudocucumis thompsoni</i>
<i>Amphiura pusilla</i>	<i>Psolidiella nigra</i>
<i>Peridontaster benhami</i>	<i>Comanthus benhami</i>

Species endemic to New Zealand here comprise as much as 83% of the provincial fauna. The Australian-Indo-Pacific element falls to only 11%, a figure much below the average for the whole of New Zealand, while the Magellanic element is relatively high, being 4%. In other respects the province shows some resemblance to the Cookian, and possesses species in the Fiords area known otherwise only from the northern part of the Cookian province.

Rossian Province. Although the littoral fauna of the Auckland and Campbell Islands has been studied more closely in recent years, the total number of echinoderms remains small, namely 25. Of these, however, 6 are stenotopic, namely:

Eulittoral:

<i>Amphiura praefecta</i>	<i>Calvasterias laevigata</i>
<i>Asterina aucklandensis</i>	<i>Cucumaria leoninoides</i>
<i>Henricia lukinsii</i>	

Sublittoral:

Chiridota carnleyensis

The proportion of endemic New Zealand forms in this province reaches the remarkably high figure of 92%. The Magellanic element remains low, 4%, though this is relatively high as compared with the whole New Zealand fauna. What is of interest is the complete absence of any Australian-Indo-Pacific element, elsewhere the chief external influence in the fauna.

Interrelations of the Faunal Provinces.

Histograms (Figs. 2-5) may be used to illustrate the faunistic interrelationships between the several provinces.

Endemic Species: Relatively greater effective isolation of the southern provinces is suggested by the peaking of endemic species there (Fig. 2). This is to be correlated with the distribution of Australian-Indo-Pacific species.

Australian-Indo-Pacific element: Fig. 3 illustrates the peaking of this element in the northern provinces, falling off evenly towards the south, disappearing in the Rossian. It suggests an influx from the north and north-east, the invasion falling off in the more distant southern areas, where presumably unfavourable environmental conditions serve as a barrier, especially to the larval forms. Palaeontological evidence would be desirable to show whether such an influx occurred in the past, or whether it is a process in active operation now.

Magellanic element: The Magellanic element (Fig. 4) presents a histogram almost the reverse of the preceding, though in all cases the figures are much lower. Presumably a minor incursion has occurred from the south-east, terminating in the Cookian, which forms the northern limit of the element. The species concerned are all such as could be transported by ocean currents either as larvae or on drifting material.

Cosmopolitan species: As might be expected, the proportion of such forms shows no significant variation, being uniformly low (Fig. 5).

Mixed associations: It is noteworthy that the middle provinces alone contain all the above-mentioned elements. The variety of character of these faunas and their richness in species (especially the Cookian) may be interpreted as a consequence of the zone of "mixed waters" occurring there; *vide* Fleming (1944, p. 216).

Eurytopic Species.

Species occurring in two or more provinces number 127. It is not necessary to present a check-list of these here, though certain facts emerging from an examination of such a list may be noted. *Ophionereis fasciata*, a common endemic eulittoral ophiuroid, is known to occur in every province. The same appears true of the cosmopolitan *Amphipholis squamata*, though its presence in the Chathams requires verification. Other strongly eurytopic species include *Amphiura amokurae*, *Allostichaster polyplax*, *Ophiomyxa brevissima* and *Evechinus chloroticus*. Since these species include some of the most characteristic New Zealand

forms (in the sense of being morphologically distinct from exotic forms) their wide distribution within New Zealand suggests their differentiation at a relatively early date. It is also noteworthy that, with the apparent exceptions of *Brissopsis luzonica* and *Ophiocreas constrictum* (known each from only one locality in New Zealand, though neither is endemic), all euryzonal species are also eurytopic. Since the two species named are widely distributed in the Pacific, a more widespread distribution in New Zealand is to be expected.

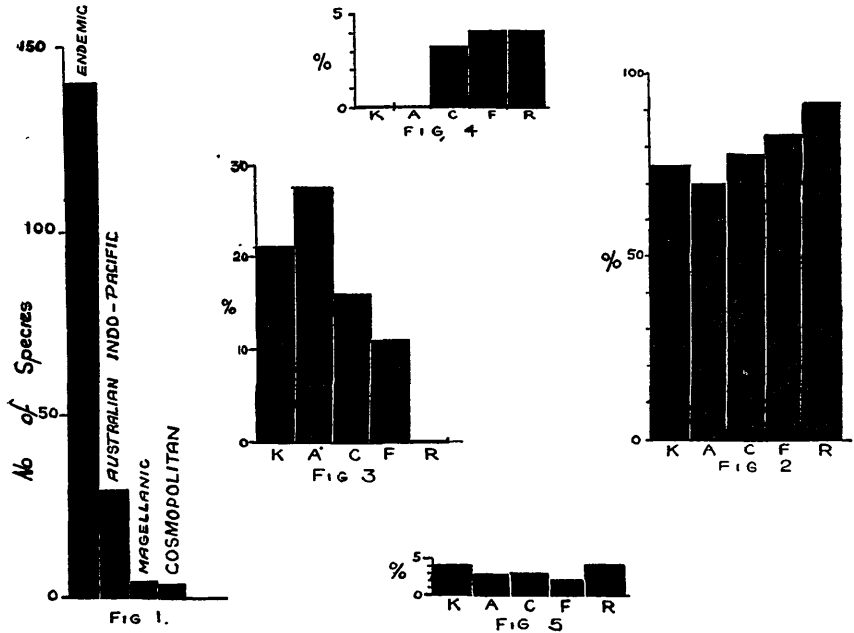


FIG. 1—Histogram showing relative proportions of the constituent elements of the New Zealand echinoderm fauna. FIGS. 2-5—Histograms showing incidence of constituent elements in provincial faunas, expressed as percentage of the total echinoderm fauna of each marine province. FIG. 2—Endemic element; FIG. 3—Australian-Indo-Pacific element; FIG. 4—Magellanic element; FIG. 5—Cosmopolitan element. In FIGS. 2-5 the provinces read in order from left to right to correspond with their relative north to south disposition. Abbreviations: K, Kermadecian; A, Aupourian; C, Cookian; F, Forsterian; R, Rossian.

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OCEANOGRAPHY OF THE NEW ZEALAND SEAS

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Introduction.

IF New Zealand's field of oceanographical interests be taken to be congruent with its political boundaries which reach as far north as the mandated territory of Samoa and as far south as the coasts of the Ross Dependency, it will cover a vast expanse of ocean roughly 4,000 miles long from north to south and about