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Conclusions

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Conclusions

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From the papers presented at this meeting it is apparent that before the Expedition visited the New Hebrides in 1971 the flora and fauna of the islands were little known and that a great deal of new knowledge has resulted from the Expedition's work. Many more specialized papers based on the Expedition's collections are in hand and some are already published, but we realize that there was much we could not cover in our four months' work, and there is wide scope for further exploration of the islands' biota. We visited only the six large western islands of the archipelago, covering only selected portions of them, and also a few smaller islands adjacent to them. The northern and eastern islands, extending over some 500 km from the Torres Islands in the north to Epi and the Shepherd Islands in the south, were neglected by the Expedition. Their flora, and especially their fauna, are still little known. For instance, of 22 species of earthworms now known from the New Hebrides, only three have been recorded from the northern and eastern islands, and these only from isolated localities on two islands.

The New Hebrides form a natural geographic unit, isolated from other archipelagoes, and though we have not covered the whole range of islands some conclusions may be drawn from our knowledge of the biota of those islands we now know better. These are discussed under four main headings: (1) the composition of the flora and fauna, (2) distribution of the flora and fauna within the New Hebrides, (3) affinities with the flora and fauna of other Pacific islands and adjacent mainland areas, (4) origins and dispersal of the flora and fauna.

1. The composition of the flora and fauna

(i) There is a general paucity of major groups of plants and animals, with few genera per family and species per genus. Of the phanerogamic plants 123 families, including 451 genera and 870 species, are represented. Only six families have more than 16 genera, and 88 families (71 %) have three genera or less. Of the 451 genera, over 90 % have three species or less, 58 % have only one species, and only three genera (< 1 %) have more than eight New Hebridean species (Chew, this report). There is an average of 1.93 species per genus. In 159 genera of five groups of invertebrates covered in Gross's paper there are 237 species, an average of 1.49 species per genus. Of the 71 genera of terrestrial vertebrates, one has ten New Hebridean species, four have three species each, ten two species each, and the remaining 56 (79 %) have only one New Hebridean species. Some groups that might reasonably be expected are unknown, e.g. there are no native frogs, although native species are known from the Solomons to the west and from Fiji to the east.

(ii) Many species of plants and animals have wide environmental ranges. There are many plants that are found from sea level to altitudes above 1500 m, and associated with this is great intraspecific variability, perhaps a response to the species' great ecological amplitude (Chew, this report). Similarly, the same species of earthworms are found from lowland forests to the tops

of the highest ridges, but without apparent morphological variability. This contrasts with the situation, for instance, in New Zealand, where altitudinal zonation of earthworms is very marked (Lee 1959), and is comparable with that recorded in subantarctic islands (Lee 1968), most of which would have been uninhabitable for earthworms during the last glacial maximum and have apparently been repopulated within the last 10000 to 20000 years by a few species of *Microscolex* that can tolerate immersion in the sea and so have been able to cross wide ocean gaps. In contrast, Solem (1959*b*) found much morphological variation in New Hebrides land snails, correlated with differing moisture conditions and with the altitudinal ranges of species.

(iii) There is a generally low level of endemism at all taxonomic levels above species. Only one of the 451 genera of phanerogamic plants is regarded as endemic. None of the 83 genera of ferns is endemic. Among five groups of invertebrates – Megascolecidae (earthworms), Isoptera (termites), Dermaptera (earwigs), Hemiptera-Heteroptera, and Rhopalocera (Lepidoptera) – selected by Gross to exemplify relationships of invertebrates in general, ten of the 98 genera of Hemiptera-Heteroptera are endemic, while among the 61 genera in the other four groups none is endemic. One of the 45 genera of land birds is endemic, and there are no other endemic terrestrial vertebrates.

(iv) The level of endemism at species level varies widely between various groups within the flora and fauna (see table 4). Chew regards 22% of the species of phanerogamic plants as endemic while Braithwaite finds that only 4.4% (11 spp) of ferns are endemic, and both authors believe that further investigation may show these figures to be too high. There is much greater variation in endemism of species among animal groups Gross reports that 50% of earthworms, 42% of termites, 31% of earwigs, 35% of Hemiptera-Heteroptera, and only 3% of Rhopalocera (Lepidoptera) are endemic. The high figures for some groups may reflect comparative inadequacy of collections from other southwest Pacific islands, although Solem (1959*b*) recorded 57 endemic species (72%) of a total of 79 species of land snails in the New Hebrides and the land snails appear to be a relatively well known group in the Pacific. The very low figure for Rhopalocera probably reflects the high vagility of many Lepidoptera and perhaps more thorough collecting in other island groups than is general for other invertebrates. Medway & Marshall found that 11% of birds, 17% of bats, and 20% of reptiles are endemic species.

2. Distribution within the New Hebrides

(i) The climate of the northern islands of the group is less seasonal, more uniformly warm and humid, than that of the southern islands (Lee, this report: Introduction). This may account for the greater diversity of some phanerogamic plants noted by Chew, e.g. Urticaceae achieve their maximum dominance and diversity on the lowland plain of northern Espiritu Santo, and are not so important an element in the flora of the southern islands. Medway & Marshall note a clear progressive impoverishment among species of bats and birds from north to south, especially well illustrated by the seven endemic bird species, of which only two are known from Erromanga and Tanna and one from Aneityum. This meridional trend of increasing impoverishment is not seen, however, in some other groups. Lizards do not show it, neither do earthworms, nor the insect groups for which data are available, and Aneityum, the southernmost island visited, has a remarkably large number of species of plants in proportion to its area (see below).

(ii) Other environmental factors modify the effects of the north–south trend of increasing seasonality. The predominant winds during the 'dry season', from about April to November,

are the moist southeast trade winds, and consequently there is a rain shadow on western and northern aspects of the mountainous islands during the dry season. Large areas on the dry sides of the islands were formerly forested but have been burned and are now covered by scrub or savanna. Schmid reports that such areas in northern and western Aneityum bear *Miscanthus floridulus* scrub; at Tanna, Erromanga, Efate, Malekula, and Espiritu Santo, western or northern burned areas have grass savanna, known locally as 'white grass' (*Imperata*, *Apluda*, *Paspalum*), or low grassland, e.g. in western Erromanga, with *Chrysopogon aciculatus* dominant. On eastern and southern aspects of the islands forest fires more commonly lead to replacement by scrub.

On the flights of coral limestone terraces in western central Malekula, where drainage is predominantly by deep subsurface channels, accentuating the effect of the rain shadow, there is extensive development of open canopied *Leucaena leucocephala* forest and semi-deciduous notophyll vine forest.

Active volcanoes, especially at Tanna and Ambrym, are surrounded by bare or sparsely vegetated cinder plains. We did not visit Ambrym but it seems likely that at Tanna there has been very recent local extermination of flora and fauna by heavy falls of volcanic ash and scoria. Continuous eruptions of basalt ash, rich in plant nutrient elements, are a feature of the New Hebrides environment. The ash is thickest and its effect on nutrient availability in the soil must be most important close to the volcanic vents, but Quantin concludes that most soils of all the New Hebrides islands are derived at least partly from volcanic ash, and frequently have little affinity with the underlying rock.

(iii) The biota of the southern islands may include some relict groups, formerly present but now absent, or at least rare, in the northern islands. For example, the New Hebrides kauri (*Agathis obtusa*) is now largely confined to Erromanga and Aneityum, where it is a dominant canopy species on many ridges and upper slopes (Beveridge, this report), but it is also known in scattered clumps and as isolated trees in the mountains of western Espiritu Santo. It may formerly have been more common in the northern islands as a dominant canopy species.

TABLE 1. NUMBERS OF SPECIES OF FIVE GROUPS OF INVERTEBRATES KNOWN FROM SIX MAJOR ISLANDS IN THE NEW HEBRIDES

(Data from Gross, this report.)

animal group	Espiritu Santo	Malekula	Efate	Erromanga	Tanna	Aneityum
earthworms (Megascolecidae)	7	11	10	8	3	7
termites (Isoptera)	6	8	7	2	2	1
earwigs (Dermaptera)	12	6	4	10	2	4
Hemiptera-Heteroptera	52	45	30	27	22	29
Rhopalocera (Lepidoptera)	33	27	39	28	20	19

(iv) The flora of Aneityum is remarkably diverse compared with that of other islands in the New Hebrides. Schmid compares total species numbers of phanerogams and vascular cryptogams on Aneityum, Tanna, and Erromanga, and finds that they have 606, 410, and 462 species respectively. If numbers of species of these groups are compared on the basis of the relative island area it is found that Aneityum has 3.76 species/km², Tanna 0.75 species/km², and

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Erromanga 0.54 species/km². Braithwaite has listed 135 species of ferns from Aneityum, 51 from Tanna, 60 from Erromanga, 64 from Efate, 65 from Malekula, and 167 from Espiritu Santo. The flora of Aneityum may well be rather better known than that of some other islands in the group, but it is of interest to compare the ferns of Aneityum with those, for instance, of Efate, which is a considerably larger island (910 km²; Aneityum 165 km²) with much mountainous forested country where ferns are common, yet has rather less than half as many species of ferns as Aneityum. Also, Schmid notes that the flora of Tanna is poor in species and attributes this to pressure from the relatively high human population density and possibly to periodic extermination by volcanic activity. Numbers of species of five invertebrate groups on the six islands whose ferns are compared by Braithwaite are listed in table 1. There is no evidence in these groups of increased diversity in Aneityum compared with the other islands.

3. Biogeographical affinities of the flora and fauna

The ultimate origin of the great majority of the flora and fauna must be presumed to be Indo-Malayan, Oriental, or Australian, and all groups except the ferns (Braithwaite, this report) are characterized by the impoverishment and lack of diversity at all levels that typify the biota of isolated oceanic islands. More immediate affinities can be recognized, with the biota of New Guinea and the Palaeo-oriental region, of which New Guinea may be regarded as a part, with a 'south temperate area' comprising New Caledonia, Australia, and New Zealand, and with a 'Pacific area' comprising the Solomons, Fiji, and other islands of the Pacific basin. These three divisions, based on the Expedition's collections, correspond with those recognized on the basis of distribution of land snails by Solem (1959*b*) and Peake (1969), except that these two authors regarded the Solomons, with New Guinea, as an integral part of the Palaeo-Oriental region. A number of other biogeographers interested in the southwest Pacific area have recognized similar divisions among various groups of animals and plants.

(i) Table 2 illustrates the affinities in five groups of invertebrates from the New Hebrides and New Guinea. There is much in common, and taking a superficial view it might be concluded that New Guinea is the primary source of immigrants that make up the New Hebrides biota.

Table 2. Numbers of species and genera of five groups of invertebrates recorded from the New Hebrides with numbers and percentages of these taxa recorded (*a*) also from New Guinea, and (*b*) from New Guinea and elsewhere

	species					genera				
	total in New Hebrides	also in New Guinea		in New Guinea and elsewhere		total in New Hebrides	also in New Guinea		in New Guinea and elsewhere	
animal group		no.	%	no.	%		no.	%	no.	%
earthworms (Megascolecidae)	22	7	32	2	9	6	5	83	4	67
termites (Isoptera)	12	4	33	4	33	7	5	71	5	71
earwigs (Dermaptera)	16	5	31	2	13	10	6	60	4	40
Hemiptera-Heteroptera	124	29	23	26	21	98	57	58	52	53
Rhopalocera (Lepidoptera)	63	43	68	39	62	38	38	100	38	100

However, many of the taxa shared with New Guinea are very widely distributed in one or more of Indonesia, southeast Asia, and other Pacific islands, or are pantropical or cosmopolitan. The apparent close affinity results very largely from the presence of these widespread taxa, whose eventual origins are uncertain and whose subsequent wanderings are unknown. It can only be said that many of them are likely to have originated in the Palaeo-Oriental region. Similarly, the vertebrates and the phanerogamic plants have much in common with those of New Guinea, but many of the taxa involved are cosmopolitan or are found at least in the Palaeo-Oriental region.

TABLE 3. NUMBERS OF SPECIES AND GENERA OF FIVE GROUPS OF INVERTEBRATES RECORDED FROM NEW HEBRIDES WITH NUMBERS AND PERCENTAGES OF THESE TAXA RECORDED (*a*) ALSO FROM 'SOUTH TEMPERATE REGIONS' (NEW CALEDONIA, AUSTRALIA, OR NEW ZEALAND), (*b*) FROM 'SOUTH TEMPERATE REGIONS' AND ELSEWHERE

	species					genera				
		also in 'south temperate regions'		in 'south temperate regions' and elsewhere			also in 'south temperate regions'		in 'south temperate regions' and elsewhere	
animal group	total in New Hebrides	no.	%	no.	%	total in New Hebrides	no.	%	no.	%
earthworms (Megascolecidae)	22	3	14	3	14	6	2	33	2	33
termites (Isoptera)	12	3	25	2	17	7	3	43	3	43
earwigs (Dermaptera)	16	3	19	3	19	10	7	70	4	40
Hemiptera-Heteroptera	124	34	27	27	22	98	73	74	56	57
Rhopalocera (Lepidoptera)	63	46	73	42	67	38	34	89	34	89

(ii) Table 3 illustrates affinities with 'south temperate regions' (New Caledonia, Australia, New Zealand) of the same five groups of invertebrates as in table 2. Nearly all the species found in New Caledonia, Australia, or New Zealand and in the New Hebrides are much more widely distributed and many are the same as those in common with New Guinea. Their eventual origins are uncertain, but it is likely that the majority of them originated from the Oriental region. There is very little affinity among the phanerogamic plants. For example, of 17 species of *Ficus* in the New Hebrides one is regarded by Corner as a New Caledonian species; Chew has calculated an index of discrepancy of the New Hebrides and New Caledonian phanerogamic floras at the generic level and has shown a high level of discrepancy, i.e. a low level of similarity, between them.

(iii) In table 4 are listed, for a number of animal groups, numbers of species and genera endemic in the New Hebrides, known from the New Hebrides and otherwise confined to the 'Pacific area', i.e. islands of the Pacific Ocean excluding New Guinea, New Caledonia, and New Zealand, and the total of these two, which represents the 'Pacific area' element in the New Hebrides fauna. Numbers of species and genera in these categories, where known, are expressed also as percentages of the total New Hebrides species and genera.

Dermaptera and Hemiptera-Heteroptera include a significant proportion of 'Pacific area' genera, and there is one endemic genus of birds, but other groups have no genera that are

confined to the Pacific islands. At the species level a high proportion of all groups except the Rhopalocera are 'Pacific area' taxa. This section of the New Hebrides fauna includes the Pacific 'tramps', which are particularly widespread, are often associated with man, and probably have been spread accidentally or deliberately by man. The remainder includes a fairly readily recognizable Melanesian assemblage with varying ranges in the New Hebrides, Solomons, Fiji, and with related species of some of the genera more rarely extending to New Caledonia. It seems likely that movements between islands have been in many directions, and

TABLE 4. NUMBERS OF SPECIES OF EIGHT GROUPS AND NUMBERS OF GENERA OF FIVE GROUPS OF ANIMALS RECORDED FROM THE NEW HEBRIDES WITH NUMBERS AND PERCENTAGES OF THESE TAXA THAT ARE ENDEMIC IN THE NEW HEBRIDES, THOSE CONFINED TO THE NEW HEBRIDES AND THE 'PACIFIC AREA', I.E. ISLANDS IN THE PACIFIC OCEAN EXCLUDING NEW GUINEA, NEW CALEDONIA, AND NEW ZEALAND, AND THE TOTAL OF THESE TWO, I.E. THE 'PACIFIC AREA' TAXA KNOWN FROM THE NEW HEBRIDES

	species							genera						
animal group	total in New Hebrides	(*a*) endemic		(*b*) common to New Hebrides and 'Pacific area' only		total 'Pacific area' species in New Hebrides (*a*) + (*b*)		total in New Hebrides	(*c*) endemic		(*d*) common to New Hebrides and 'Pacific area' only		total 'Pacific area' genera in New Hebrides (*c*) + (*d*)	
		no.	%	no.	%	no.	%		no.	%	no.	%	no.	%
earthworms (Megascolecidae)	22	11	50	5	23	16	73	6	0	0	0	0	0	0
termites (Isoptera)	12	5	42	2	17	7	58	7	0	0	0	0	0	0
earwigs (Dermaptera)	16	5	31	2	12	6	37	10	0	0	2	20	2	20
Hemiptera-Heteroptera	124	44	35	16	13	60	48	98	10	10	2	2	12	12
Rhopalocera (Lepidoptera)	63	2	3	4	6	6	10	38	0	0	0	0	0	0
reptiles	20	4	20	5	25	9	45							
land birds	61	7	11	20	33	27	44							
bats	12	2	17	3	25	5	42							

though the original source of most taxa would logically have been in the Oriental or Papuan region, there appears to have been local speciation giving rise to specialized insular faunas. In most groups some species are found on islands close to the New Guinea coast, apparently able to compete in their insular environment with immigrants from the mainland but unable to establish themselves on the mainland.

A similar, well developed 'Pacific area' assemblage is recognizable in the flora. Of 74 species of New Hebrides ferns comprising a Pacific element in the fern flora, 60 are found also in Fiji and 29 in the Solomons (Braithwaite, this report). Phanerogams also have more in common with the Fijian than with the Solomons flora; the tests of discrepancy between assemblages of genera made by Chew (this report) show that the New Hebrides assemblage is most like the Fijian while there is a large discrepancy between the New Hebrides and the Solomons assemblages.

Within the New Hebrides archipelago there is some differentiation between the flora and fauna of northern islands, which are most closely related to those of the Solomons, to the north-

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west, and those of the southern islands, which are more closely related to those of Fiji and also have more representatives than the northern islands of the minor New Caledonian element. For example, four New Hebrides termite species are known also from the Solomons and they are all confined, in the New Hebrides, to the islands from Efate northwards; in the phanerogamic plants Chew has found that the northern islands have more Indo-Malesian species than the southern islands. He attributes this partly to the difference in seasonality between northern and southern islands, partly to the greater area and altitudinal range of northern compared with southern islands. Perhaps most significant are the conclusions of Gillison and Beveridge, based on structural analysis of forest types. Of 12 major structural vegetation types, ten, the more complex types, are apparently restricted to islands from Efate northwards and two, less complex types, to islands south of Efate. Within the northern islands there is an attenuation in floristics and in structural complexity of the vegetation from Espiritu Santo to Efate, but a major disjunction appears to exist between Efate and Erromanga (*ca.* 18° S), so marked that it is suggested that the northern and southern islands should be regarded as separate phytogeographical entities.

In some groups there is a sharp distinction between Solomons and New Hebrides biota. Corner recognizes 17 species of *Ficus* in the New Hebrides and, from previous collections, 64, including 24 endemics in the Solomons. The collecting of the Expedition failed to reveal any of the 24 Solomons endemics in the New Hebrides.

The New Hebrides appear to lie in a position where many Oriental and Papuan species reach the easternmost limit of their range and many Pacific species reach their westernmost limit. For example, Braithwaite records 20 fern species whose easternmost limits are in the northern islands of the New Hebrides and 14 other Pacific islands species whose westernmost limits are also in the northern islands of the New Hebrides. A thorough examination of the little known flora and fauna of the Santa Cruz Islands and of the northeastern and extreme northern New Hebrides is an essential further step to provide more information on the relationships and distribution of Indo-Malesian and Pacific plants and animals.

4. Origins and dispersal of the flora and fauna

The geological history of the New Hebrides imposes rather narrow limits within which feasible explanations of the origins and dispersal of the flora and fauna must fit. The islands of the archipelago are very recent in origin. Mallick (this report) concludes that though the New Hebrides was well established as a volcanic island arc by the late Oligocene and possibly late in the Eocene, the total land area was very small and it was not until Quaternary times that the land area became appreciable. Land area has increased at least tenfold in Quaternary times, and mainly in the last half million years. The islands, then, are much younger than the Solomons and Fijian archipelagoes, which are largely pe-Quaternary. The New Hebrides are oceanic islands, separated by deep ocean from other islands and mainland areas.

Three main hypotheses are available to explain the immigration of the islands' biota: ocean floor spreading and associated drift of crustal segments moving islands away from mainland areas to which they were formerly joined or adjacent; former land connexions (land bridges) joining land areas that are now separated; chance dispersal by various means across ocean gaps.

Ocean floor spreading and crustal drift might account for some of the relationships and for some apparent anomalies. Northeastern movement of the Australasian plate has brought

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Australia and New Caledonia closer to the New Hebrides, while east–west spreading on the Fiji plateau has progressively increased the distance between Fiji and the New Hebrides. The time scale of ocean floor spreading is too great for the process to be very significant, especially since most of the land surface of the New Hebrides is so recent. However, it may be partially responsible for the close relationships of the New Hebrides and Fijian biota and for the lack of similarities between the biota of both these archipelagoes and those of New Caledonia and Australia.

The surrounding oceans are very deep, and the present islands are so recent in origin that former land bridges, sufficient to account for long distance dispersal to or from the New Hebrides, are not credible. It is possible that other islands have existed in the past and that inter-island distances could have then been shorter, making dispersal easier. It is also possible that adjacent islands, now separated, were formerly joined by short connexions, e.g. Espiritu Santo and Malekula were probably joined at the last glacial maximum.

Chance dispersal across ocean gaps is feasible, and probably accounts for most, if not all, immigration of plants and animals to the New Hebrides. The essential unpredictability of trans-oceanic dispersal and the very recent emergence of the New Hebrides islands would account for the paucity of species and larger taxa and the absence of some groups.

Four principal mechanisms are available to transport terrestrial plants and animals across ocean gaps – winds, ocean currents, accidental carriage by migrating or wind-blown birds, and accidental or deliberate transport by man.

The New Hebrides are subject in the November to April period to frequent hurricanes, which reach the islands mainly from the northwest. These are capable of lifting small animals and at least parts of plants thousands of metres in the air and of transporting them at high speeds over long distances before allowing them to fall. For the remainder of the year winds are fairly constant from the southeast. Many living insects, including winged and flightless forms, have been trapped from aeroplanes at high altitudes and up to several thousand kilometres from land, and wind dispersal could account for much of the immigration of insects and arrival of seeds and spores in the New Hebrides. Braithwaite (this report) comments on the dispersal of fern spores, concluding that the evidence for wind dispersal seems so compelling that it scarcely seems necessary to examine other views in detail.

Logs, trees, and smaller fragments of plants carried by ocean currents or driven over the sea by storms may be important in the dispersal of seeds and of small animals. For example, the most widespread termites of the New Hebrides are log-dwelling species that form small colonies and have the ability, which many termites lack, to produce new primary reproductives from supplementary reproductives within a colony. Even a fraction of a colony that survived drifting in a log to an island could establish a new colony. Other small log-inhabiting insects that have no social organization are even more likely to be successfully dispersed in floating logs than are termites.

Chew (this report) comments on the suitability of the diaspores of New Hebrides plants for transport by wind and by floating in water. Although there is not a preponderance of phanerogamic plants with diaspores adapted for such modes of dispersal, many species of secondary communities and of coastal vegetation do have such diaspores, and in the inner forest the Orchidaceae have wind-borne diaspores. It is of interest to note that of the 123 families of phanerogamic plants in the New Hebrides, the Orchidaceae, with 45 genera and more than 80 species (about 10% of the total genera and species), is the best represented.

The importance of birds in transporting the diaspores of phanerogamic plants is accentuated

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by Chew (this report), who points out that the majority of species in lowland and high altitude forests have diaspores that are specially adapted for dispersal by birds, some internally and some externally. It is generally believed that small invertebrates may be carried about by birds, although there is very little direct evidence. The collections made by the Expedition include ectoparasites of vertebrates, but we did not collect non-parasitic invertebrates from vertebrates.

It seems likely that man has been a potent agent of dispersal of plants and animals in the Pacific. Solem (1959*a*, *b*) discussed dispersal of land snails in the Pacific by man, and distinguished 'coral island taxa', which he believed to be dispersed by native people, and 'tropical tramps', which he believed to be dispersed by Europeans. These snails are generally confined to coastal areas and differ from the predominantly endemic inland taxa, most of which have probably not been dispersed by man. Three families are represented among New Hebrides termites; J. C. Buckerfield (personal communication) distinguishes those (Kalotermitidae and Rhinotermitidae) that have small colonies, live in logs, are widely dispersed in the New Hebrides and in the Pacific generally, and have probably been carried in drifting logs and in firewood, canoes, house poles, and other wooden articles associated with man, from those (Termitidae) that have large colonies, more sophisticated social systems, nests on the ground or closely associated with the soil, confined to northern islands in the New Hebrides and not so widely dispersed in the Pacific, often associated with man and his villages and wooden articles, and have probably been carried about the Pacific entirely or predominantly by man. New Hebrides earthworms include three well known 'tropical tramp' species and another, apparently from Madagascar, four pan-Pacific peregrines, and 14 species not known elsewhere. There is no evidence of altitudinal zonation of species. Gates (1959) and Lee (1969) concluded that most of the Solomons earthworms had been brought there by man, and it seems likely that the same might be true of the New Hebrides earthworms. Knowledge of Pacific islands earthworms is incomplete, and supposedly endemic New Hebrides species may in fact be more widely distributed. Food plants and many other garden and forest plants that are essential to human culture are carried by native people from island to island and this has been going on for thousands of years in the Pacific. Earthworms and probably many other invertebrates must have been carried with them, together with small plants and seeds in soil and litter taken with the larger garden and forest species.

It is apparent that the origins and dispersal routes and mechanisms of the New Hebrides biota are varied and that the islands lie in an area of overlap between Palaeo-Oriental organisms that have originated from Indo-Malaya, New Guinea, and eastern Asia, a minority of 'southern temperate' organisms with closest affinities in Australia, New Caledonia, and New Zealand, a major component of 'Pacific area' organisms, confined to the Pacific islands and including some whose very wide dispersal is probably due to human agency, and a variety of pan-tropical and cosmopolitan organisms whose means of dispersal are varied but in most cases are probably due to man.

There are very marked differences from the Solomons biota, and I suggest that we should now explore the biota of the eastern and northern New Hebrides and of the Santa Cruz Islands which lie between the New Hebrides and the Solomons. Little is known of these islands' biota, and an expedition there may now provide a basis for a fairly complete understanding of the relationships of the flora and fauna of Australasia and the Pacific basin.

I am grateful to all the contributors to this Discussion Meeting, from whose data I have drawn in writing this paper.

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